The impact of livestock support measures on groundwater depletion in Turkey

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Abstract

Turkey is a major agricultural player and serves as an important food hub for its neighboring countries in the water-scarce Middle East and North African region. However, partly due to a lack of natural pasture land, the Turkish livestock sector exhibits low productivity, and this is why the Turkish government has introduced various policies in support of this sector, including direct payments to irrigated fodder crops such as maize for silage. In order to assess the effect of these policies, a single country CGE model has been linked to a water footprint module. Results suggest that removal of Turkish subsidies and tariffs that currently support the livestock sector may not lead to water savings in absolute terms, but would redirect a substantial amount of irrigation water towards crops that Turkey can produce more competitively. Also, it is found that programs for the improvement of livestock genetics in Turkey may lead to net economic gains and overall water savings.

Keywords: Water, Turkey, Livestock, CGE model, Agricultural subsidies

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1. Introduction

Turkey is a major agricultural producer and a key food exporter to its net food importing neighboring countries in the Middle East and North Africa (MENA) region (FAO 2016). However, the comparative advantage of the Turkish agri-food sector lies primarily in food processing and the production of high value crops such as fruit and vegetables. Relatively short on pastureland and rain-fed areas that would be suitable for the competitive production of roughage, the opportunity cost of supplying Turkey's large and growing population primarily with domestic beef and milk seems to be high (Koc et al., 2012). This opportunity cost is exacerbated by a relatively small-scaled livestock sector in Turkey where markets for beef and milk face relatively high transaction costs and suffer from technical inefficiencies and low average productivity (Yolcu and Tan, 2008). Livestock and livestock products in Turkey are supported in several ways: firstly, direct subsidies are paid to producers of meat and dairy products. Secondly, import tariffs protect Turkey's unproductive livestock sector. Thirdly, the livestock industry receives indirect support through subsidies paid to inputs that are extensively used in livestock and dairy production. This is especially problematic in the case of maize produced as fodder that receives subsidies for irrigation using groundwater (FAO, 2016).

This means that the livestock support measures are not only likely to distort economic welfare by allocating resources to unproductive sectors but also foster the depletion of groundwater resources, which are already under severe stress in some regions (FAO, 2016). However, apart from the distortion of markets, it is the encouragement of forage crop production on irrigated land through coupled subsidies that is in addition contributing to the depletion of groundwater resources (FAO, 2016).

Our study evaluates the role of different livestock support measures for groundwater consumption and the agricultural sector in Turkey by combining a computable general equilibrium (CGE) model with a water accounting module. Our aim is to quantify the potential distortion of Turkey's livestock sector support both in terms of economic losses and potential degradation of domestic water resources.

The paper is structured as follows: section 2 reviews livestock support policies in Turkey in the context of groundwater depletion. Section 3 describes our modeling framework and our scenarios. Section 4 discusses our results, while section 5 concludes.

2. Livestock support policies in Turkey[1]

Turkey's overall political priorities and strategic targets are laid out in the 10th Development Plan 2014-2018 (Ministry of Development, 2013). The plan constitutes that livestock enterprises in Turkey are small scale and the productivity of livestock herds would generally be low according to international comparisons.

[1] This section is based on the analysis in FAO (2016, section 5.3).

The limited availability of pastures and other land suitable for the production of roughage is in the 10th Development Plan also mentioned as a structural problem of the livestock sector, along with the need to overcome it through "*…increased production and product diversification*" (Ministry of Development, 2013, p 102). However, the 10th Development Plan also acknowledges that the design of agricultural support programmes should take the effects on available water resources into account. (Ministry of Development, 2013, p 10)

In order to boost farm incomes, productivity gains are being targeted in beef, dairy and sheep production, and as part of this, policymakers consider it appropriate to increase the supply of maize and e.g. alfalfa from irrigated areas. However, political incentives to increase the domestic supply of food products based on animals that depend largely on roughage may increasingly shift domestic water resources towards feed production.

Table 1 presents different water footprints in m^3 per ton of maize produced in Turkey in comparison to the average global water footprints for maize. The water footprint is defined as the total volume of freshwater used to produce the unit of goods in question. A water footprint can be divided into three parts: the blue water footprint, green water footprint and grey water footprint.

The blue water footprint refers to the volume of surface and groundwater consumed during production. Consumption refers to the volume of freshwater used and then evaporated or incorporated into a product. It also includes water abstracted from groundwater or surface water that does not return to the catchment from which it was withdrawn. The green water footprint is the volume of rainwater consumed during the production process. Finally, the grey water footprint is an indicator of freshwater pollution that can be associated with the production of a product along its entire supply chain. Table 1 shows that the average ton of maize produced in Turkey requires about 2-3 times more water than the average ton of maize in the rest of the world requires.

[Insert Table 1 here]

Table 2 presents recent levels of output subsidies for bovine animals in Turkey. The table shows that, in line with the strategic goals of the 10th Development Plan, incentives are provided for the adoption of higher productivity genetic breeds. In addition, production support is also provided in terms of a direct premium per head. Given the objectives of the 10th Development Plan, it would appear logical to subsidize beef production in this way. However, such policies typically distort market incentives and do not include incentives to reduce the blue water footprint of beef in Turkey.

