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Jonas Luckmann[1], Khalid Siddig[2] and Johanes Agbahey[3]

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Send correspondence to:
Jonas Luckmann
Humboldt-Universität zu Berlin
luckmann@hu-berlin.de

[1] Humboldt-Universität zu Berlin, International Agricultural Trade and Development Group. Unter den Linden 6, 10099 Berlin. Position: Research associate. Phone: +49 30 2093 46811. Fax: +49 30 2093 46321.
[2] Humboldt-Universität zu Berlin, International Agricultural Trade and Development Group. Unter den Linden 6, 10099 Berlin.
[3] Humboldt-Universität zu Berlin, International Agricultural Trade and Development Group. Unter den Linden 6, 10099 Berlin.

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Abstract

In this study, we analyze the effects of increasing Palestinian access to shared groundwater aquifers with Israel. We apply a water focused computable general equilibrium model to the economies of the West Bank and Israel and analyze two simulations. In the first, we raise the water abstraction rate of the West Bank to the maximal allowance according to the current interim agreement on shared water resources with Israel. In the second, we implement a new agreement that assumes an equiproportionate access to shared aquifers. Thereby, we quantify the implications for the two territories as well as for the overall region. Results show that the economic gains from increased water access to the West Bank economy by far outweigh the losses to the Israeli economy, as the latter is less dependent on shared groundwater resources and has other alternative sources including reclaimed wastewater and desalinated seawater. This is the first study to address this issue taking into account the economy-wide implications of such a new agreement on the use of shared water resources between Palestine and Israel. The modelling approach presented here can be used to substantiate the political negotiation process towards a final agreement on access to shared water resources between Israel and the West Bank.

Keywords: water rights, transboundary water resources, Palestine, West Bank, Oslo II, applied general equilibrium model, Mountain Aquifer.
JEL Classifications: D58, F53, Q25.

1 Introduction

The Mountain Aquifer constitutes the main domestic source of water supply in the West Bank as the Jordan River to which the West Bank is riparian is largely diverted by Israel, Jordan and Syria and the remaining river-flow is heavily polluted (Brooks and Trottier, 2012). The Mountain Aquifer stretches beyond the political boundaries of the West Bank (Figure 1) and thus constitutes a transboundary water resource shared with Israel. This implies that water extraction in one territory may negatively affect the water abstraction potential in the other territory. In order to manage the aquifer sustainably and avoid a sinking of the groundwater table as well as a depletion of the water quality through salinization (Gvirtzman, 2012; Harpaz *et al.*, 2001), coordination between the two territories is required.

The Israeli-Palestinian Interim Agreement on the West Bank and the Gaza Strip of 1995, commonly known as Oslo II agreement, was the first transboundary contract to define water use rights for the two political entities sharing the Mountain Aquifer (Brooks *et al.*, 2013). Despite having been foreseen to be replaced by a final agreement within a period of five years after its signature, it is still in force today. Its provisions are often criticized as inequitable, with the Palestinian side been given a groundwater extraction allowance of 118 Million m^3 annually and the option of developing another 78 Million m^3 per year, i.e. a total of 196 Million m^3/year, while Israel is allowed to extract 483 Million m^3/year (Israeli Ministry of Foreign Affairs, 1995). The Israeli-Palestinian Joint Water Committee (JWC) has been established as part of the Oslo II agreement. This joint governing body is in charge of approving any water-infrastructure decisions affecting the Mountain Aquifer. However, as decisions within the JWC are required to be taken in consensus and due to political tensions, most new Palestinian projects are objected or delayed by the Israeli side and Palestinian authorities are not able to exploit their full allowance (Selby, 2013). In 2018, only 122 million m^3 were extracted, while additional 74 million m^3 of water had to be purchased from Israel (Table 1).

Table 1: Water supply in the West Bank and Israel 2018

	West Bank [million m^3]	Israel [million m^3]
Wells/Springs	122	1112
Desalination	0	645
Reclaimed water	0	514
Imported water	74	0
TOTAL	196	2271
Population [Mio]	2.67	8.97
Water supply per capita [m^3]	73	253

Data sources: PCBS, 2018; CBS, 2019.

Figure 1: Shared Water Resources between Palestine and Israel

Source: Brooks and Trottier, 2010, p. II.

While water is a scarce resource in both economies, its per capita availability, in the West Bank is considerably lower than in Israel as Israel has access to other freshwater sources and developed alternative sources such as desalination and wastewater reclamation (Table 1). Moreover, in both countries the agricultural sector is an important water consumer, accounting for more than 41% of total water consumption in Israel and more than 43% in the West Bank. However, the agricultural sector in the West Bank is more important in terms of provision of local livelihoods and share in the Gross Domestic Product (GDP) as compared to Israel (Brooks *et al.*, 2013). Moreover, the Israeli agricultural sector relies to an increasing extend on alternative water sources such as brackish groundwater and reclaimed wastewater. Hence, the economic value of the Mountain Aquifer to the two economies differs and there are potential overall gains from redistributing water rights to the Palestinian side.

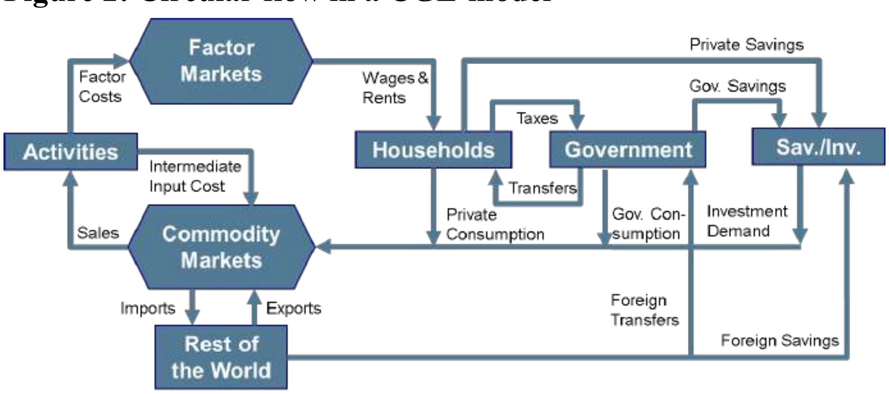
Several studies attempted to assess the implications a new agreement or a redistribution of water rights between Israel and the West Bank would have. Brooks et al. (2013) develop a framework for water sharing between Israel and Palestine. They suggest that giving additional water rights to the West Bank would be only a small burden for Israel and could easily be accommodated. They justify this by that the agricultural sector, which would be most affected by a redistribution of water rights, contributes relatively smaller share to Israeli GDP. However, these claims are not further quantified. Fisher et al. (2002) develop an optimization model of the water sector (Water Allocation System; WAS) to investigate the gains from trading water use rights between Israel, Jordan and Palestine. They find that cooperation in terms of water use would lead to increased economic efficiency and thus trading water-rights leads to win-win situations. They estimate the gains from trade between Israel and Palestine at 35 to 80 Million USD annually. Fisher and Huber-Lee (2011) develop WAS further into a dynamic Multi-Year Water Allocation System (MYWAS). They apply MYWAS to investigate the gains from cooperation on shared water resources between Israel and Palestine, with a focus on the Jordan River. They investigate three different Jordan water ownership cases, while setting four different distributions of Mountain Aquifer use-rights as base-comparisons. Fisher and Huber-Lee (2011) find that Palestine (and Jordan) gain from increasing water ownership rights of Mountain Aquifer and Jordan River and from selling water use-permits to Israel. They further suggest that such a trading scheme would also generate gains for Israel. However, WAS and MYWAS capture the demand for water in a rather simplistic way as they are single-sector models. Moreover, they do not depict changes in the rest of the economy and to the governmental budgets as well as the behavior of economic agents such as households resulting from a redistribution of water rights.

