Modelling Sectorally Differentiated Water Prices in a Computable General Equilibrium Model

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Abstract: This study presents a Computable General Equilibrium (CGE) model, STAGE_W that includes multiple water commodities produced from different water resources as well as several taxation instruments, which allow for price differentiation between consumer groups. With the help of the model economy-wide effects of changes within the water sector can be simulated. To demonstrate its capabilities, the model is applied to the case of Israel, where the current water pricing scheme supplies potable water to municipalities at fees above the supply costs and subsidizes water delivered to the agricultural and the manufacturing sectors. Due to limited freshwater resources, climate change and population growth, water scarcity is an increasing problem in Israel. Therefore, pricing systems which lead to a more efficient allocation of water are intensively debated. This study analyzes two alternative pricing schemes under discussion in Israel: price liberalization, which unifies the prices for all potable water consumers at cost recovery-rates, and marginal pricing, lifting the potable water price to the cost of desalination. Both schemes reduce water demand with limited economic costs. Price liberalization is the most favourable option from a national welfare perspective, while the marginal pricing allows for larger water savings and, in the long run, independence from fresh water resources.

Key words: CGE; STAGE_W; water-pricing; water-policy; cost-recovery price; marginal pricing; wastewater reclamation; desalination

Highlights:

- The study presents, a general equilibrium model, for different types and uses of water including tax instruments allowing for price differentiation.
- The model is applied to Israel, where despite of scarcity low agricultural water prices prevail, cross-subsidized by high municipal water prices.
- For Israel, price liberalization (cost recovery pricing) is the most favourable option from a national welfare perspective.
- Marginal pricing allows for larger water savings and, in the long run, independence from natural water resources.

1. INTRODUCTION

Water in Israel is a very scarce resource (Fleischer et al. 2008): the annual supply of less than 250 m³ per capita is 50% below the threshold of severe water scarcity of the Falkenmark indicator (Tal 2006). The long-term sustainable average annual renewable supply of freshwater from natural sources is estimated at about 1,800 million m3 including aquifers shared with the Palestinian Territories (Weinberger et al. 2012), which is equivalent to be about 80% of the total Israeli water consumption. However, the actual supply is highly variable (Fleischer et al. 2008). In recent years, Israel faced almost seven consecutive years of drought (Lavee and Ash 2013). Replenishment rates of aquifers have been as low as 1,091 million m³ in 2008 (Weinberger et al. 2012). This, together with an increasing demand for potable water due to economic growth and immigration, has led to a situation of overexploitation of renewable water resources within the country.

To meet the annual demand of about 2,130 million m3 and to mitigate overexploitation of aquifers, alternative water sources have been explored in recent years. In 2010 about 450 million m3 reclaimed wastewater and 300 million m3 desalinated water were supplied in addition to natural sources. At the same time 174 million m³ of brackish groundwater were extracted. Agriculture is the main user of water at 1,044 million m3 per year (more than 50% of which is recycled wastewater and brackish water), followed by municipalities at 764 million m3 and industry at 120 million m3. 143 million m3 are diverted to Jordan, as agreed in the 1994 peace treaty, and to the Palestinian Water Authority, while 60 million m3 is reserved for the rehabilitation of natural habitats (IWA 2012).

The problem of water scarcity is expected to become more severe in the future. Climate models predict increases in temperature as well as changes in the amount and distribution of rainfall (Fleischer et al. 2008), while domestic water demand in Israel is rising with population growth (Kislev 2011). Moreover the supply of water to the Palestinian National Authorities is expected to increase in the future (Kislev 2011).

Water prices are set by the Israeli Water Authority (IWA) which is a governmental agency. When the IWA was established in 2007 an agreement with the farmers stipulated a gradual shift to cost-recovery prices, however, in 2010 the agricultural sector still received potable water at subsidized prices (Kislev 2011). The same holds true for the manufacturing sector, though to a lesser extent what contradicts the declared aim to restrain water consumption (NIC 2010) and therefore the current pricing system is under debate. This study estimates the implications of different pricing regimes currently being discussed in Israel on water use, welfare and economic performance using a Computable General Equilibrium (CGE) model.

2. THE ISRAELI WATER ECONOMY

Israeli law classifies water as state property. In 2007 the IWA was established to implement the water law and govern water resources within Israel. The IWA also is in charge of setting water prices (Kislev 2011).

The exploration of new water sources has been encouraged by the effects of a lasting drought: by 2010 about 75% of all wastewater produced in Israel was reclaimed and used. The IWA aims to further increase this share, which in line with growing municipal potable water consumption should in 2020 provide about 600 million m³ of reclaimed wastewater mainly to the agricultural sector (IWA 2012, Lavee and Ash 2013). Further, several reverse osmosis seawater desalination plants have been constructed on the basis of Build-Operate-Transfer contracts by private companies. The installed capacity is expected to reach 750 million m³ per year by 2020 (IWA 2012), to cover most of the municipal demand.