[Insert Table 2 here]

In addition, specific input subsidies are provided by the Turkish government for the production of forage crops, such as specific subsidies for fertilizer use and fuel in forage crops (Ministry of Food, Agriculture and Livestock 2014). These subsidies incentivize the use of irrigated land for fodder production, which is a fuel-intensive process. These input subsidies constitute further distortions to the otherwise already heavily distorted (or partly non-existent) market for irrigation (ground) water in Turkey (FAO 2016). A water market that is distorted in this way provides more incentives to use water than the long-term societal (social) optimum for Turkey would allow. Further policy-induced incentives to use irrigated land for fodder production will only aggravate this set of distortions.

Further support for the production of fodder on irrigated land may come from investment incentives such as government loan programmes or deductions on interest rates for other loans. Such programmes do exist, but their effect on water usage in the bovine sector is difficult to assess. Furthermore, the development of infrastructure, such as investment in efficient irrigation technology, is in principle a contribution to more resource-efficient water use. It is therefore important that such programmes are not be tied to the production of specific fodder crops; in other words investment programmes should not require the production of fodder on irrigated land, but should allow a profit-maximising choice of crops according to undistorted market conditions.

Concerning output subsidies for forage crops, it should be stated that the official PSE figures for corn (maize) in Turkey provided by the OECD do not include the so-called category C supports, which comprise direct subsidies per animal or per hectare. Category A (B) refers to general price-based output (input) subsidies. Such additional category C supports are published in the Bulletin of the Turkish Ministry of Agriculture and Food (2014) and name 75 TL/da/year for maize for (irrigated) silage as specific subsidies.

For irrigated maize in particular, per hectare subsidies were substantially increased between 2012 and 2013 (by 36%) until they reached the range of annual EU single farm payments per hectare. A similar level of support applies to artificial meadows and pastures.

The harvested area of maize in Turkey has grown by 17% between 2004 and 2014, while maize used in animal feed more than doubled in the same period. In particular, the share of irrigated maize in total irrigated agricultural land in Turkey has considerable increased, taking 20% - 25% of the irrigated area in Turkey alone, as Figure 1 shows.

[Insert Figure 1 here]

3. Measuring economic and groundwater impacts

Turkey's livestock support measures affect both production and consumption linkages as well as product and factor markets in the Turkish economy by influencing prices of both livestock inputs and outputs. Computable general equilibrium (CGE) models capture these linkages and market interactions within an economy and are thus valuable tools to analyze the economy-wide impacts of policy measures on output, prices, welfare and trade. Since CGE models can only measure market interactions and groundwater is essentially free and not traded at markets in Turkey, we link the CGE model with a newly developed water accounting module to measure both economic and water use impacts of Turkey's livestock support measures.

3.1 Economy-wide modeling approach

We use a comparative-static CGE model of Turkey based on the single country IFPRI Standard CGE model described in Lofgren et al. (2002). The model consists of several economic agents in the form of producers, households, the government and the rest of the world. Producers maximize their profit subject to constant elasticity of substitution (CES) production functions that govern the substitution between production factors, while intermediate inputs enter the production technology subject to Leontief functions with fixed input-output shares. The households maximize their utility subject to a Stone-Geary-utility function that gives rise to a linear expenditure system. Both input and output commodities are traded with the rest of the world under the Armington assumption of imperfect substitution between domestic and foreign commodities. A CES function determines the substitution between domestic and imported commodities. Likewise a constant elasticity of transformation function governs the output quantities for export. Producers and consumers decide how much to export and import dependent on relative prices of commodities and considering taxes and transaction costs. World market prices are assumed to be exogenous. The equations can be found in Schuenemann et al. (2018).

We calibrate the model to a 2011 Turkey social accounting matrix (SAM) extracted from the GTAP9 (Global Trade Analysis project) database with 57 activities and commodities (Aguiar et al., 2016), including 8 crop production activities and four animal husbandry sectors (e.g. bovine cattle, smaller livestock such as pigs and poultry) and three livestock processing sectors (2 types of meat and milk processing). Looking at the input output shares in the SAM allows to identify the fodder crops which include wheat, maize, barley, vegetable, oilseeds and a few other crops. We are aware of the caveats with respect to extracting SAMs from GTAP data such as outdated input-output tables and the need to estimate a consistent global dataset at the potential expense of precise regional SAMs. Given that other existing SAMs of Turkey only feature an aggregate agricultural sector, we prefer the detailed disaggregation of agriculture in the GTAP data for now that allows us to analyze the linkages between livestock and fodder crops. In addition, a comparison of the 2011 GTAP Input-Output Table with a recent Input-Output Table for Turkey for the year 2012 shows a very similar share of value-added in agriculture (60% vs. 63%) and a similar share of agriculture in total value added (8.3% vs. 7.8%). Getting the GTAP SAM to the format needed for the single country CGE model requires several adjustments. In particular, GTAP SAMs feature the so called regional household that functions as an intermediary collecting taxes and factor rents that are then distributed to a private household, the government and the savings-investment account (Corong et al., 2017). We have removed this intermediary so that households directly pay taxes to the government and savings to the savings-investment account, while they directly receive returns from factors. As our SAM features only one representative household, we cannot measure welfare changes for different types of households such as farm and non-farm households. Since we are mainly interested in water use impacts of livestock support measures, we leave the analysis of detailed distributional impacts to follow up work.