In this study, we go beyond those approaches, avoiding the highlighted weaknesses and additionally consider indirect effects from a redistribution of water rights by using a water focused computable general equilibrium (CGE) model. CGE-models capture all economic transactions within an economy. Thereby, all economic agents, such as households, firms and the government are linked through commodity-and factor-markets (Figure 2).

A set of linear and non-linear equations, which are solved simultaneously defines the behavior of these actors. Producers are assumed to maximize profits and consumers maximize their utility, which is implemented through first-order optimality conditions. All markets are assumed to be in equilibrium, which is brought about through model constraints (Lofgren, 2004). A CGE-model is generally based on an economy-wide database, i.e. a Social Accounting Matrix (SAM). A SAM is a squared matrix in which each account has a row and a column entry. Receipts from different sources are captured in the rows and payments in the columns. The number of accounts representing single economic agents and markets, but also different taxation instruments, reflects the level of detail depicted by the SAM (compare Table 2).

Due to their capability to capture an economy as a whole as well as the interlinkages between economic agents and markets, CGE models have become a popular analytical tool to study the implications of a wide range of policy changes as well as changes of other exogenous factors such as climate. Also in the analysis of water management CGE-models have been increasingly applied in recent years (Calzadilla *et al.*, 2016), as changes in the water sector usually have complex implications and affect many sectors within an economy. A state-of the art CGE-model, which depicts the water sector in detail has been developed by Luckmann et al. (2014). This model (STAGE_W) has been applied to analyze consequences of reduced fresh-water availability in Israel (Luckmann *et al.*, 2014; Luckmann *et al.*, 2016b) and the economy-wide impacts of changes in the water tariff system (Luckmann *et al.*, 2016a). A variant of this framework will be the underlying tool used in this study.

Figure 2: Circular flow in a CGE-model



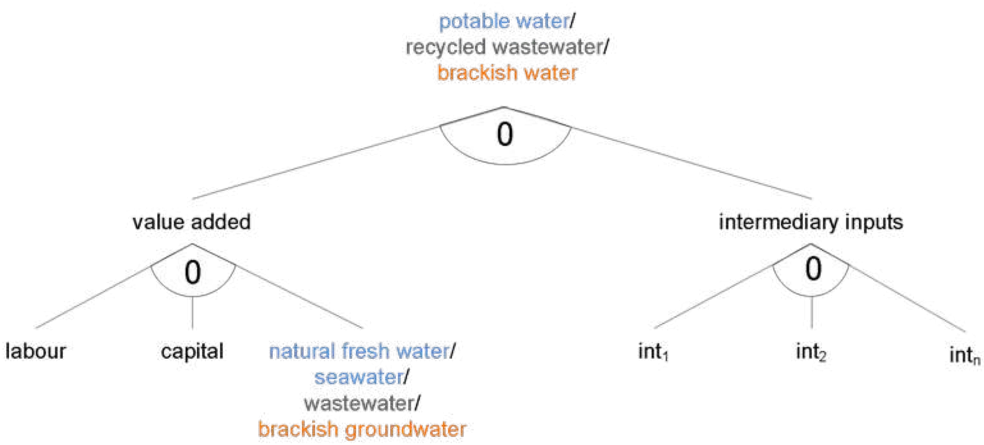
Source: Own elaboration based on Lofgren, 2004.

2 Methodology and Analysis

2.1 Model

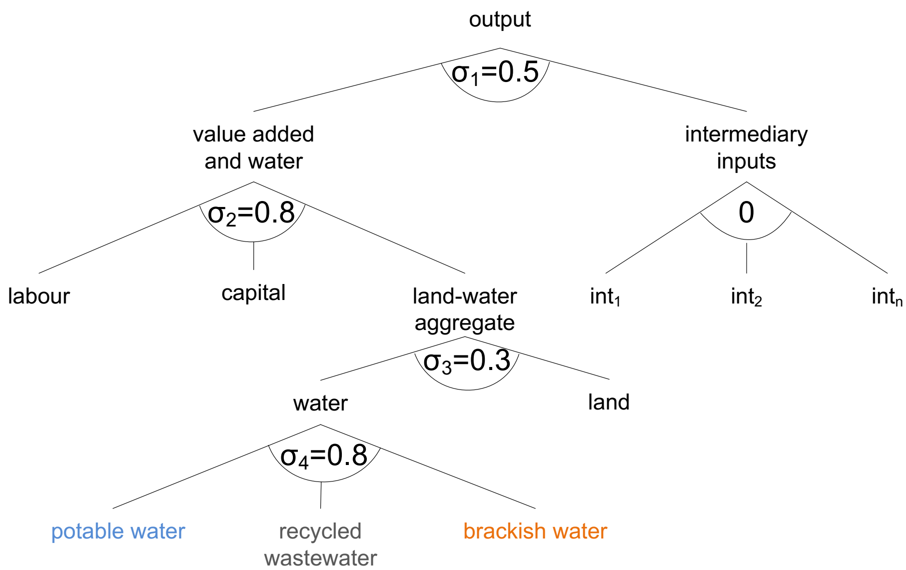
The analyses in this study are conducted using STAGE_W, a static, single country model. It is a water-focused extension of the basic STAGE-model as described in McDonald (2007). STAGE_W includes a detailed depiction of water supply and demand. The water supply is represented by water resources, which are depicted as production factors. These water-factors (e.g. natural fresh water, seawater, wastewater) can only be used by specific water-activities, which turn those water-resources into commodities such as potable water or recycled wastewater. Thereby the production structure is kept fixed (Leontief-nesting; Figure 3), as the water resources need to be complemented by other production factors and intermediate inputs (such as energy and materials) and cannot be substituted. The model further allows for multiple activities producing the same (homogenous) commodity (e.g. potable water is produced by the seawater desalination activity and through the purification of natural fresh water). Similar to other commodities, water can be internationally traded, governed by an imperfect substitution (Armington) elasticity. Yet, as water is a quite homogenous commodity independent of origin, the Armington elasticity is set to a very high value (1500), making domestic and imported water easily substitutable.

Figure 3: STAGE_W production structure - Water activities



The water-commodities are then used in the production process of other activities (e.g. for irrigation) or are consumed by households. Thereby, some agricultural activities may allow for substitution between different water-commodities (e.g. potable water and purified sewage), which is governed through a Constant Elasticity of Substitution (CES) elasticity (Figure 4). All non-agricultural activities only consume potable water and no land, so the lower two nests collapse for these activities and the land-water aggregate consists of potable water only.

Figure 4: STAGE_W production structure- Non-water activities



In order to capture differences in the costs of water provision and the water tariffs charged, price discrimination and other water-related policies, the model includes several water-related tax instruments (compare Figure 5, right hand panel). Further, STAGE_W includes water-satellite accounts to depict water quantities. This allows to calibrate the model with real water quantities and prices and to set quantitative restrictions as well as to interpret results in terms of price and quantities for the water commodities without further post-simulation calculations. The consumption of water and other commodities by households is governed by a linear expenditure system allowing for a fixed subsistence consumption and a variable supernumerary consumption, dependent on disposable income levels of households. Thus, all direct and indirect interlinkages between the water sector and the rest of the respective economy are captured. The model and all its equations are described in detail in Luckmann and McDonald (2014).

