Food, Agriculture, and Economic Policy in the Middle East and North Africa

Structural change in agriculture and water requirements in Turkey

Serdar Sayan, , Nazmi Demir,

STRUCTURAL CHANGE IN AGRICULTURE AND WATER REQUIREMENTS IN TURKEY

Serdar Sayan and Nazmi Demir

ABSTRACT

This paper investigates the effects of the post-1980 structural reforms in Turkey on the strength of inter-industry linkages between agricultural and non-agricultural sectors, and discusses the implications of the changing strength of these linkages for water consumption by the Turkish economy as a whole. For this purpose, we first solve demand- and supply-side input-output models under alternative scenarios concerning the nature of linkages between agricultural and non-agricultural sectors in 1979 and 1990. We then calculate the direct and indirect water requirements of production in 32 sectors and estimate the amount of water embodied in agricultural and manufacturing exports of Turkey.

1. INTRODUCTION

Its relatively large stock of arable land with the required climatic diversity for a variety of crops and its self-sufficiency in water resources have made Turkey the leading producer and exporter of agricultural products in the Middle East and North Africa region. While maintaining its rank regionally, primary agriculture has gradually lost its position within the national economy as the

Food, Agriculture, and Economic Policy in the Middle East and North Africa, Volume 5, pages 289–315.

ISBN: 0-7623-0992-X

largest employer and exporter, and a major contributor to the GDP as Turkey followed the standard pattern of development. The process leading to diminishing shares for primary agriculture has been accelerated by an ambitious set of structural reforms introduced in the 1980s to transform the primarily agricultural, inward-looking economy of Turkey into an outward-looking, export oriented, industrial economy. When the reforms were started with the introduction of a major structural adjustment package in 1980, primary agriculture in Turkey absorbed 60% of the civilian workforce; accounted for 57% of total exports, and contributed 25% of real GDP. At the end of the decade in 1990, the same shares stood at 47%, 17% and 17%, respectively, and continued to decline further in the 1990s, reached 43%, 10% and 14% in 1998 (see Table 1). While witnessing this decline in primary agriculture's relative contribution to national output, employment and exports, the 1980s have also been a decade when Turkish agriculture ceased to be a relatively isolated sector and became better integrated into the rest of the economy. In this sense, the 1980s (and 1990s) may be viewed as a period that led to a changing, rather than declining, role for agriculture in Turkish economy.

Even though the increasing strength of linkages between primary agriculture and the rest of the economy during this period is an essential element for a complete understanding of recent structural change in Turkish economy, this remained a largely overlooked issue in the literature. One purpose of this paper therefore is to discuss this neglected aspect of the transformation of Turkish economy in the 1980s. A similarly important yet equally underinvestigated question in this context concerns the effects of this transformation on the use of water by Turkish economy. So, the paper aims also to contemplate the implications of the changing role of agriculture on total water consumption in Turkey by placing special emphasis on the amount of water embodied within merchandise exports.

The main findings of the paper include the following: Despite the continuing decline in its employment, output and exports shares since the beginning of the 1980s, primary agriculture has become an integral part of Turkish economy, particularly through its role as the major supplier of inputs to the agro-processing sector. Following the switch in the orientation of the economy from import substitution to export promotion after 1980, Turkey experienced an export boom with the nominal value of exports increasing from $2.61 billion in 1979 to $12.96 billion in 1990 (SPO, 1997) – and exceeding $27 billion in 1998. Agro-based industries, such as textiles and food processing, ranked among the leading contributors to this boom. As a result, the amount of water embodied in Turkish merchandise exports increased by more than 150% between 1979 and 1990. This implies that the shift to export promotion policies brought export

Table 1. Real GDP, Employment and Exports Shares of Primary Agriculture in Turkey.

Years	Agricultural Exports (millions of current US$)	Share of Agriculture (%) in Total Exports	Real GDP	Employment
1980	1,672	57	25	60
1981	2,219	47	24	
1982	2,140	37	23	
1983	1,881	33	22	
1984	1,749	26	21	
1985	1,719	22	20	59
1986	1,886	24	19	
1987	1,853	10	18	
1988	2,341	20	19	
1989	2,012	17	17	
1990	2,249	17	17	47
1991	2,585	19	17	48
1992	2,134	15	16	45
1993	2,292	15	15	43
1994	2,301	13	16	44
1995	2,133	10	15	48
1996	2,455	11	15	46
1997	2,679	10	13	45
1998	2,690	10	14	43

Sources: Muthoo and Onul (1996). SIS, Statistical Yearbook of Turkey (Various Issues).

patterns of Turkey in line with the comparative advantage it had in water-intensive commodities due to the relative abundance (Sayan, 2000), especially by regional standards, of its water resources.