The IWA is also seeking to reduce potable water consumption, particularly by the agricultural sector, where the IWA aims at a higher usage of reclaimed wastewater, which is made more attractive by a lower price (Kislev 2011). However, sanitary restrictions apply and therefore in most cases it can be used only for the irrigation of non-food crops, such as cotton and timber, or for plants which can be irrigated without the water being in contact with the harvested parts, such as orchards. In addition, the use of brackish water, mainly for the irrigation of salt tolerant crops, such as cotton, tomatoes, and melons, has been fostered and reached 174 million m³ in 2010 (IWA 2012). These additional supplies are from large fossil aquifers in the Negev in the south of Israel.

The IWA operates a pricing regime whereby prices are differentiated according to user-group (municipalities, industry, and agriculture) and water qualities (brackish, reclaimed, and fresh), as depicted in Figure 1. The taxes and subsidies in the water sector are not explicitly identified but can be calculated as the difference between the costs of water provision and the fee charged to each consumer group. The IWA guarantees prices to the operators of the desalination plants, but the costs of provision of potable water by seawater desalination are far higher than the costs of fresh water purification. Therefore, there is an implicit production subsidy for desalination. However, the IWA sets the final consumer price independent of the costs of supply. After the sales tax, which applies to all water commodities, this results in an implicit consumer subsidy for potable water consumption in the agricultural and manufacturing sectors, with additional taxes levied on wastewater and brackish water consumption, and on potable water consumption of the municipal sector.

The National Investigation Committee report on the water economy in Israel recommended introducing a water pricing scheme, which reflects total average water supply costs including extraction, transportation, and environmental costs, to limit water extraction to a level below the average annual recharge (NIC 2010). Alternatively it has been argued that the water price should equal the marginal cost of potable water, i.e., the cost-level of desalination, since in this case the water price would equal the marginal cost of potable water provision in Israel; at which price all water demands could be supplied (Kislev 2011). This price can be considered the benchmark price on efficiency grounds. These water pricing strategies are the basis for the analyses reported in this paper.

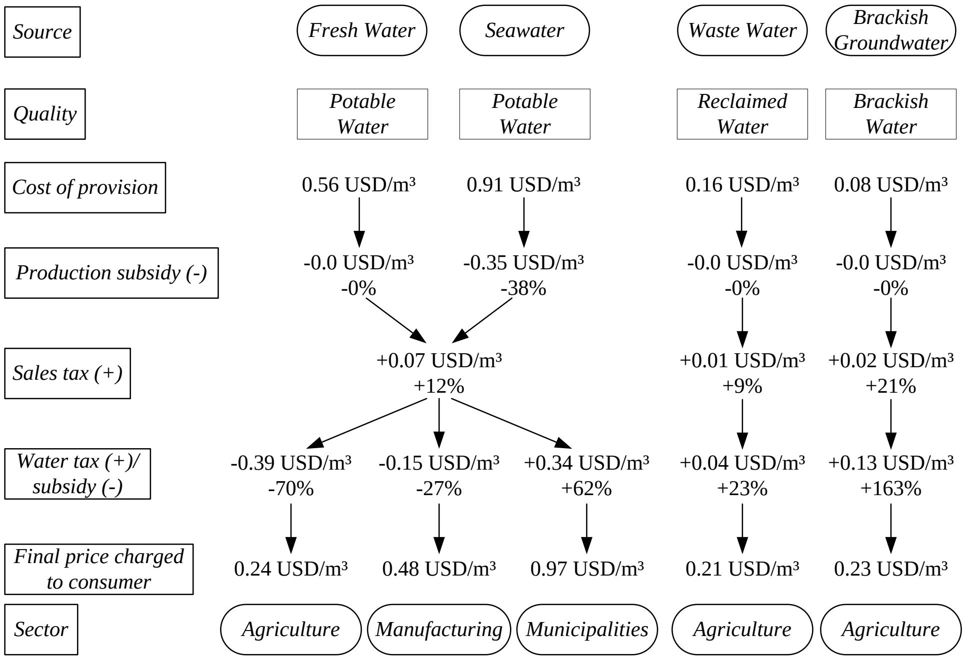

Figure 1. Israeli water pricing scheme (2006), prices and tax rates. Source: own compilation based on CBS 2011 and Siddig et al. 2011

3. WATER AND CGE MODELLING

CGE models, based on general equilibrium theory, are often used to study the economy-wide effects of changes in exogenous factors such as policies, technology or factor endowment. The advantage of this class of models lies in their ability to capture feedbacks within the economy and thus allow for the assessment of second round effects. Especially for analyses regarding the water sector CGE models are suitable as water is used across the economy in production and by households while the sector is often managed by the government and subject to complex policies. Thus, changes in the water sector affect many economic agents directly, e.g., if water prices increase, and indirectly, e.g., increasing prices of agricultural products if water prices increase. CGE models require a large data-base, usually compiled in a SAM, which captures all economic interactions within an economy, together with a set of assumptions regarding the behaviour of the different economic actors. A recent and comprehensive overview on water related CGE approaches is provided by Dinar (2014).