2.2 Data

The model is calibrated to two recent social accounting matrices (SAMs), of the West Bank (Agbahey *et al.*, 2016) and Israel (Siddig *et al.*, 2011). The SAMs have been updated and further disaggregated, creating additional water-related activity, commodity, factor and tax accounts in order to be compatible with STAGE_W model (Table 2). Both SAMs provide a high disaggregation of the production sectors and households. The SAMs are enhanced by water satellite accounts, capturing water quantity data as well as non-revenue water (loss rates, leakage). With respect to the water sector in the West Bank, the only resource used to a considerable extend is natural fresh water. Thus, the water supply sector is represented by one resource being used by one activity to produce one commodity (potable water). In Israel, four water resources are transformed by four specific activities into three water commodities as indicated in Figure 3. Potable water in Israel thus is produced by desalination and purification of natural fresh water activities. Cost structures of water-activities as implemented for this study are depicted in Table 7 in the appendix. In both countries, the water-sector is not privatized but it is managed by the government. Supply and demand are brought into balance in both countries through pricing policies. These are represented in the SAMs by water-specific (implicit) tax instruments. Desalination costs in Israel are subsidized and potable water fees are differentiated according to sector, with agriculture paying lower rates than industry, which in turn pays lower fees than municipal users (households and service sector) (compare Appendix, Figure 6). The water pricing system in the West Bank and Israel are further described in the next sections.

Table 2: The social accounting matrices of the West Bank and Israel

	West Bank	Israel
Source	based on Agbahey et al. (2016)	based on Siddig et al. (2011)
Base year	2011	2010
Accounts	120: - 45 commodities - 37 activities - 8 factors - 10 household-groups	205: - 45 commodities - 45 activities - 41 factors - 10 household-groups
Water sector	1 resource → 1 activity → 1 water quality 3 specific tax instruments: - Import subsidy - Commodity subsidy (non-revenue water) - User subsidy (non-metered/paid water)	4 resources → 4 activities → 3 water qualities 3 specific tax instruments: - Production subsidy (desalination) - Commodity tax - User subsidy (price discrimination)

2.2.1 The water sector in the West Bank

In 2011 (the base year of the West Bank SAM) close to 87 Million m³ were extracted from wells and springs (65.5 Million m³ and 21.4 Million m³, respectively). These quantities do not include the abstraction from unlicensed wells and illegal connections to pipelines of the Israeli water provider Mekorot, (estimated at 10 and 3 Million m³/year, respectively; Gvirtzman, 2012), for which no economic transactions occur and which are therefore outside the boundaries of the system of national accounting. The domestic water supply was complemented with purchases of water from Mekorot, which made up about 38% of total water supply to the West Bank (Figure 5, left hand panel)[4]. 63% of the water was delivered to the domestic sector, including household consumption, industry and service sectors while the remainder was supplied for irrigation-purposes.

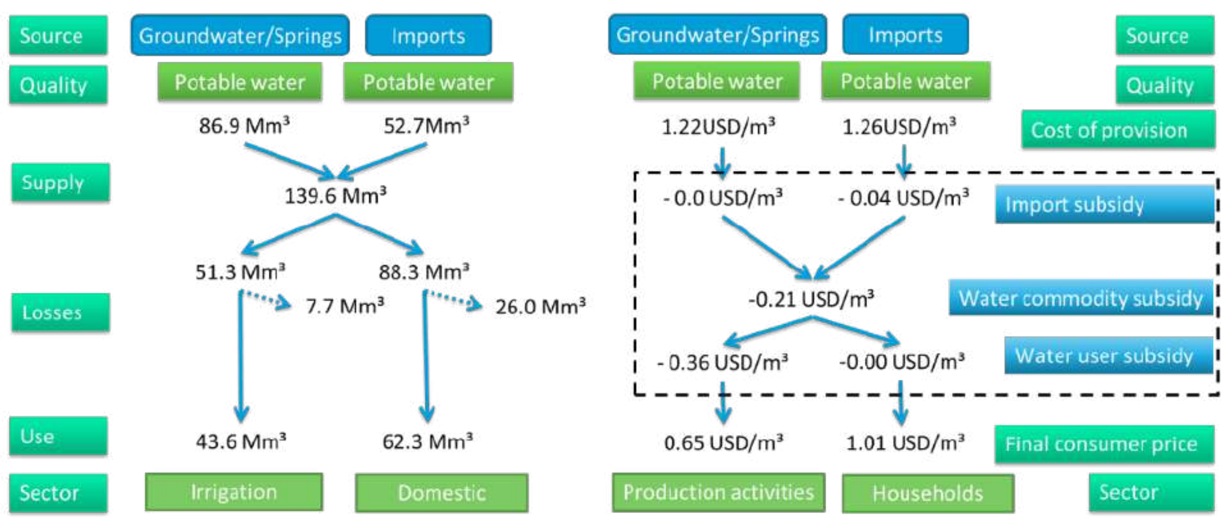
While the water supply network in the West Bank in recent years has been expanded, such that about 93% of the population is connected, the service-quality is lagging behind: there are regular intermittences of supply, such that only about 50% of the households in the West Bank have daily

[4] By the year 2018, the most recent year for which data is available, this share, as well as the overall water intensity of the West Bank's economy remained stable.

supply (for limited hours). 92% of the population relies on water storage tanks to buffer this unsteady supply (World Bank, 2018). Another important problem is the high share of non-revenue water (NRW), which includes losses due to leakage from the system, theft through illegal connections and supply of water to unbilled consumers. The latter category includes refugee-camps, mosques, public buildings as well as families of martyrs. The total NRW in the West Bank has been estimated to account for 29% of domestic use and 15% of bulk-usage (World Bank, 2018). Moreover, water user fees are below cost-recovery rates and water-fee collection rates are low (World Bank, 2018) resulting in a considerable share of uncollected water revenue.

In the model, this is reflected by a set of implicit subsidies (Figure 5, right hand panel, dotted rectangle). At the top, the provision costs of water are depicted. The costs of water supply from domestic sources in 2011 has been calculated using the output value of the water activity in the national accounts statistic (89.6 Million USD) (Palestinian Central Bureau of Statistics, 2014) dividing it by the quantity of water consumed from domestic supply after deducting NRW for which no economic transaction occur (73.3 Mm^3)[5]. The price of water purchased from Israel is calculated similarly, based on the value of imports (Palestinian Central Bureau of Statistics, 2012b). At the bottom of Figure 5, the water fees payed by consumers are depicted. A lower rate for production activities reflects the lower fee collection rate in agriculture and other production activities.