The organization of the paper is as follows. The next section gives some background information about Turkish agriculture. Section 3 employs an input-output technique to investigate the change in the relative position of the agricultural complex (made up of primary agriculture, food and non-food agro-processing sectors) and discusses the implications of the structural change of agricultural sector in the 1980s within an economywide framework. Section 4 first identifies the sectors that heavily use water in production and then, compares the (direct and indirect) water contents of Turkish merchandise exports in 1979 and 1990. Finally, Section 5 concludes the paper by discussing the implications of the results presented and pointing to the policy lessons, which might be derived from these results.

2. RECENT DEVELOPMENTS IN TURKISH AGRICULTURE

Even though the Turkish economy is no longer predominantly agricultural, agriculture remains an important activity for Turkey. In 1998, exports of primary agricultural commodities alone were valued at $2.7 billion and accounted for 10% of Turkey's total earnings from merchandise exports. The same year, the share of primary agriculture in real GDP stood at 14% and the sector absorbed about 43% of the civilian workforce. While still significant – particularly with respect to employment, these shares have been on a steady decline over the past decades due to the structural transformation that Turkish agriculture has been experiencing along with the whole economy (see Table 1).

In the 1970s, high-yielding varieties (HYVs) were adopted and agricultural mechanization intensified (Bulutay, 1998; Akder, 1998). This transformation has accelerated as Turkey introduced a structural adjustment program and began to liberalize its economy after 1980. Steps taken included the devaluation of the Lira and the introduction of a set of measures to liberalize trade and financial markets. With further measures adopted to increase the degree of market-orientation of the economy and to raise the share of the private sector in economic activities, the program represented a switch for Turkish economy away from an import substitution-based development strategy to an export oriented strategy. Legal arrangements were made to facilitate improved market access for private agents and to allow for the privatization of state-owned enterprises. As a result, the private sector began to get more actively involved in competition in markets including the ones for agricultural goods. The increased participation of the private sector in agricultural commodity purchases helped Turkish agriculture to slowly, but steadily, transform itself into a new form compatible with the other sectors in the economy. Also helping this process were additional policies implemented to pave the way for the development of an export-oriented agricultural sector. Taxes on exports of key agricultural products such as wheat were abandoned, farm exports began to be promoted through special subsidies, and the adoption of new technologies was facilitated. As a result, Turkey's competitiveness in world produce markets improved visibly. Yet, some of the desirable effects of these policies on exports were canceled as Turkey lagged behind in liberalizing domestic support policies. The governments continued to announce high support prices for agricultural produce, particularly during periods of high inflation and especially for wheat. Even though high domestic support prices impeded the development of a sound export sector (Yildirim et al., 1998; Gurkan & Kasnakoglu, 1991), exports of both primary agricultural commodities and agro-based industries steadily increased.

Since the increase in exports in sectors other than primary agriculture has been faster, however, the share of agriculture in total exports declined.

Real agricultural output also increased continuously during this period achieving an average annual growth rate of 1.2% from 1980 to 1996 (SPO, 1997). Agricultural value added grew at an average rate of 1.3% per annum from 1980 to 1990, and 1.2% from 1990 to 1997. For the same periods, the average annual growth in manufacturing value added was 7.8% and 4.6%, respectively, whereas the corresponding rates for services were 4.4% and 3.7%. Combined together, these growth rates implied annual real GDP growth rates of 5.3% over 1980–1990 and 3.6% over 1990–1997 periods (World Bank, 1999). So, as in the case of exports, the decline in the real GDP share of agricultural sector was due to the slower growth (rather than a contraction) recorded in this sector's output, particularly during 1980–1990 period. As this growth in agricultural value added remained relatively stable, however, the sector did not experience the slow down that the non-agricultural economy experienced in the second half of the period.