With respect to Israel only few water related CGE studies were conducted so far. Yerushalmi (2012) investigated the efficiency of the administrative water allocation in Israel. The database was highly aggregated and included three productive sectors, two factor accounts (labour and capital), and one representative household-government account. While analysing social welfare effects of the introduction of a water market, Yerushalmi did not consider distributional effects and consequences for different household groups or limited domestic water resources and the use of desalination to preserve those resources. The STAGE_W model has been used to investigate the effects of compensating for water scarcity by increasing the desalination capacity (Luckmann et al. 2014). The study concluded that due to the current pricing policy, which involves large subsidies, the social benefits of water supplied from additional desalination facilities may be negative This finding was the motivation to analyse the current pricing system and possible alternatives in the study presented here.

4. DATA AND THE MODEL

The database used for this study is an extension of the 2004 Social Accounting Matrix (SAM) for Israel by Siddig et al. (2011) and additional water satellite accounts. As 2004 can be considered a normal year for the Israeli economy, in a period of growth after a recession in 2000 and 2001 due to the Second Intifada and before the worldwide economic crisis in 2009 (CBS 2013), the results obtained by simulations based on this SAM can be considered representative and allow for extrapolation to more recent years. The SAM has 45 commodity and activity accounts, 38 factor accounts, and 18 tax instruments. Distributional issues are addressed by 10 representative household groups, categorised by ethnic background (Jewish and Non-Jewish) and income (5 quintiles). The original SAM has one water sector, which has been further disaggregated into four water resources (groundwater, seawater, wastewater, and brackish groundwater), four related activities and three water commodities (potable water, reclaimed wastewater and brackish water) which reflect the water sector in Israel, using data from the IWA (in Zaide 2009), FAO (2009) and the Israeli Statistical Office (CBS) (2009; 2011). Additional satellite accounts record the use of physical water quantities. Detailed information on costs of water supply and fees are sourced from the 2006 Satellite Account of Water in Israel (CBS 2011) (summarized in Figure 1).

Desalination played a minor role prior to the opening of the Ashkelon desalination plant in mid-2005. A pre-simulation is implemented to update the water accounts of the SAM to the situation in 2007, including desalination in the database.

Agriculture is the largest user of water in Israel; the use of water by the different agricultural activities identified in the SAM is reported in Figure 2. Within the cropping sector, vegetable and fruit plantations are by far the largest water users followed by “other crops”, including cotton, sunflowers, and other field crops. The usage of brackish water is limited to vegetable and fruit plantations and “other crops”, these activities include plants that are tolerant of elevated salinity levels. Similarly, recycled wastewater can only be used by these activities in addition to “mixed farming and forestry” due to sanitary regulations explained above. Figure 2 reports the cost shares of water in total production costs, with “other cereals” being most water intensive and “other animals” being least water intensive.

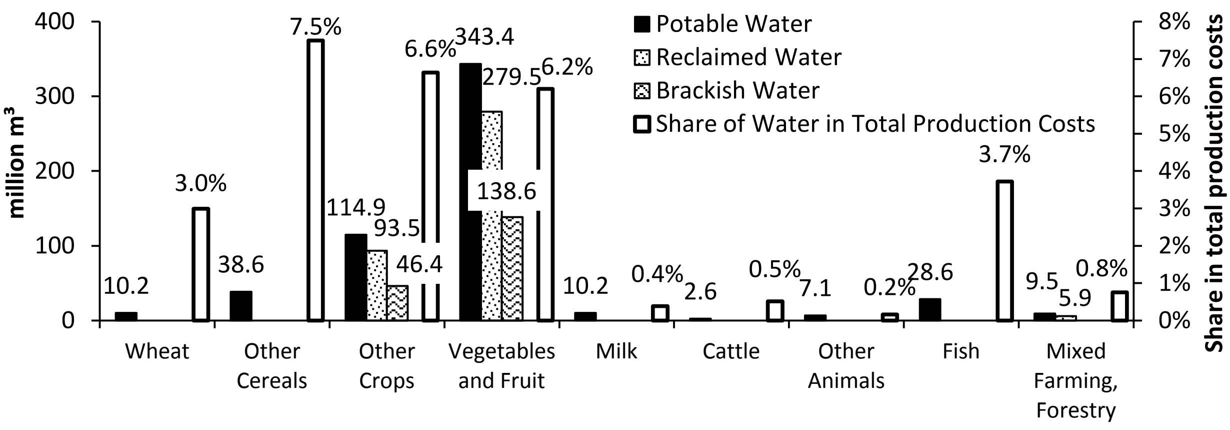

Figure 2. Water use in the Israeli agricultural sector in 2004. Source: own compilation based on FAO 2009; Zaide 2009; Siddig et al. 2011