Figure 5: Water supply and water pricing in the West Bank as implemented in STAGE_W



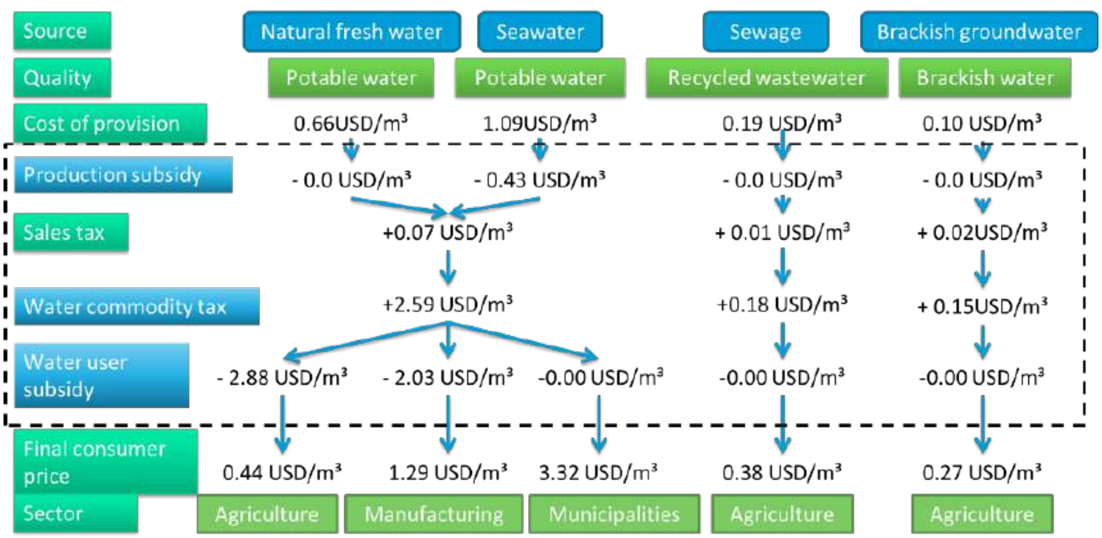
Source: own elaboration based on (Palestinian Central Bureau of Statistics, 2012a, 2017; World Bank, 2018; Palestinian Central Bureau of Statistics, 2012b).

[5] All prices calculated here are based on quantities supplied to consumers not extracted quantities. This means NRW, for which no economic transaction occurs is deducted. The production price per unit extracted would be 1.03 USD/m^3 (89.6 Million USD/86.9 Million m^3), this fits well with average costs reported for Palestine by IB-Net ((2019)).

2.2.2 The water sector in Israel

The water sector in Israel has been described in detail in Luckmann et al. (2016a). Its representation for this study is depicted in Figure 6. Potable water is produced from natural fresh water and desalination, whereby the latter is more expensive due to its high energy cost-share (compare Appendix, Table 7). As the desalination plants in Israel are run by the government through build-operate-transfer contracts, these additional provision costs are implicitly subsidized by the government. In general, the potable water tariff charged to municipalities is above provision costs. This is captured by an implicit water commodity tax. However, agriculture and industry sectors receive potable water at a lower subsidized rate. Recycled wastewater and brackish water are supplied at much lower costs, but it can only be used for the irrigation of a limited range of crops, such as non-food or tree-crops for brackish water and salt-tolerant species for brackish water. These marginal water qualities account for almost 60% of the agricultural water consumption (compare Table 4).

Figure 6: Water pricing in Israel as implemented in STAGE_W



3 Simulation scenarios

In this study, we analyze two scenarios, both increase the supply of natural fresh water from the Mountain Aquifer to the West Bank economy. The outcomes of the two scenarios are compared to a "base" scenario that depicts the *status quo* (i.e. no intervention). The distinction between the two scenarios is made as follows:

3.1 "New Wells" Scenario

In the first scenario "new-wells", we assess the implications of raising the extraction rate of the Palestinian National Authority (PNA) to its full allowance according to the Oslo II agreement. This means that the West Bank access to natural fresh water more than doubles from 87 Million m^3 to 196 Million m^3. This scenario represents a situation in which both parties adhere to the current agreement on exploiting shared water resources. It could be implemented even without needing further negotiations on water resources. The outcomes of this scenario can provide meaningful insights to the PNA on the economy-wide gains of developing new wells.

3.2 "New Agreement" Scenario

In the second scenario "new agreement", we investigate the implications of negotiating a new agreement with Israel resulting in a balanced supply of water from the shared Mountain Aquifer to both political entities. In this scenario, the water extraction in the West Bank is raised to 340 Million m^3. At the same time, Israel would commit itself to reduce its extraction by the same annual amount. As Israel is extracting freshwater also from other sources, this would mean a reduction of about 24% of its total supply whereas for the West Bank domestic supply would almost quadruple.

3.3 Implementation

Despite water resources being freely available, their extraction needs to be limited for sustainability reasons. Therefore, we fix the output of the natural fresh water activities in both economies to the observed base value (West Bank: 87 Million m^3, Israel: 1.061 Million m^3). Implementing the two scenarios in the model, we exogenously increase the output of the potable water activity in the West Bank to the respective new values, while reducing the output of the Israeli potable water activity accordingly in the "new agreement" scenario. In the "new wells" scenario, Israel is unaffected.

In the "new agreement" scenario, for Israel two sub-cases are investigated: the first sub-case (fix dsal) reflects the short-run with constant desalination capacity by fixing the output quantity of the desalination activity. The background for this is that it will take some years to establish additional desalination plants and to expand desalination capacity. In the second sub-case (flex dsal), a long-run perspective is considered, with desalination output being a variable and therefore the desalination subsidy being fixed at the base level. As in Israel almost all wastewater is already recycled, the provision of reclaimed wastewater is limited by the production of sewage which in turn depends on municipal potable water consumption (Luckmann *et al.*, 2016b).

When potable water supply is altered, demand needs to be adjusted in the same direction in order to keep the water sector in balance. In general, this can be achieved through the price mechanism. As water prices in the West Bank and Israel are regulated by the respective authorities, in this study, the market balance is maintained by letting the implicit water consumer subsidy (in the West Bank) and tax (in Israel) rates adjust endogenously. Changes in tax and water consumption rates affect in turn the government revenue. In order to internalize all positive and negative welfare effects within the modelling horizon and avoid a transfer of debts or gains to future periods, the government budget is balanced by an endogenous adjustment of the income tax rate in both countries, while all other tax rates remain constant. Further government consumption quantities and government savings are fixed.

Trade of water between Israel and the West Bank is not a free market. It is rather politically determined and thus exogenous of the model. As this is not the focus of this study, we leave the water imports from Israel to the West Bank constant[6]. For all other commodities, both countries are assumed to be price-takers on international markets and the foreign investment is assumed to be constant. For Israel the external balance remains fixed, through a flexible exchange rate. Palestine uses the same currency as Israel. However, its economy is about 30 times smaller than the Israeli economy. Thus, Palestinian policy changes hardly affect the exchange rate. Therefore, in this study the Palestinian exchange rate is assumed to be fixed while foreign savings can adjust. Finally, non-water production factors are assumed to be fully employed and mobile between sectors, while factor wages are left to adjust endogenously. An exemption to this is labor in the West Bank, for which a fixed wage rate and flexible supply is assumed. This reflects the reality in the West Bank marked by a high unemployment-rate, which allows employers to hire additional workers without having to increase wages.

4 Results

4.1 Water supply and demand

Both scenarios substantially increase the water supply to the West Bank's economy. Table 3 reports quantities of water available to the West Bank economy after NRW has been deducted. Assuming constant loss rates, NRW accumulates to 34, 51 and 73 Million m³ in "base", "new wells" and "new agreement" scenarios, respectively. With constant water imports, total water supply almost doubles in the "new-wells" scenario and triples in the "new-agreement" scenario. On the consumption side, as water prices drop, especially household water consumption increases. This result can be put into perspective with the relatively high LES-elasticity of 1.5, reflecting a large share of unsatisfied demand in the base-situation, due to supply interruptions. The use of water by productive sectors increases at a rate lower than household consumption and similar between sectors. In the production of commodities and services, water often needs to be complemented to some extend (e.g. with labor and capital in case of irrigation-use), which is why these sectors are sensitive to the prices of other production factors and intermediate inputs as well. The government's water consumption is fixed in real terms as determined in the model-setup, implying that same quantities will be consumed by the governmental organizations irrespective of water price changes.