The representative household earns income from the production factors labor, land and capital. Labor is disaggregated in skilled, agricultural and unskilled labor. For our static model version, we assume that all factors are fully employed, but mobile between sectors. The household uses its factor incomes for the consumption of commodities, savings and to pay direct taxes to the government. Consumption of commodities is governed by a linear expenditure system that is calibrated to income elasticities based on Hertel and van der Mensbrugghe (2016). Our SAM also features a detailed representation of six tax accounts to reflect the livestock support measures with activity taxes paid by producers to the government based on output and factor prices based on factor use. A negative value for these taxes reflects a subsidy. Direct taxes are paid by households on income direct to the government, whereas sales taxes are incorporated in market prices and paid by commodity accounts to the sales tax account, the same applies to export taxes and import tariffs. All six tax accounts pay their receipts to the government.

Finally, we choose a set of macroeconomic model closures. We choose a flexible exchange rate to reflect Turkey's floating exchange rate regime while receipts of foreign capital are fixed. In addition, we choose a savings-driven investment closure with a fixed private savings rate. In terms of the government closure, we fix tax rates exogenously and later simulate changes in our scenarios, while recurrent spending is flexible to balance government revenues and expenditure. The model's numeraire is given by the domestic price index.

3.2. Simulating the impact of livestock support measures

We use our Turkey CGE model to run different scenarios with regard to the effects of direct and indirect livestock subsidies on various economic outcome indicators. Since the support measures captured within the GTAP SAM of Turkey do not fully account for the actual support measures paid by the Turkish government to producers of livestock products and fodder in 2011, our first step is to create a base reference that reflects the blue-water intensive policies around the year 2011. We use data from the OECD producer support estimate database with regard to output and input subsidies for livestock and fodder crops and shock our model with the respective subsidy rates (OECD, 2018). The database lists two main types of subsidies for the Turkish livestock industry: payments based on output and market price support (MPS). The former is implemented as negative activity taxes in our model and is partly already reflected in the GTAP data. The database shows producer support was paid in 2011 mainly to producers of fodder crops including maize, barley, wheat and sunflower. Market price support is paid to producers to keep the domestic market prices of agricultural goods above world market prices, but is not included in the GTAP data until now (Huang, 2009). As MPS is listed as "support paid based on commodity outputs", we also implement MPS as a negative activity tax. MPS is paid for both fodder crops such as maize, wheat and sunflower, as well as for livestock products such as milk, beef, poultry and sheep meat.

[Insert Table 3 here]

We then run six sets of scenarios that we compare to the baseline, which are listed in Table 3. In the first three scenarios, we (1) reduce the livestock output subsidies to zero, (2) reduce the fodder crop output subsidies to zero and (3) simulate a complete liberalization of import tariffs on bovine cattle and beef. In a fourth scenario, we simulate the combined effect of the previous three scenarios. Table 4 shows the different tax rates in the baseline and the six scenarios with respect to activity and import taxes.

[Insert Table 4 here]

In a fifth scenario, we remove the factor subsidies on capital received by producers of cattle and raw milk. Bovine cattle producers receive 834 million US$ and raw milk producers 368 million US$. Without this subsidy capital costs would be 51% higher for bovine cattle producers and 25% higher raw milk producers. We implement this cost increase by raising the price for capital in the two sectors by 51% and 25%, respectively.

Finally, we run a scenario that reflects the Turkish livestock breeding subsidies under the 10th Development Plan that support investment in high yielding cattle varieties by introducing a positive productivity shock on bovine cattle (Ministry of Development, 2014). The OECD producer support database lists “livestock improvement payments” of 1.033 billion USD in 2011, which amounts to 9.6% of the combined output value of bovine and milk cattle and is chosen as the value for a total factor productivity shock (OECD, 2018). Since higher productivity cattle breeds have a higher average slaughter weight, such a policy measure could reduce the virtual water embedded in each unit of output and thus the water footprint of the cattle sector (FAO, 2016). This scenario allows to analyze the relative economic effect of improvements in productivity and technical efficiency in comparison to the effect of market liberalization in the Turkish livestock sector.

3.3. Water accounting module

While the CGE model can capture policy impacts on various economic variables such output, GDP and welfare, we assume that ground water is an essentially free resource in Turkey and needs to be assessed with a different model. This assumption is more realistic than to assume competitive water markets (FAO 2016). We therefore develop a groundwater accounting tool that translates changes in output of crops and livestock sectors to changes in water footprints of per unit of output and for Turkish agriculture as whole. Table 5 shows the indices, parameters and variables used in the module.