This study uses the STAGE_W model (Luckmann and McDonald 2014) which is a water focused CGE model development of the STAGE model (McDonald 2009). The changes in the behavioural relationships are concentrated in the production and consumption relations and water specific tax instruments. For this implementation they are conditioned on the structure of the water sectors in Israel. The model encompasses natural freshwater, seawater and brackish groundwater resources as well as wastewater and four water related activities (fresh water purification, desalination, reclamation of wastewater and pumping of brackish water) that produce three water commodities (potable water, reclaimed wastewater and brackish water), each with different cost structures. Freshwater purification and desalination produce the same output, potable water that is distributed via a single network; consequently the production of a homogenous commodity is produced by different (two in this case) activities with different costs structures. Thus the desalination activity implicitly subsidised, which reduces the output price of desalination to the one of freshwater purification.

The seven water resources, by-products and commodities, form the lowest level of the production system (see Figure 3) and constitute the potential components of water-aggregates that are specific to the activity that uses that aggregate. The composition of this aggregate is governed by each activity: each water activity (an activity which produces a certain water commodity from a water resource or by-product with the help of labour, capital (value added) and intermediate inputs) requires a specific resource, whereas for non-water activities the water-aggregate can be formed from up to three different water commodities. Where arguments/factors are not used by an activity the aggregates to which they contribute are formed without that argument.

The four water related activities employ fixed proportions of capital, labour, and intermediates. All non-water activities are modelled with more flexibility. Agricultural activities, which allow for the consumption of all three different water commodities, can substitute these water commodities with a medium to low substitution elasticity (σ_4) of 0.8 (Sadoulet and de Janvry 1995). This rather low substitutability reflects the fact that not all components of the aggregated activities can use marginal water qualities and that the option to use marginal water does not exist in all localities, although there is an extended supply network for recycled wastewater in Israel. On the third level of the production function, water and land form a CES-aggregate, whereby the substitution elasticity (σ_3) is 0.3 following estimates of irrigation-land substitutability by Faust et al. (2012). The land-water aggregate is then combined with labour and capital at the second level of the production function. Given the prevalence of drip irrigation systems in Israel which increase the water use efficiency at the cost of the investment required, the substitution elasticity (σ_2) is set at 0.8 (Berck et al. 1991). The top-level combines the value added and water aggregate with aggregate intermediate inputs with an elasticity (σ_1) of 0.5.

This setup allows for endogenous adjustments to price changes caused by exogenous shocks imposed to the model. For example, if in a simulation the price for potable water in agriculture rises, activities can substitute it with marginal water commodities, provided these activities allow for their usage. If the activity is land-based, water can be substituted by land, which would simulate a shift from irrigated to rainfed agriculture, or on the next level, as described above, activities could substitute the land/water aggregate by other factors by investing in more efficient irrigation systems which require more capital and are more labour intensive. Finally, the quantity of production (output) could be maintained by using more intermediate inputs, which in this case could be reducing evaporation through the use of plastic mulch.

Two water specific tax/subsidy instruments allow differential pricing of water according to water type and user. The (implicit) commodity tax and a user specific subsidy result in three different prices exist for potable water according to user group: municipalities, agriculture and manufacturing. This is illustrated, with the applied rates for Israel, in Figure 1.

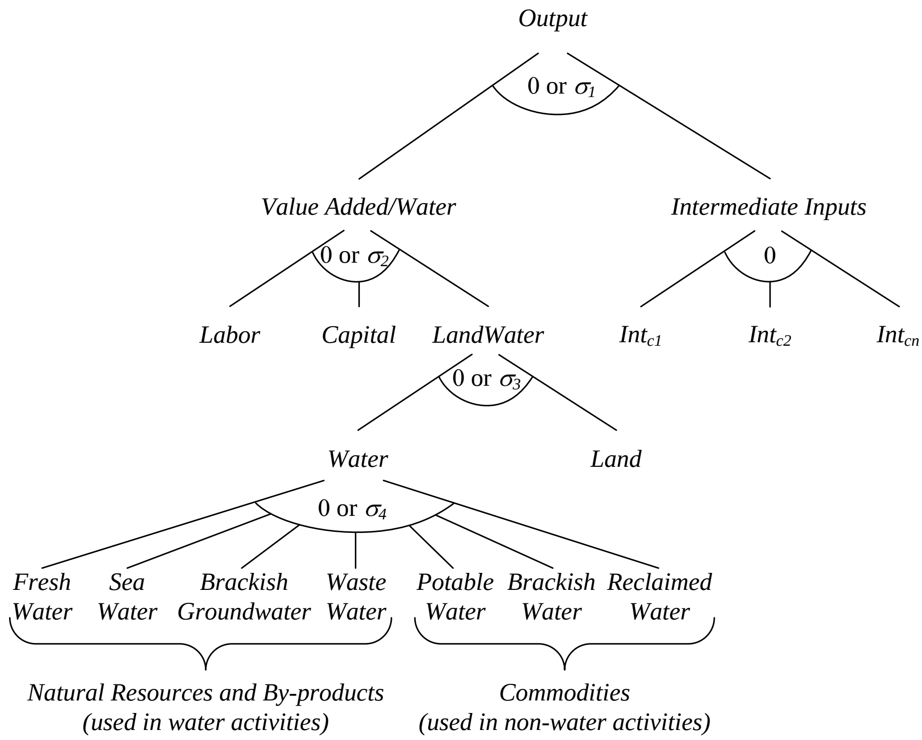

Figure 3. Production System for Activities in STAGE_W.