[6] An alternative scenario in which water imports from Israel into the West Bank are reduced to zero shows, that for Israel results almost do not change, as the lost revenue from the water sales as well as the additional production through the water which now is available domestically only constitute a very small share of the Israeli GDP. For the West Bank results would be slightly diminished but in line with those reported here.

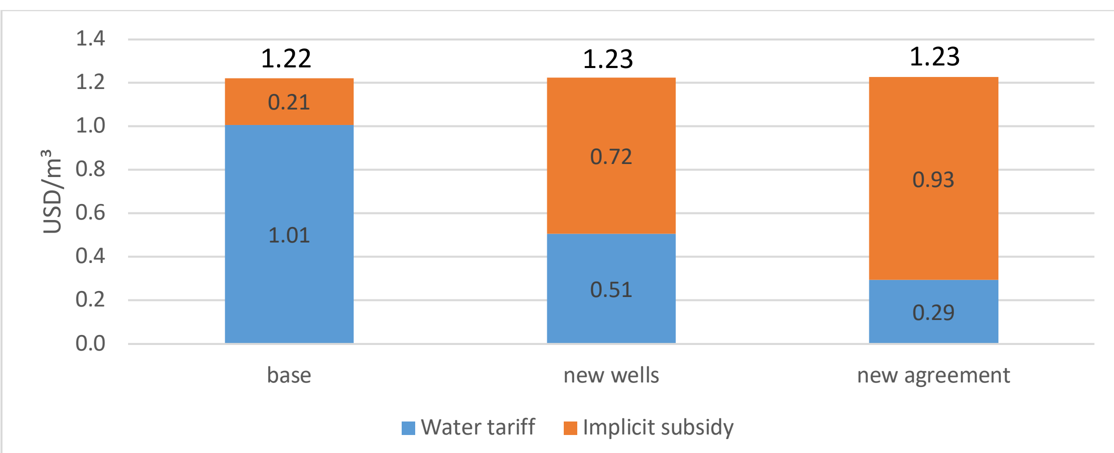
Table 3: Water supply and demand in the West Bank, net of non-revenue water

		Water quantity			Change compared to base	
		[Million m³]			[%]	
		base	new wells	new agreement	new wells	new agreement
Supply	natural fresh water	73	165	286	125.5	290.7
	imports	33	33	33	0.0	0.0
	Total	106	198	319	86.9	201.2
Use	agriculture	44	73	106	66.6	142.9
	industry	2	4	6	75.0	173.0
	services	16	28	43	76.3	174.1
	households	43	93	163	114.3	277.0
	government	1	1	1	0.0	0.0

Source: model results.

In order to bring the water market into balance and to avoid excess supply, the water tariff needs to drop in both scenarios significantly (Figure 7). As the water provision costs even increase slightly, due to the general economic upturn, the difference between costs and tariffs need to be financed by the government through an implicit subsidy. This implicit subsidy is partly financed by higher tax revenue from indirect taxes, as the West Bank economy is growing (see section 4.3). However, also about 67 and 189 Million USD of additional tax revenue is required under the "new wells" and "new agreement" scenarios, respectively, in order to keep the government's budget balanced. In this study, this is achieved by an increase of the direct tax rate by 0.8 and 2.3 percentage points in the "new wells" and "new agreement" scenario, respectively.

Figure 7: Water provision costs and its financing in the West Bank, additional water user subsidy not considered



Source; model results.

Table 4 shows the implications for the Israeli water-sector. As defined in the scenario-description, only the "new-agreement" scenario, has consequences for Israel in terms of a reduced freshwater supply. However, this leads to a significant drop in water supply only in the short-run (fix dsal) as brackish water can be used as a substitute in few agricultural activities only[7] and the output of reclaimed wastewater is limited by the reduced municipal water consumption.

In the longer run (flex dsal), the reduction in water abstraction from the Mountain Aquifer will be compensated by expanding the desalination capacity. Thus, total water supply only drops very slightly and hence, the demand-side is almost unaffected in the long-run in all sectors. Only with fixed desalination-capacity, specifically the industry and service sectors would reduce water consumption. The agricultural sector would be less affected due to its substitution possibilities with marginal water qualities (reclaimed and brackish water). Households in Israel are characterized by a relatively inelastic water demand, leading only to slight reduction in their consumption. Government consumption in the Israeli case mainly includes minimal environmental flows, which need to be kept constant as defined in the model setup. This short-run reduction in water supply would be managed by an increase of the potable water price to all users by 38%. The price of reclaimed wastewater would increase by 23% at the same time, due to reduced sewage supply (compare Appendix, Figure 13).

Table 4: Water supply and demand in Israel

		Water quantity			**Change compared to base**	
		[Million m³]			[%]	
		base	new agreement			
			fix dsal	flex dsal	fix dsal	flex dsal
Supply	natural fresh water	1,061	808	808	-23.8	-23.8
	desalination	313	313	564	0.0	80.1
	brackish	179	185	179	3.6	0.0
	reclamation	447	383	446	-14.3	-0.1
	Total	2,000	1,689	1,997	-15.5	-0.1
Use	agriculture	1,062	887	1,061	-16.5	-0.1
	industry	129	94	129	-26.9	-0.2
	services	196	144	196	-26.7	-0.2
	households	556	508	555	-8.7	-0.1
	government	57	57	57	0.0	0.0

Source: model results.

[7] Limited to irrigation of certain crops, which are tolerant to increased salinity levels, such as tomatoes, melons and cotton.

4.2 Production

Higher availability of water will reduce production costs of water intensive production activities. In the West Bank, water makes up to between 2.3% and 8.9% of the total production costs of the agricultural activities. Thus, agricultural production is increasing under the two scenarios (Table 5), generating some positive multiplier impact on industry and services. The industry-sector profits to a lower extend, as in this sector water makes up a very low share of the production costs (0.1%). The increased production in this sector is mainly due to a higher demand for industrial goods caused by the growing economy. The growth in the service sector is mainly driven by the boasting water supply activity, which is part of this sector, as well as construction benefitting from more investments (see section 4.3). For Israel, where the agricultural sector exhibits a similar water intensity (on average, about 4% of total production costs), production effects are only noticeable in the short run, with fixed desalination capacity. Effects are smaller relative to the West Bank, as the relative water supply shock is smaller and there are more substitution options for farmers as explained earlier.

Table 5: Change in Output of production sectors compared to the base

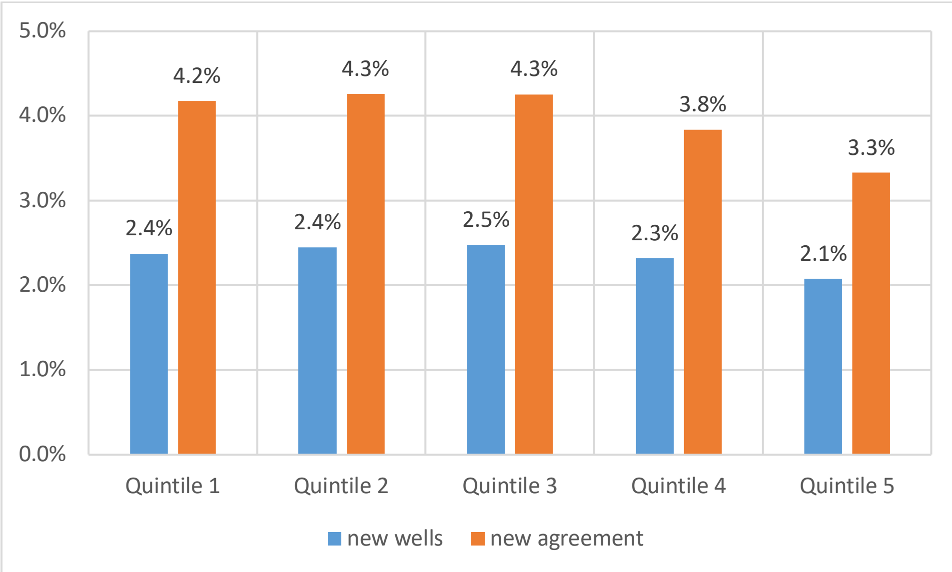
	West Bank		Israel	
	new wells	new agreement	new agreement	
			fix dsal	flex dsal
Agriculture	1.4%	2.0%	-1.5%	0.0%
Industry	0.5%	1.1%	-0.2%	0.0%
Services	3.6%	6.3%	-0.1%	0.0%

Source: model results.