[Insert Table 5 here]

We first use water footprint data of crops in Turkey from Mekonnen and Hoekstra (2011) that list the water footprint in terms of blue, green and grey water per ton of production and multiply this with crop production data in tons from FAOSTAT for the year 2011 in Turkey. Since our model crop sectors are more aggregated than the standard FAOSTAT crops, e.g. our model features a grain sector that includes maize and barley, we sum over the water footprint of FAO crops WFP_{FAO_crop} and multiply with the output share of these crops in our model crop sectors $crp\_share_{a,FA0\_crop}$ as shown in equation 1. This gives us the water footprint of Turkish agriculture in the baseline WFP_a.

$$WFP_a = \sum_{FAO\_crop} WFP_{FAO\_crop} * crp\_share_{a,FA0\_crop} \qquad (1)$$

We then proceed to link the CGE model with the water accounting module by passing down the crop production numbers in each scenario from the economic model to the water module. To calculate the water footprints in each scenario $WFP_{a,scen}$, we multiply the water footprint in the baseline with the change in output for each crop sector in each scenario (equation 2)

$$WFP_{a,scen} = WFP_a * (1 + \Delta Q_{a,scen}) \tag{2}$$

Finally, to calculate the water footprint of the Turkish livestock sectors in each scenario, we take the sum over the water footprint of fodder crops and multiply this with share of each livestock sector's demand in total demand of fodder crops in each scenario (equation 3).

$$WFP_{live,scen} = \sum_{fod} live\_shr_{fod,live,scen} * WFP_{fod,scen} \tag{3}$$

The combination of CGE model and water accounting tool allows us to measure the economic and biophysical impacts of different livestock support measures in Turkey as discussed in the next section.

4. Results

We simulate the above described scenarios in which we remove different livestock support measures in the Turkey CGE model and compare them to our baseline that captures the structure of the Turkish economy in 2011 as shown in the first column of Table 4. Services dominate the Turkish economy with 62% of GDP, while the agricultural sector accounts for only 7% of total Turkish GDP. In addition, meat and dairy processing exhibits only a small share of Turkish industrial production. This means that any policy shock to agriculture is likely to have small repercussions on the rest of the economy. However, products of animal origin should account for an important and rising share of households' food expenditure and therefore we cannot rule out relevant GE effects a priori.

However, in the GTAP9 data, most of the agriculture's GDP share is generated by crops that can be used as fodder and not so much by livestock production, indicating the relative low productivity of livestock production in Turkey. How the subsidies change the composition of and the water used in Turkish agriculture is discussed in the following.

[Insert Table 6 here]

Removal of livestock subsidies

In the first scenario, we remove the subsidies that are directly paid to Turkish livestock producers per unit of output. The economic impacts can be seen in the second column of Table 6. As expected output of all livestock sectors decreases. Both "raw" livestock and meat and dairy processing fall by around 13%. This also affects other sectors that are used as inputs in the livestock industry, mainly fodder crops but also trade services. Even though demand for fodder crops decreases, negative effects on this sector are much smaller than on the livestock industry because additional land becomes available to fodder crops that was formerly used for pasture. As fodder crops such as wheat are also directly consumed by households and not only used as intermediate inputs in livestock production, there is no equivalent reduction in output and land use of fodder crops compared to livestock. Some of the land also becomes available to exports crops such as cotton and tobacco, which grow by 2%. Total industry benefits and grows slightly as the contraction of the livestock sector sets free labor that migrates to other industrial sectors. Total GDP effects are positive but turn out to be small, which is plausible given the relatively small size of agriculture in GDP. The reduction in the livestock sector is indeed mainly felt by households and not so much by producers as shown in the household effects in the second column of Table 7. As livestock output decreases, prices for livestock products increase, leading to a one percent lower real consumption compared to the baseline. Similarly the value for equivalent variation shows that households would have to get paid a thousand US$ after the policy shock and price change to be as well off as before.

Looking at the blue water use impacts in Table 8 on the other hand shows favorable outcomes. Water use of the livestock sector is calculated as the virtual water entering livestock production through inputs in the form of the virtual water embedded in the fodder crops (see section 3.3). By removing the livestock subsidies, blue water use is reduced by almost 53 million m^3 or 14% compared to the baseline. The effects are most pronounced for other livestock such as poultry, sheep and pigs that has a higher share of fodder crop input compared to cattle that is partly kept grazing on pasture land. Results are less promising in terms of the water intensity of total Turkish agriculture. Since some of the previous pasture land is replaced with cropland that is partly irrigated, the water used per unit of value added increases by 0.5%. Overall, the removal of livestock subsidies mainly reduces livestock output and hurts households by increasing prices. The problem of excessive blue water use and groundwater pumping on the other hand does not seem to be solved by lowering direct subsidies on the livestock industry.