5. WATER POLICY SCENARIOS AND MODEL CLOSURES

5.1 Scenarios

This study evaluates the implications of two alternative water pricing strategies on the Israeli economy with a focus on the different end users of water commodities: price liberalization for potable water and marginal cost pricing for potable water. These pricing regimes are depicted in two scenarios and the outcomes are presented against the current pricing system with a differentiated pricing structure for potable water, whereby agricultural and manufacturing use are subsidized and municipalities are taxed.

1. Lib: liberalization of the potable water sector

This scenario estimates the economic costs of the current Israeli water policies relative to a free-market scenario, i.e., all taxes and subsidies on potable water are removed, so that the final price paid by all consumer groups is equal to the producer price plus the value added tax which is held constant. Thus consumers of water cover the full costs of provision, which is a major policy objective of the IWA (Rejwan 2011). Taxes on marginal water commodities are not altered in this simulation, since they are widely accepted and not under debate, which allows the simulation to capture the outcomes of a policy change solely in the potable water sector.

2. Marg: marginal price scenario

This scenario simulates the declared objective of the IWA to reduce dependency on natural fresh water resources (Rejwan 2011). This scenario imposes the marginal price for potable water in Israel on all consumers, which is the full cost of desalination inclusive of capital costs of building desalination plants and delivery (Kislev 2011). This increases all consumer prices. In the long-run, all potable water can be supplied at this price since it includes investment costs for further desalination plants. Therefore, this scenario allows for independence from natural fresh water resources in the long-run. Again, policies on marginal water commodities are not altered.

5.2 Macroeconomic Closure and Factor Market Clearing

Israel is a small country and therefore world market prices are fixed. The external balance is fixed, reflecting the large current account transfers received by Israel, and the external account is cleared by variations in the exchange rate. The volume of investment is fixed as well as government savings. Changes in the government income are redistributed to households via changes in household transfers, transfers to enterprises remain constant. The savings rates of domestic non-government institutions (households and enterprises) adjust to clear the capital account. Tax rates remain constant with the exception of the subsidy to the desalination activity, which endogenously adjusts to balance changes in production price differences between the two potable water producing activities. The other water tax instruments are exogenously adjusted in the simulations.

All factors of production are fully employed and mobile between activities, such that model results reflect a long-term perspective. Exceptions are the water resources and by-products: these have fixed values per unit while the quantities used are flexible, to allow for changes in water consumption. The potable water price shifts in the simulations cause a reduction in demand. It is a political decision whether supply from natural fresh water or from desalination should be reduced. We decide here to fix the desalination supply, as the Israeli government is legally obligated to purchase the water produced from the existing desalination plants.

6. SIMULATION RESULTS

6.1 Water Prices and Production Costs

In all simulations applied in this study, potable water prices are unified. In the *lib-scenario*, this results in a price reduction for municipalities and a price increase for agricultural and industrial users, whereas in the *marg-scenario* this results in a price increase for all user groups. The changes for the agricultural sector, in particular, are large since the price of potable water used in this sector increases by 159% in the *lib-scenario* and quadruples in the *marg-scenario*.

In both scenarios, price shifts are predominantly due to the abolishment of taxes and subsidies on potable water. Yet, part of these price shifts stem from second round effects since price changes also affect the economy as a whole. Due to unified pricing, water is shifted to activities in which it is used more efficiently. As potable water becomes cheaper for the services sector in the *lib-scenario*, this sector expands and uses additional production factors coming from reduced agricultural and industrial activities. Due to higher demand for factors and intermediate inputs motivated by the increased overall production, most factors of production and intermediary inputs become more expensive and therefore production costs for potable water increase by 0.7% due to the *lib-scenario*. In the *marg-scenario*, water becomes more expensive for all sectors, which is why the economy as a whole is slightly negatively affected. Therefore, all factors of production and most non-agricultural intermediate inputs become cheaper and thus production costs of potable water decrease by 0.3%.

The production costs of both marginal water commodities are affected similarly in the different scenarios. Since the respective tax instruments are not altered in the simulations, these changes directly translate into consumer price changes (Table 1).

Table 1. Changes in consumer prices of water commodities and in water demand and supply.