4.3 Welfare and macroeconomic effects

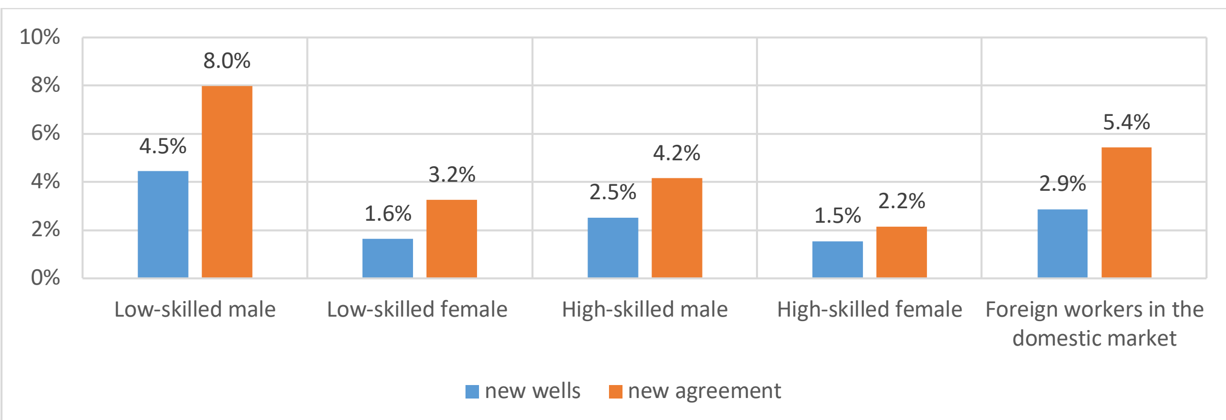
The additional water supply in the West Bank under the analyzed scenarios leads to increases in the income of all household groups (Figure 8). Similar to the effect on production, household income increases with the “new agreement” scenario more than with the “new wells” scenario. This is explained by the overall expansion of the economy, which leads to additional employment (Figure 9), from which income accrues to household. Poorer households benefit over proportionally, as they derive a higher income share from low skilled labor, which is employed more in construction and agriculture.

Figure 8 West Bank - Changes in household income



Source: model results.

Figure 9: West Bank - Changes in labor demand

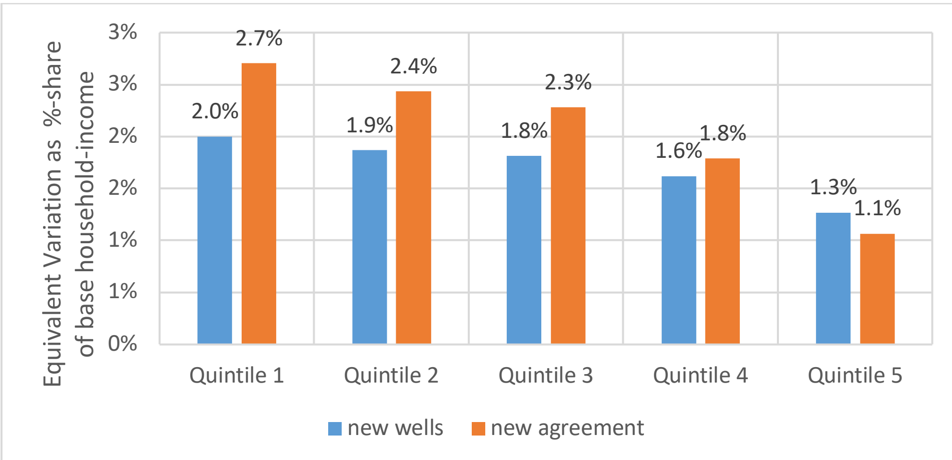


Source: model results.

As production costs in the agricultural sector fall due to the additional water supply, consumer prices of agricultural commodities drop by up to 1.9% and 3.2% in the "new wells" and "new agreement" scenarios, respectively. However, prices of industrial commodities and most service commodities slightly increase (by up to 1.4% and 2.2%, in the two scenarios, respectively).Yet, the increased household income triggers welfare gains for all household groups, whereby poorer households benefit more, due to their higher consumption share for agricultural and food commodities (Figure 10).

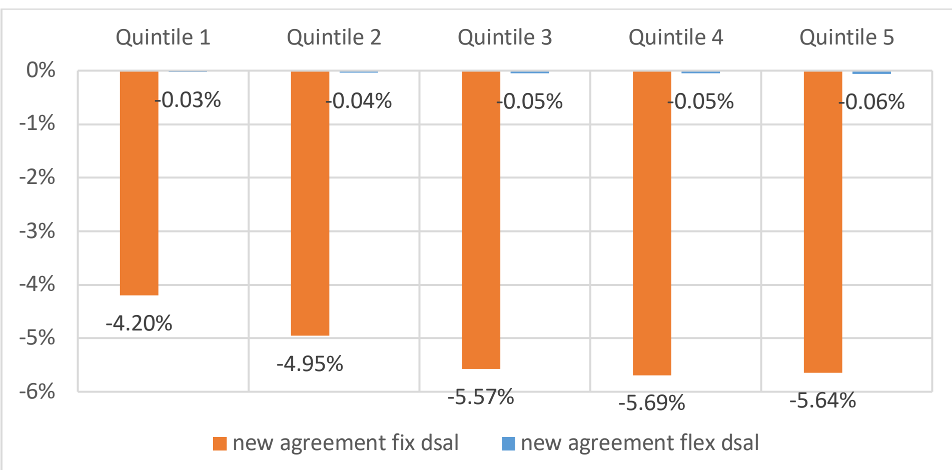
For Israel, Figure 11 shows the short-run (fix dsal) and long run (flex dsal) effects of the "new agreement" scenario. While in the short-run household income drops, by up to 5.7%, with richer households being slightly more affected, in the long-run income effects are negligible for all household groups. The stronger effect on richer households is due to the contraction of the agricultural sector in the short run decreasing the rents from land, which is mainly owned by richer households. On the other side, poor households in Israel derive up to 20% of their income from social transfers, which have been kept fixed in the model.

Figure 10: West Bank - Equivalent Variation in percent of base household income



Source: model results.