[Insert Table 7 here]

Removal of fodder subsidies

In the second scenario, we remove the subsidies paid to producers of fodder crops, which leads to a decline of fodder crop production by 4.7% as shown in the third column of Table 4. Given the dominance of crop production in Turkish agricultural GDP, the removal of fodder crop production subsidies has a larger effect on Turkish agriculture than the removal of livestock subsidies. Livestock producers on the other hand are only marginally affected and their output decreases by less than one percent. This is because as output of domestic fodder crops decreases and their prices increase, livestock producers compensate most of the lower domestic production of fodder crops through cheaper imports of fodder. Similarly, land use of fodder crops is reduced 0.75 percent, which is taken up mainly by export crops and the livestock sector. Export crop production even increases by 4.5%. As in the previous scenario, trade services are negatively affected while other industrial sectors benefit from additional labor. Impacts on household consumption are also less pronounced than in the previous scenario (third column of Table 5). But given that prices of fodder crops such as wheat, maize and barley, which are also consumed by households, increase, the equivalent variation shows that households would still have to receive almost a thousand US$ to be as well off as before the price changes.

The third column of Table 8 shows impacts of removing fodder crop subsidies on water use. As domestically produced fodder crops are replaced with imported fodder crops, the water use in the Turkish livestock industry decreases very little by overall 1%. Note that for simplicity reasons we assume here that the imported fodder crops contain the same amount of virtual blue water than domestic fodder crops. This assumption also implies that the water intensity of Turkish agriculture thus not decreases relative to the baseline, also because some of the crowded out fodder crops are replaced by other water intensive crops such as vegetables. If the imported fodder is produced less water intensively than the domestic fodder however, this would mean a potentially strong reduction in the water footprint of the Turkish livestock industry and reduction of the pressure on groundwater resources. The removal of domestic fodder crop subsidies would thus be a first step to reduce the water intensive production of Turkish livestock through imports of less water intensive inputs.

[Insert Table 8 here]

Liberalization of import tariffs on bovine cattle and beef

Turkish livestock subsidies are not only directly paid to producers of livestock output and inputs used in the livestock industry, but also indirectly through protecting them from competition from foreign producers through import tariffs. In our third scenario, we remove these imports tariffs to capture their impacts on the economy and water use. This leads to large reductions in the production of both “raw” and processed livestock commodities as shown in the fourth column of Table 6. Meat and dairy production decreases by 12%, bovine cattle production only by 9%. This is because import tariffs for processed livestock products were much higher than for cattle as shown in Table 4. Interestingly, it is not so much industry that benefits from the liberalization of the livestock sector but rather the crop sector. The reduction in import tariffs leads to a depreciation of the exchange rate, making Turkish exports more competitive on the world market and increasing exports especially in the crop sector. In addition, both direct livestock subsidies as well as indirect fodder crop subsidies are still in place and the crop sector can absorb the labor that was previously employed in livestock processing as well as more land from pasture. Households very much benefit from lower prices of livestock products and their real consumption increases slightly (fourth column of Table 7). In addition, they also have higher utility and would have to give up income of 700 US$ to be as well off as before the price changes.

The large reduction in livestock output also translates in a 9% reduction of water use from the livestock sectors as shown in the fourth column of Table 8. Given the growth in land use and production from the crop sectors however, the water intensity of Turkish agriculture still increases slightly compared to the baseline. The liberalization of import tariffs mainly benefits consumers and in general increases the competitiveness of the Turkish economy. Since the subsidies paid to livestock and fodder crop producers are still in place, there is not much saving of water and protection of groundwater resources.

Combination of nolivsub, nofodsub and livlib

Therefore, in the fourth scenario, we combine all previous scenarios to measure the impact of a domestic and international liberalization of the livestock industry in Turkey. As expected, both fodder crop and livestock production decreases a lot once all subsidies are removed and respective imports enter the markets (sixth column of Table 6). Raw livestock production decreases by almost 25%, meat and dairy production by 30%. Together with a 5% reduction in fodder crops, this leads to a contraction of the agricultural sector by almost 8%. Given the loss of producer subsidies, especially the market price support, both fodder crop and livestock producers cannot compete with world market prices and exports contract. Trade services are only marginally affected as the service sector can absorb some of the workers from agriculture. The main winner is the export crop sector whose output grows by more than 10% compared to the baseline and can increase its land area by more than 15%. In addition, industry has grown by 2% as workers migrate from livestock processing in more productive industrial sectors. Households on the other hand are the loser of combined subsidy and tariff liberalization (sixth column of Table 5), since they have previously benefitted much more from lower price through subsidies compared to the removal of import tariffs. Especially prices for meat and dairy products increase a lot leading to a reduction of real consumption by 1.34%. In addition, they would have to be paid 1057 US$ to be as well of as in a situation with subsidies and tariffs.

Due to the extremely large reduction in livestock production, water use of the livestock industry decreases by almost 25%. The previous fodder crops and pasture land gets replaced by even more water intensive crops such cotton and tobacco so that the overall water intensity of Turkish agriculture increases by 2% per unit of output. Yet, irrigated agricultural land is now directed towards the production of higher value crops, for which Turkey is internationally more competitive. Importantly, the scenario shows that the protection of the livestock industry has two effects: first, consumers of livestock commodities receive lower prices leading to higher welfare. Secondly, the subsidies and tariffs partly protect an inefficient and water intensive agricultural sector, whose resources in terms of land and labor could be better employed in export crops and other industrial sectors.