Water quality	Sector	base	lib	marg	lib	marg
		Average water price charged				
		2006 USD/m³			*% Change compared to base*	
Potable water	Agriculture	0.24			159.1	303.5
	Manufacturing	0.48	} 0.63	0.97	30.9	103.9
	Municipalities	0.97			-35.3	0.8
Reclaimed wastewater	Agriculture	0.21	0.21	0.21	0.8	-0.3
Brackish water	Agriculture	0.23	0.24	0.23	0.8	-0.3
		Water quantity				
		million m³			*% Change compared to base*	
Potable water	Agriculture	565	280	198	-50.4	-65.0
	Manufacturing	113	91	63	-19.1	-43.9
	Municipalities	712	883	709	24.1	-0.5
Reclaimed wastewater	Agriculture	379	398	403	5.0	6.5
Brackish water	Agriculture	185	194	197	4.8	6.3
All	Agriculture	1129	872	798	-22.8	-29.3
All	All	1954	1846	1570	-5.5	-19.7
Natural fresh water	All	1267	1132	847	-10.7	-33.2
Desalinated	All	123	123	123	0.0	0.0

6.2 Agricultural Sector

In both scenarios, the agricultural sector experiences the highest potable water price increase. Consequently the use of potable water in agriculture declines sharply. Some agricultural activities also allow for the use of marginal water commodities, which become cheaper in relation to potable water (Table 1, upper section). Hence, the usage of these water types slightly increases, which mitigates the reduction in the overall consumption of water in agriculture (Table 1, lower section). The increase in demand for marginal water commodities is not larger since substitution is relatively low and limited to only a few agricultural activities.

The changes in water use by the agricultural sector are shown in detail in Figure 4a. The consumption of potable water by agricultural activities declines by up to 54% in the *lib-scenario* and up to 69% in the *marg scenario*. On the other hand, the share of marginal water use increases to up to 72% and 79% in the *lib-* and *marg-scenarios*, respectively in those activities which allow for its usage, since marginal water becomes relatively cheaper. The overall water-balance is negative for all activities, and the production particularly of water intensive commodities declines, (compare Figure 4a and 4b). Moreover, water is substituted by land and other factors of production which become cheaper. The absolute quantity of marginal water used in the production of “other crops” declines because of the comparatively strong decrease in the production of this activity (Figure 4b) resulting from its high export dependency and the pronounced decline in exports due to rising production costs in combination with constant export prices.

The increased prices of water inputs cause higher producer prices for all domestically produced agricultural commodities. Due to higher production costs, agricultural exports become less profitable, while imports become comparatively cheaper and increase slightly. Taken together, composite consumer prices do not increase as much as consumer prices for domestic supply of agricultural goods (Figure 4b). The magnitude by which the consumer prices for domestic supply of agricultural goods increase is mostly correlated with the water use intensity of the respective activity.

Domestic demand for all agricultural commodities decreases due to increasing prices. Most strongly affected are “other cereals”, for which demand is reduced by 13% and 20% in the *lib-* and *marg-scenarios*, respectively. Export quantities are reduced even more than supply to the domestic market. The total effect on domestic production can be seen in Figure 4b. Since in both scenarios potable water becomes more expensive while export prices remain stable, the output is particular reduced for commodities which have a high share of water in their input costs (see Figure 2) and which are to a large extent exported.