Figure 11: Israel - Changes is household income under the "new agreement" scenario

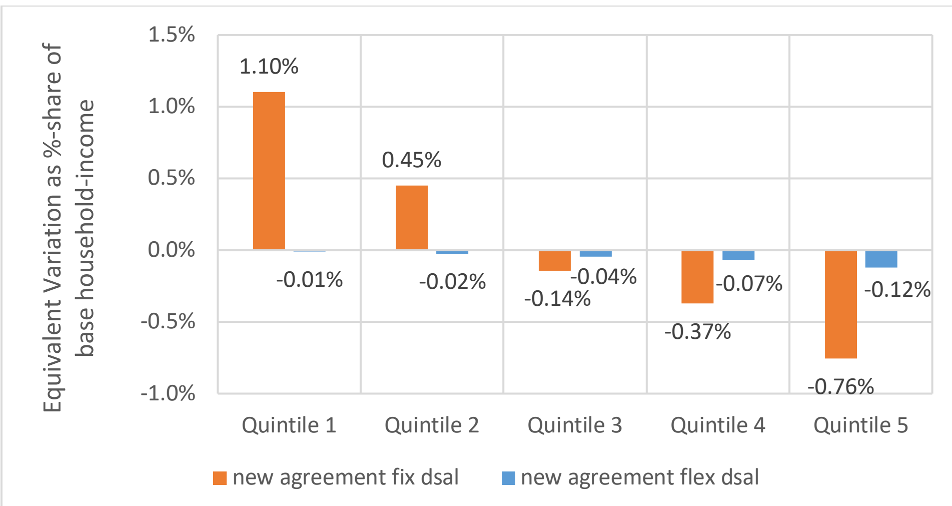


Source: model results.

In the short-run, the decreasing household income, together with an increase in the direct tax rate by 5.6%, which is required to maintain the government-balance due to the downturn of the economy, provokes that household welfare, measured as equivalent variation for wealthier households turns negative (Figure 12). The two poorest quintiles, however, spend a higher share of their household income on consumption and thus profit more from the general drop in consumer prices. In addition, they face a lower income reduction and direct tax rate. This is why this situation is actually welfare enhancing for these households, resulting in a more equal distribution of welfare.

In the long run, with additional desalination (flex dsal), equivalent variation-effects are almost cancelled out. Yet, desalination is more costly compared to the purification of natural fresh water, which in the model is financed through an increase in the direct tax by 0.7%. Due to this, equivalent variation turns slightly negative, the more the richer the households. This is due to the escalating direct tax rate scheme in Israel, resulting in rich households being more affected by this multiplicative tax increase.

Figure 12: Israel Equivalent variation in % of base household income



Source: model results.

On the aggregate level, both the "new wells" and the "new agreement" scenario lead to a considerable growth of the West Bank's economy (Table 6). Domestic production grows by more than 625 Million USD in the "new agreement" scenario. At the same time, household consumption and thus total absorption[8] grows, leading to an increase in GDP by 129 and 226 Million USD, in the "new wells" and "new agreement" scenarios, respectively. Furthermore, the trade integration of the West Bank's economy improves with mainly imports growing in the two scenarios. These are largely financed by increasing foreign savings.

For Israel, all aggregate economic indicators are negatively affected in the "new agreement" scenario in the short-run (fix dsal), as the economy is slightly contracting. With additional desalination capacity being put in place, most changes in these indicators turn positive. Domestic

[8] The other components of absorption government consumption and investment demand have been kept constant in the model setup.

production increases due to the expansion of desalination capacity, which replaces the water supply lost in the short run. Desalination requires more intermediate inputs compared to the purification of natural freshwater, which are produced domestically and imported. As domestic demand is falling, because households have to pay higher taxes to finance the higher desalination costs (compare Figure 6) as compared to the purification of natural fresh water, the domestic price level slightly sinks and thus exports become more attractive. The reduced domestic demand however results in a decline in GDP. It should be noted, however that the adverse GDP-effect in Israel is much smaller compared to the gains accruing to the West Bank economy. Thus considering the two economies together, a new agreement on the shared Mountain Aquifer under which Israel and the West Bank equally utilize groundwater, would lead to a net GDP growth of about 201 Million USD per year. This is due to the higher relative dependence on the Mountain Aquifer as a water source of the West Bank economy.

In both scenarios, the gains to the West Bank economy would be higher, if the efficiency in the water sector could be enhanced by a) increasing the water fee collection rates, b) reducing the leakage and theft from the water supply system and c) preventing the extraction of groundwater through unlicensed wells. This however, was not the focus of this study.

Table 6: Macroeconomic effects in Million 2010 USD (and %-change compared to the base)

	West Bank				Israel			
	new wells		new agreement		new agreement			
					fix dsal		flex dsal	
Domestic production	346	(+2.6%)	625	(+4.7%)	-674	(-0.2%)	15	(+0.0%)
Household consumption	133	(+1.8%)	194	(+2.6%)	-366	(-0.3%)	-136	(-0.1%)
Imports	207	(+3.7%)	343	(+6.1%)	-9	(-0.0%)	43	(+0.0%)
Exports	-2	(-0.1%)	7	(+0.4%)	-24	(-0.0%)	48	(+0.1%)
Foreign savings	189	(+12.3%)	304	(+19.7%)	0	(+0.0%)	0	(+0.0%)
Real GDP	129	(+1.6%)	226	(+2.9%)	-25	(-0.0%)	-25	(-0.0%)

Source: model results.

5 Conclusions and Policy Implications

In this study, we present an economy-wide simulation modelling approach to analyze the effects of increasing the Palestinian abstraction of groundwater from the Mountain Aquifer shared with Israel. To the best of our knowledge, this is the first attempt to quantify the economy-wide economic costs and benefits of a redistribution of water rights between Israel and Palestine. Using a water focused CGE-model allows capturing not only the direct effects from increased water access (e.g. on agricultural production) but also indirect effects from a growing economy such as additional production in upstream and downstream sectors, increased demand for labor, adjustments of the government budget and overall effects on household income and expenditure (i.e. GDP, income and consumption multipliers).

We analyze two scenarios, namely a "new wells" scenario, in which Palestine increases its groundwater abstraction from the Mountain Aquifer to the level foreseen in the Oslo II agreement, while Israel is not affected and a "new agreement" scenario in which the PNA and Israel agree on equal abstraction rates from the Mountain Aquifer. The "new-wells" scenario could be used to give an indication of the additional economy-wide revenue, which would be generated if the PNA managed to increase the abstraction from the Mountain Aquifer to its full allowance, independently from a new agreement with Israel. In case the annualized costs of exploiting these additional resources are higher than current average domestic water supply costs in the West Bank (1.22 USD/m^3, Figure 7), the economy-wide gains of 0.63 USD/m^3 of the additional water supply would shrink accordingly. These figures therefore could be used as indication for a cost-benefit analysis of developing additional wells.

The effects of reallocating water rights between the two economies sharing the Mountain Aquifer are analyzed from the Palestinian as well as the Israeli perspective, which allows for an overall assessment of the impacts on the two economies. This provides insightful findings: because of the different economic structures of the two economies and the broader options to replace groundwater from the Mountain Aquifer for Israel, the economic value of this water resource differs in the two economies. This is indicated by the different absolute changes in GDP in the new-agreement scenario, when an annual water extraction allowance of 253 Million m^3 is shifted from Israel to the West Bank.

As the outcomes of the new-agreement scenario indicate, the absolute GDP-losses to Israel are much lower than the gains to the West Bank. Considering that the Israeli economy is almost 30 times larger than that of the West Bank, this becomes even more pronounced in relative terms (+2.87% GDP growth in the West Bank versus -0.01% in Israel). Thus, especially in the long-run, with additional desalination capacity development, Israel would lose only little economically when giving up some of its water abstraction rights it is entitled to according to the Oslo II agreement, in exchange for removing a big obstacle in improving the tense relationship with the Palestinian National Authority.