Removal of factor subsidies received by producers of bovine cattle

Another livestock support measure that is supposed to reduce production costs but does not directly affect the use of groundwater like the fodder subsidies are factor subsidies on capital. These are predominantly paid to producers of cattle and raw milk and amount to up to 50% of capital costs. Once we remove these subsidies, we see a reduction in the output of “raw” livestock of 2.5% but not so much of processed meat and milk production (seventh column of Table 6). Given that the factor subsidies are only paid to producers of bovine cattle, effects on the total livestock sector are small as other livestock such as poultry, sheep and pigs are not affected. Similarly, household real consumption in the seventh column of Table 7 decreases only marginally due to a slight rise in the beef and milk prices. These results are also mirrored with regards to water use (seventh column of Table 8). Water use in beef production decreases by 6% but the water intensity of Turkish agriculture remains essentially unchanged.

Overall, the capital subsidies paid to producers of bovine cattle do not play a large role for the Turkish economy and water use.

Total factor productivity increase of bovine cattle

All previous scenarios did not lead to lower utilization of groundwater. Therefore, we run a final scenario where we increase the productivity of bovine cattle as aimed at by the Turkish 10th Development Plan. Economic impacts can be found in the last column of Table 6. As would be expected after a positive productivity shock, livestock output increases by 2.2% whereas meat and dairy production is 1% higher than in the baseline. This increases the demand for fodder crops. As cattle production becomes more productive, land and labor is set free and is now available to fodder and export crops. Overall, the agricultural sector grows by 0.7% and total GDP grows by 0.09%. The growth in the agricultural sector evokes general equilibrium effects leading to higher demand for services. Industry grows due to the growth in meat and dairy processing. These favorable economic effects also influence household welfare. Household real consumption increases by 0.09% and the equivalent variation is negative, so that consumers would gain 174 US$.

The most promising impacts of this policy shock however come in terms of water (last column of Table 6). Even though water use in the livestock sector increases due to higher output, the water intensity of Turkish agricultural per unit of output actually decreases. The Turkish bovine cattle sector is still rather unproductive in terms of cattle varieties, so that our productivity shock was small in absolute terms. This means that raising the productivity of the Turkish livestock sector through high yield cattle varieties has a large potential to reduce both the water intensity of Turkish agriculture as well as the pressure on groundwater resources. The productivity shock appears to be not only an option to reduce water input substantially, but also to increase welfare and economic growth.

5. Conclusion

The Turkish livestock sector is heavily protected by a large number of direct and indirect subsidies including direct producer and market price support based on output as well as import tariffs on processed livestock commodities. Most importantly however, producers of livestock receive indirect subsidies through subsidized irrigated fodder crops that are exploiting already scarce groundwater (blue water) resources. This paper aims at understanding the impacts of different subsidies for the Turkish economy, welfare and especially the groundwater intensity of Turkish agriculture. For this purpose we couple a computable general equilibrium (CGE) model of Turkey with a water accounting module to measure both economic and ecological impacts of livestock support measures.

Our study shows that Turkey is paying a relatively high prize for its present support to the livestock sector, both in economic terms and also in terms of depletion of groundwater resources. The direct subsidies paid to livestock producers make the livestock artificially more competitive and allocate additional water to livestock products that could be used more efficiently in agricultural products for which Turkey has a comparative advantage. Given that beef, dairy products or even roughage feed could be imported from the world market under relatively favorable conditions, the question arises if policymakers should not pay more attention to the full opportunity cost of the present livestock sector support policies. Our simulations show that without the subsidies paid to fodder crops, livestock producers would indeed import feed from abroad. This means that domestic groundwater resources could be spared and, assuming that imported fodder has a smaller blue water footprint than domestically produced fodder, the the water footprint of Turkish livestock products would decline.

Moreover, we find that the removal of import tariffs on livestock products does not only benefit the welfare of consumers, but also increases the overall competitiveness of the Turkish economy. While a complete liberalization of the markets related to beef and milk products would increase prices and negatively affect welfare of consumers, irrigated agricultural land is redirected towards production of high value crops, for which Turkey is internationally more competitive, both in terms of economic cost of production and blue water footprint. Finally, our simulation results show that alternative policy options that aim at supporting modernization and technical efficiency improvements in the sector are an efficient way to increase livestock sector output, while benefiting consumers, increasing economic growth and lowering the blue water footprint per unit of livestock sector output.