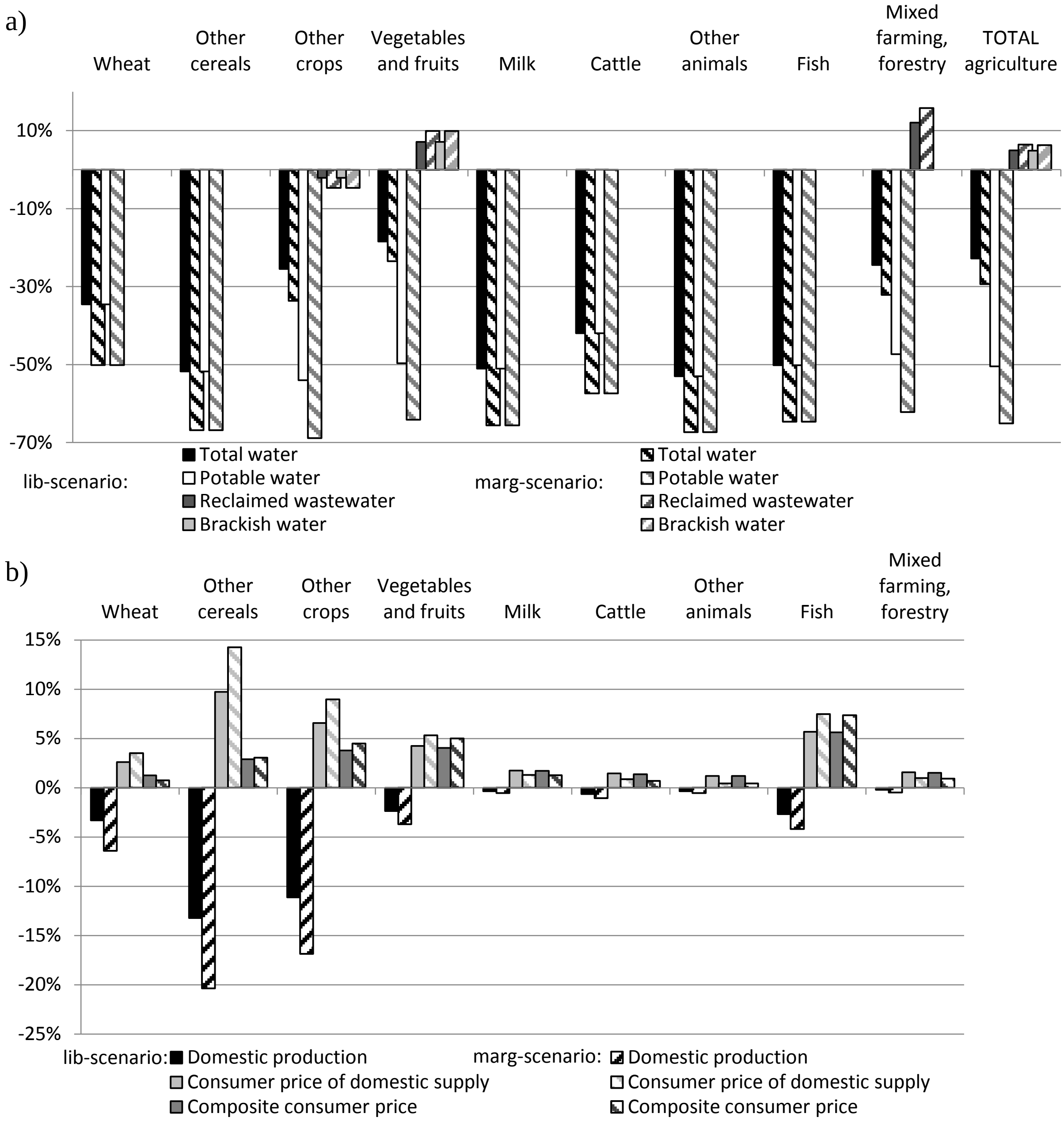

Figure 4. Changes in water consumption by the agricultural sector (a) and in the output and prices of agricultural commodities (b).

6.3 Manufacturing and Municipalities

Because of the higher price in both scenarios, potable water consumption is reduced in the manufacturing sector by 44% in the *marg-scenario*. Although this seems high, such a reduction could be achieved through internal water recycling, which allows for saving rates of up to 95% (Levine and Asano 2002). The magnitude of the reduction in individual activities is correlated with the increase in overall production costs, which are caused by the rise of the potable water price. The same holds true for municipalities in the *marg-scenario*. In contrast, the *lib-scenario* causes potable water prices to decrease for municipalities and therefore consumption increases (Table 1). However, total potable water consumption decreases in both scenarios by 10% and 30%, respectively, since in the *lib-scenario* the reduction of potable water consumption of the other sectors outweighs the increase of its consumption by municipalities.

The producer and consumer prices of all non-agricultural commodities rise in the *lib-scenario*. For the manufacturing sector, this is mainly due to the higher potable water prices as well as the increase in agricultural commodity prices which are inputs in food processing activities. However, because of the low share of water in the production costs and the relatively low price increase of agricultural commodities, prices of manufactured goods increase by no more than 2%.

The decrease in the price of potable water for municipalities in the *lib-scenario* has two effects: First, it decreases household expenditures for water, leaving more disposable income to be spent on other goods, and second, it decreases water costs for the service sector. Nevertheless, output prices in the service sector increase by about 0.7%. This is because of the price increase of industrial products, which, as intermediates, make up for a higher share in production costs in the service sector compared to water. Additionally, household demand for services increases, driving prices up.

In the *marg-scenario*, on the other hand, prices in the service sector and most prices in the manufacturing sector drop slightly (by about 0.3%), only products of the food industry become more expensive (by about 0.7%), because of the increase in the prices of agricultural commodities. The reason for the general price decrease, despite even stronger price increases for potable water compared to the *lib-scenario*, is the decreased production of agricultural and most industrial goods, which frees up labour and thereby lowers the wage rate. The lower wage rate overcompensates for the effect of increasing water prices and thus results in a lower output price. Household income declines as a result of the decrease in wages, while consumer prices of water and foodstuff increase. The result is a decrease in the domestic demand for most commodities. However, demand for a few commodities increases slightly due to household substitution and the expanding production of marginal water which requires additional intermediary inputs.

6.4 Macro and Welfare-Effects

The effect on the total output of the Israeli economy of the *lib-scenario* is positive due to the removal of distortions in the water sector. The *marg-scenario*, on the other hand, has an adverse effect since water prices increase for all users, which can be considered as an additional tax. The overall welfare effects of the two simulations are small since the share of the water sector in the Israeli economy is small (about 0.7% of total domestic production in the base situation) and all household groups spend less than 1% of their total expenditure on water. Therefore, GDP increases by only 0.8% in the *lib-scenario* and decreases by about 0.1% in the *marg-scenario*.