As pointed out by Fisher et al. (2002), in designing a new agreement on shared water resources, it is important to distinguish between the questions of water use and ownership. This study indicates from an efficiency perspective that total welfare would increase if water use rights would be shifted from Israel to the West Bank. As the Coase-Theorem indicates, this holds independently of water-ownership, which would need to be addressed politically. The modelling approach presented here can be used to substantiate the political negotiation process towards a final agreement on access to shared water resources between Israel and the West Bank. It could easily be expanded to incorporate additional water resources such as the Jordan River or analyze different sharing agreements. Thereby, this CGE-approach overcomes several shortcomings of previous approaches such as the rather simplistic water demand functions of the agricultural sector in MYWAS (Fisher and Huber-Lee, 2011). In addition, different from previous, single-sector simulation modelling approaches, the economy-wide model presented here allows for a detailed analysis of indirect, welfare and macroeconomic effects, as well as a wide set of policy instruments to manage the water sector.

References

Agbahey, J.U.I., Siddig, K. and Grethe, H. (2016), *A 2011 Social Accounting Matrix for the West Bank with detailed representation of households and labour accounts*. Humboldt University, Department of Agricultural Economics Working Paper No. 93, available at: https://ageconsearch.umn.edu/record/245157/files/wp93.pdf.

Brooks, D.B. and Trottier, J. (2010), "A modern agreement to share water between Israelis and Palestinians: The FoEME proposal", *Friends of the Earth Middle East, Tel Aviv*.

Brooks, D.B. and Trottier, J. (2012), "An Agreement to share water between Israelis and Palestinians: The FoEME proposal", *Friends of the Earth-Middle East (FoEME)*.

Brooks, D.B., Trottier, J. and Doliner, L. (2013), "Changing the nature of transboundary water agreements: the Israeli–Palestinian case", *Water International*, Vol. 38 No. 6, pp. 671–686.

Calzadilla, A., Rehdanz, K., Roson, R., Sartori, M. and Tol, R.S.J. (2016), "Review of CGE Models of Water Issues", in Bryant, W.D.A. and Dinar, A. (Eds.), *The WSPC Reference on Natural Resources and Environmental Policy in the Era of Global Change*, Vol. 3, World Scientific, New Jersey, pp. 101–123.

CBS (2019), *Statistical Abstract of Israel 2019: 23. Water and Sewage*, available at: https://www.cbs.gov.il/en/publications/Pages/2019/Water-and-Sewage-Statistical-Abstract-of-Israel-2019-No-70.aspx.

Fisher, F., Arlosoroff, S., Eckstein, Z., Haddadin, M., Hamati, S.G., Huber-Lee, A., Jarrar, A., Jayyousi, A., Shamir, U. and Wesseling, H. (2002), "Optimal water management and conflict resolution: The Middle East Water Project", *Water Resources Research*, Vol. 38 No. 11, 25-1-25-17.

Fisher, F. and Huber-Lee, A. (2011), "The value of water. Optimizing models for sustainable management, infrastructure planning, and conflict resolution", *Desalination and Water Treatment*, Vol. 31 No. 1-3, pp. 1–23.

Gvirtzman, H. (2012), *The Israeli-Palestinian Water Conflict: An Israeli Perspective*, Begin-Sadat Center for Strategic Studies.

Harpaz, Y., Haddad, M. and Arlosoroff, S. (2001), "Overview of the Mountain Aquifer A Shared Israeli-Palestinian Resource", in Feitelson, E. and Haddad, M. (Eds.), *Management of shared groundwater resources: The Israeli-Palestinian case with an international perspective*, *Natural resource management and policy*, Kluwer Academic, Boston, pp. 43–56.

IBNET (2019), "IB-NET Database - custom reports", available at: https://database.ib-net.org/countries_results?ctry=145,157&years=2010,2011,2014,2015&type=indicator&ent=country&mult=true&report=1&indicator=69,71,70,64&table=true&chart=false&chartType=column&lang=EN&exch=1.

Israeli Ministry of Foreign Affairs (1995), The Israeli-Palestinian Interims Agreement-Annex III: Oslo II.

Lofgren, H. (2004), "A Standard Framework for Village General Equilibrium Modeling", in Dixon, J., Taniguchi, K., Wattenbach, H. and TanyeriArbur, A. (Eds.), *Smallholders, globalization and policy analysis*, Food and Agriculture Organization, Rome.

Luckmann, J., Flaig, D., Grethe, H. and Siddig, K. (2016a), "Modelling Sectorally Differentiated Water Prices - Water Preservation and Welfare Gains Through Price Reform?", *Water Resources Management*, Vol. 30 No. 7, pp. 2327–2342.

Luckmann, J., Grethe, H. and McDonald, S. (2016b), "When water saving limits recycling. Modelling economy-wide linkages of wastewater use", *Water research*, Vol. 88, pp. 972–980.

Luckmann, J., Grethe, H., McDonald, S., Orlov, A. and Siddig, K. (2014), "An integrated economic model of multiple types and uses of water", *Water Resources Research*, Vol. 50 No. 5, pp. 3875–3892.

Luckmann, J. and McDonald, S. (2014), *STAGE_W an applied general equilibrium model with multiple types of water; technical documentation*, available at: http://opus.uni-hohenheim.de/volltexte/2014/984/pdf/STAGE_W_technical_paper_net.pdf.

McDonald, S. (2007), A Static Applied General Equilibrium Model: Technical Documentation STAGE Version 1: July 2007 DRAFT.

Palestinian Central Bureau of Statistics (2012a), *Prices and Price Indices Annual Bulletin 2011*, Ramallah, Palestine.

Palestinian Central Bureau of Statistics (2012b), Registered Foreign Trade Statistics - Goods and Services, 2011: Main Results, Ramallah, Palestine.

Palestinian Central Bureau of Statistics (2014), *National Accounts at Current and Constant Prices 1994-2012*, Ramallah, Palestine, available at: http://www.pcbs.gov.ps/PCBS_2012/Publications.aspx?CatId=25&scatId=297.

Palestinian Central Bureau of Statistics (2017), "Selected Indicators for Water Statistics in Palestine, 2010 – 2017", available at: http://www.pcbs.gov.ps/Portals/_Rainbow/Documents/water/water-E-selected%20indicator%20PAL.html.

PCBS (2018), *Annual Available Water Quantity in Palestine by Region and Source, 2018*, Ramallah - Palestine, available at: http://www.pcbs.gov.ps/Portals/_Rainbow/Documents/water-E4-2018.html (accessed 25 August 2020).

Selby, J. (2013), "Cooperation, domination and colonisation: The Israeli-Palestinian joint water committee", *Water Alternatives*, Vol. 6 No. 1, pp. 1–24.

Siddig, K., Flaig, D., Luckmann, J. and Grethe, H. (2011), A 2004 social accounting matrix for Israel documentation of an economy-wide database with a focus on agriculture, the labour market, and income distribution, available at: http://opus.uni-hohenheim.de/volltexte/2011/625/pdf/haa20_online.pdf.

World Bank (2018), *Securing water for development in West Bank and Gaza sector note, The World Bank*, available at: http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP//.

Appendix

Table 7: Water provision costs as implemented in STAGE_W

	West Bank	Israel			
	Fresh water purification	Fresh water purification	Wastewater recycling	Brackish water pumping	Desalination
Energy	0.22	0.25	0.27	0.32	0.38
Machinery	0.10	0.05	0.04	0.05	0.09
Other intermediates	0.40	0.19	0.30	0.20	0.24
Labour	0.25	0.22	0.18	0.27	0.08
Capital	0.03	0.13	0.20	0.15	0.21
Water resource	0.001	0.15	0.00	0.00	0.00
Costs [USD/m³]	1.22	0.66	0.19	0.10	1.09

Figure 13: Water tariffs in Israel, Source: model results