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Figures

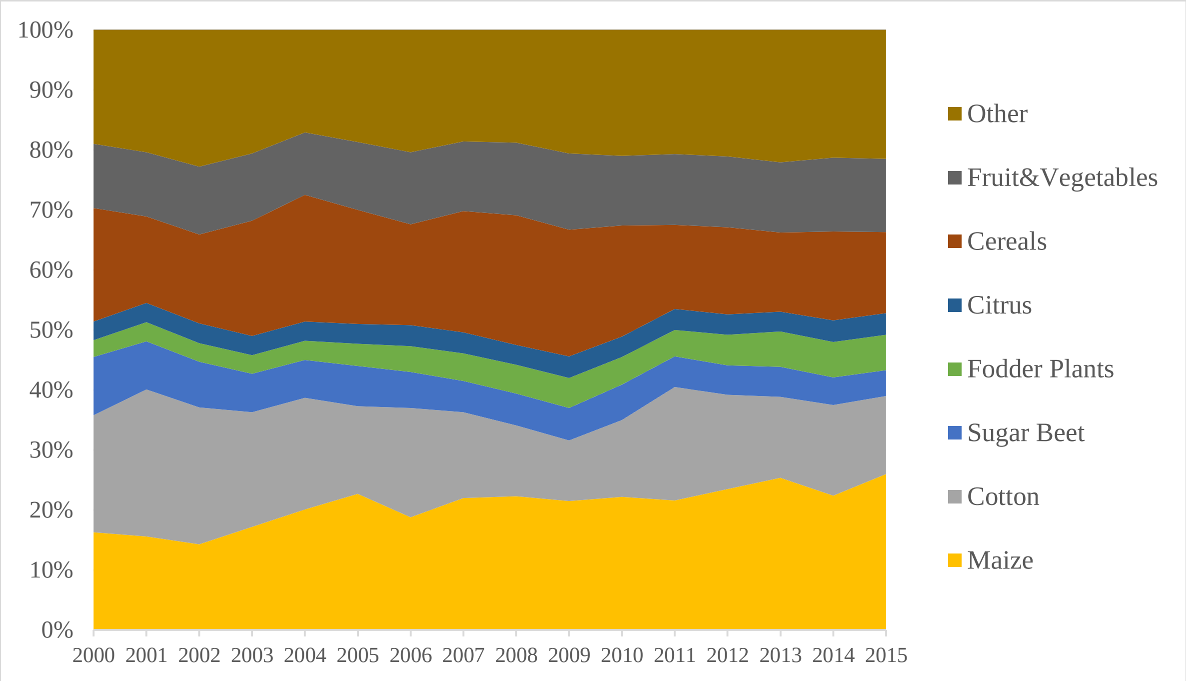

Figure 1: Share of maize in total irrigated agricultural land in Turkey. Source: DSI (2019).

Tables

Table 1: Water footprints of maize in Turkey

HS Code	SITC Code	Crop	Water Footprint (m^3/ton)	World Average	Turkey
1005	044	Maize (corn)	Green	947	646
			Blue	81	208
			Grey	194	277
100590	0449	Maize (corn) nes	Green	947	646
			Blue	81	208
			Grey	194	277

Source: Mekonnen and Hoekstra (2011)

Table 2: Output subsidies for cattle and relevance for Turkey's development goals

Support subject		Unit premium (2014) (TL/head)
Cattle for dairy and combined breeds and their hybrids Cattle for meat and combined breeds and their hybrids		225 TL/head
Rootstock cattle for breeding		350 TL/head
Rootstock buffalo		400 TL/head
Addition to pedigree of cattle for dairy and combined breeds and their hybrids		70 TL/head
Production support for fattening material (cattle for fattening)	Rootstock	350
	Calf	150

Source: Ministry of Food, Agriculture and Livestock (2014)

Table 3: Scenario description

Scenario name	Description
Base	Baseline reflecting fodder and livestock subsidies in 2011
nolivsub	Removal of livestock subsidies
nofodsub	Removal of fodder subsidies
Livlib	Liberalization of import tariffs on bovine cattle and beef
Comb	Combination of nolivsub, nofodsub and livlib
nofacsub	Removal of factor subsidies received by producers of bovine cattle
Livprod	Total factor productivity increase of bovine cattle by 9,6%

Source: own compilation.

Table 4: Tax rates in the baseline and the scenarios

	base	nolivsub	nofodsub	livlib	comb	nofacsub	livprod
Tax/subsidy rates							
Fodder crops							
Wheat	-0,15	-0,15	0	-0,15	0	-0,15	-0,15
Maize and Barley	-0,11	-0,11	0	-0,11	0	-0,11	-0,11
Vegetables	-0,06	-0,06	0	-0,06	0	-0,06	-0,06
Oilseeds	-0,11	-0,11	0	-0,11	0	-0,11	-0,11
"Raw" livestock sectors							
Bovine cattle	0,00	0	0	0,00	0	0,00	0,00
Other livestock	-0,29	0	-0,29	-0,29	0	-0,29	-0,29
Raw milk	0	0	0	0	0	0	0
Processed livestock products							
Cattle meat	-0,19	0	-0,19	-0,19	0	-0,19	-0,19
Other meat	-0,10	0	-0,10	-0,10	0	-0,10	-0,10
Milk	-0,16	0	-0,16	-0,16	0	-0,16	-0,16
Import tariffs							
"Raw" livestock sectors							
Bovine cattle	0,44	0,44	0,44	0	0	0,44	0,44
Processed livestock products							
Cattle meat	0,66	0,66	0,66	0	0	0,66	0,66
Milk	1,40	1,40	1,40	0	0	1,40	1,40

Source: own compilation using data from the GTAP database (Aguiar et al., 2016) and the OECD producer support database (OECD, 2018).