Also the effects on household welfare, measured as changes in equivalent variation (EV) relative to household consumption expenditure, are small, for similar reasons. In the *lib-scenario*, the EV shows a clear trend in favour for richer households, while it is negative for the poorest quintile of Jewish households (Figure 5). The reasons for this are the opposing effects of decreasing water prices charged to municipalities, on one side, and the increasing prices of agricultural commodities along with decreasing wages in the agricultural sector on the other side. The later affects the poorer households disproportionately, as this population group derives a relatively high share of income from employment in the agricultural sector and at the same time spends a comparatively high share of income on agricultural and food-commodities.

In the *marg- scenario* the EV-effects are slightly negative for 6 of the 10 household groups, as the lower wages and the higher prices of agricultural and food commodities reduce the disposable income of most households. The change in EV for the richest household of both ethnic groups and the two poorest Jewish quintiles are slightly positive, however. For the latter, this is mainly due to the high share of transfer payments (mainly from the government and social enterprises) accounting for up to 50% of the income of poor Jewish households and which due to higher government transfers increase slightly. The rich households mainly profit from a high share of enterprise income which only drops marginally (-0.2%) and at the same time a relatively high consumption share of manufacturing and service goods, which mostly become cheaper.

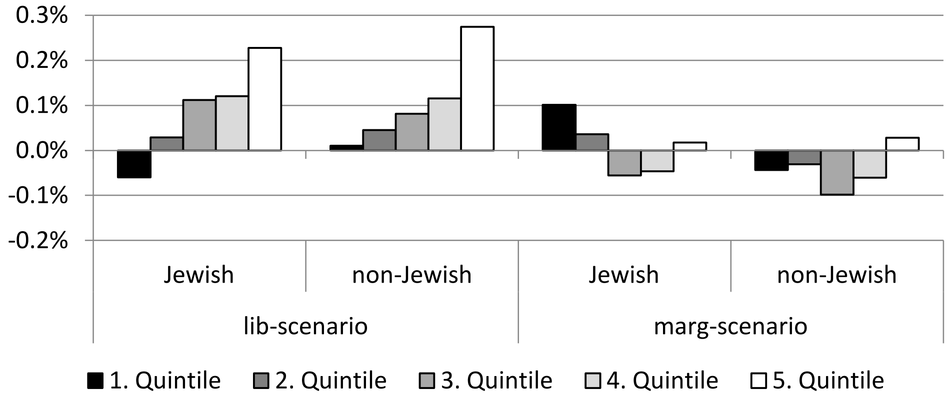

Figure 5. Changes in household welfare measured in equivalent variation as percentage share of household expenditure.

7. CONCLUSIONS

The non-sustainability of the current water supply scheme in Israel is widely recognised and the current political debate has emphasised price based policy reforms. The analysis assesses two core options for a more efficient water policy: price liberalization for potable water and marginal cost pricing for potable water. The analyses, which are based on a comparative static CGE model, arguably involve certain limitations:

i. The growth of water demand due to economic and population growth is not considered. This, however, affects mainly the liberalization-scenario since in the marginal cost pricing-scenario also additional quantities of potable water could be supplied from desalination at the same price.
ii. The model does not consider the adjustment period which would be required to shift to a new equilibrium state since factors are less flexible in the short-run. Therefore, the outcomes of the model should be considered as equilibria after a medium to long-term adjustment process.

These limitations suggest avenues for future research using dynamic CGE models that allow for growth, adjustment costs, and time. Another potential avenue would be to evaluate the implications of changes in water quality on health and the productivity of agricultural land.

Nevertheless the results and analyses provide useful insights. Both pricing options allow for a substantial reduction in the demand for potable water which would make additional investments in an increased desalination capacity unnecessary and at the same time reduce the pressure from aquifers. In the price liberalization scenario the reduction in natural fresh water would amount to 135 million m^3, while with marginal potable water pricing abstraction rates of natural fresh water would decrease by 420 million m^3 annually. Thereby, 28 and 36 million m^3 are substituted with marginal water qualities, respectively, while the larger part is substituted with other factors of production and commodities or saved due to a shrinking consumption in the marginal price scenario. Indeed, if marginal potable water prices are charged the aquifers could be protected from overexploitation even at their low replenishment rates from recent droughts.

Further, it is shown, that the current water pricing scheme is harmful to the Israeli economy: it results in an annual GDP loss of 0.8% compared to a situation in which prices are unified and cover the full costs of water supply. Increasing potable water prices further to cover marginal costs, would cause moderate economic losses to the Israeli economy (0.1% of the annual GDP), but therefore would allow Israel to be completely independent from natural fresh water resources in the long run. This would even hold if water demand is increasing in the future e.g., due to population growth, as the marginal price covers the costs of desalination including the capital costs for investing in new desalination plants, which means that at this price any quantity of potable water could be provided.

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