Table 5: Model indices, parameters and variables

Indices	
a	Model crop sectors (aggregated)
$fod \in a$	Fodder crop sectors (wheat, maize, barley, vegetables, oilseeds)
$live \in a$	Livestock sectors (bovine cattle, small livestock, milk producing livestock)
$scen$	Set of scenarios
FAO_crop	FAO crop sectors (disaggregated)
Parameters and Variables	
WFP_{FAO_crop}	Blue water footprint of FAO crops per ton in 2011
WFP_{a}	Blue water footprint of model crops per ton in 2011 and in the baseline
$WFP_{a,scen}$	Blue water footprint of model crops per ton in each scenario
$WFP_{fod,scen}$	Blue water footprint of fodder crops per ton in each scenario
$WFP_{live,scen}$	Total blue water footprint of livestock sectors due to embedded water from fodder in each scenario
$Q_{a,scen}$	Output of model crops in each scenario
$\Delta Q_{a,scen}$	Change in output of model crops in each scenario compared to baseline
$crp\_share_{a,FA0\_crop}$	Output share of disaggregated FAO crops in aggregated model crops' output
$live\_shr_{fod,live,scen}$	Share of livestock sectors' demand in total demand of fodder crops in each scenario

Source: own compilation.

Table 6: Economic impacts

	Initial share 2011	Change in GDP at factor cost in %					
		nolivsub	nofodsub	livlib	comb	nofacsub	livprod
Total GDP	100,00	0,01	0,01	0,00	0,01	0,00	0,09
Agriculture	7,14	-2,89	-3,17	-1,42	-7,73	-0,52	0,73
Fodder crops	4,96	-0,94	-4,68	0,16	-5,71	-0,11	0,39
Export crops	0,38	1,98	4,48	2,54	10,44	0,07	0,91
Livestock	1,29	-13,02	-0,93	-9,42	-24,22	-2,50	2,23
Industry	30,49	0,90	0,97	0,16	1,99	0,06	0,06
Meat and dairy production	1,54	-13,47	-0,70	-12,09	-29,52	-0,90	0,94
Services	62,37	-0,10	-0,10	0,09	-0,08	0,03	0,03
Crop land allocation (million ha)							
Total crop land area	18,12	18,38	17,38	18,37	17,89	18,11	18,31
Fodder crop land area	17,19	17,41	16,40	17,41	16,86	17,18	17,37
Export crop land area	1,08	1,13	1,15	1,12	1,25	1,08	1,09
Change in crop land allocation in %							
Total crop land area	100,00	1,39	-4,12	1,34	-1,27	-0,06	1,03
Fodder crop land area	100,00	1,30	-4,57	1,28	-1,92	-0,07	1,05
Export crop land area	100,00	4,21	6,13	3,25	15,51	0,23	1,05

Source: Results from the Turkey CGE model.

Table 7: Household impacts

	Initial 2011 in US$ or %	Change compared to baseline					
		nolivsub	nofodsub	livlib	comb	nofacsub	livprod
Change in real consumption in %	576983,42	-1,05	-0,65	0,28	-1,34	-0,04	0,09
Equivalent variation in 2011 US$	575032,70	1004,58	961,24	-694,56	1057,52	119,10	-173,75
Share of expenditure in %	100,00	0,17	0,17	-0,12	0,18	0,02	-0,03

Source: Results from the Turkey CGE model.

Table 8: Blue water use impacts

	Initial 2011	Change compared to baseline					
		nolivsub	nofodsub	livlib	comb	nofacsub	livprod
Change in water use in million m3	375,69	-52,83	-3,77	-32,63	-92,01	-9,03	8,22
Cattle for beef	112,46	-13,41	-0,70	-27,70	-42,87	-6,64	4,45
Cattle for milk	144,42	-7,71	-0,66	-7,02	-17,21	-2,18	2,89
Other livestock (poultry, sheep, pig)	112,74	-31,66	-2,34	2,01	-31,88	-0,21	0,85
Change in water use in %	100,00	-14,06	-1,00	-8,68	-24,49	-2,40	2,19
Cattle for beef	100,00	-11,92	-0,62	-24,63	-38,12	-5,90	3,95
Cattle for milk	100,00	-5,34	-0,46	-4,86	-11,92	-1,51	2,00
Other livestock (poultry, sheep, pig)	100,00	-28,08	-2,08	1,79	-28,28	-0,18	0,76
Water intensity of total agriculture							
Per ton in m3	102,80	104,00	104,43	103,59	106,76	102,93	102,76
Per unit of value added in m3	310.720,41	312.231,11	314.008,34	311.890,03	317.259,57	310.926,59	310.532,67
Change per unit of value added in %	100	0,49	1,06	0,38	2,10	0,07	-0,06

Source: Results from the Turkey CGE model and water accounting module.