Growth rates that are significantly higher than the observed rates would have been probably difficult to achieve. By the 1980s, the area under cultivation in Turkey had about reached its limits, following a substantial expansion between 1950 and 1960. The only increase in the cultivated area after 1980 came as fallow land declined by 5 million hectares (or by almost 50%) as a result of the fallow reduction program which caused fallow land to be converted to an area of production for pulses (Bulutay, 1998; MFA, 1999). So, it can safely be argued that the increases in output were due mostly to the steady increases in the yields of major agricultural crops.

These developments occurred during a period of rapid population growth and urbanization. United Nations estimates (1997) suggest that Turkey's population grew from 45 million to 61 million between 1980 and 1995. The resulting increase in demand for food went together with a significant decline in the supply of labor in the agricultural sector as the urban population almost doubled during about the same period. The productivity gains made it possible to satisfy the increased demand with fewer workers without seriously challenging the self-sufficiency of Turkey in food supplies. Despite the number of workers migrating to urban areas and the resulting decline in the share of agricultural sector in total employment, the ratio of workforce in agriculture to total workforce remained higher than what would be expected, given the contribution of the sector to real GDP (see Table 1).

Simultaneously with these changes in the relative position of agriculture within the national economy, the strength of linkages between primary agriculture and other sectors increased, leading to primary agriculture playing a different role than before. As the Turkish economy increased its competitiveness in agro-based industries commodities (Kotan & Sayan, 2002), and increasing income in Turkey slowed down the rate of increase in the demand for basic food items, primary agriculture began to serve more as a supplier of inputs to food- and non-food-processing industries within the agricultural complex. This relatively unexplored dimension of the recent structural change in Turkish agriculture is discussed in the next section.

3. THE CHANGING DEGREE OF BLOCK INTERDEPENDENCE BETWEEN THE AGRICULTURAL AND NON-AGRICULTURAL SECTORS

Each production sector in an economy is linked to others through the inputs purchased from and outputs delivered to them. The measurement of the strength of these linkages has always been of great interest to economists because of their role in transmitting the effects of various shocks across the economy. A related and equally useful problem is the measurement of the degree of interdependence between blocks that are broader groups of activities such as agriculture or manufacturing, each containing individual sectors that are interlinked (Sayan & Demir, 1998). When measured over time, changes in block interdependence provide answers to whether a certain block of sectors become more or less strongly integrated into the rest of the economy with the passage of time, and can therefore be interpreted as an indicator of the structural change. This section investigates the direction of change in block interdependence between agricultural and non-agricultural blocks in Turkish economy between 1979 and 1990 and discusses its implications using results from an input-output (IO) modeling technique. The technique is based on the demand-side and supply-side varieties of IO models and can briefly be described as follows.[1]

Let **A** be an $n \times n$ matrix of IO coefficients, a_{ij},[2] as in the standard demand-side model developed by Leontief (1936), and X and F represent n-vectors of sectoral outputs and final demands, respectively. Given F, the **X** vector solving the system could easily be obtained from:

$$\mathbf{X} = (\mathbf{I} - \mathbf{A}.)^{-1}.F \tag{1}$$

where **I** is an $n \times n$ identity matrix and $(\mathbf{I} - \mathbf{A})^{-1}$ is the Leontief inverse matrix.

Equation (1) shows how an exogenous shock leading to a change in F_j, the final demand for the output of sector j, would affect gross domestic outputs produced by other sectors.[3] Within this framework, the responsiveness of production in sector i ($i \in \{1, 2, \ldots, n\}$) to changes in F_j depends on the values of a_{ij}'s. A more comprehensive measure of the sectoral interdependence of sector

j is given by its total backward linkages that are obtained by finding the sum of the elements in the j^{th} column of $(\mathbf{I} - \mathbf{A})^{-1}$. The resulting value shows the change in total intermediate input requirements resulting from a billion Turkish Liras' (TL) worth of expansion of F_j, and can be interpreted as the output multiplier for this sector.

It is often the case, however, that exogenous policy changes target a block of sectors rather than an individual sector, or some structural transformation takes place affecting a certain block differently than others. For such cases, a measure of block interdependence is obtained by partitioning **A** into blocks first and counterfactually setting the a_{ij} coefficients capturing the linkages among sectors in different blocks equal to zero.[4] Then, a comparison of the actual (i.e. observed) gross domestic outputs and total backward linkages to those resulting from the counterfactual (and extreme) assumption of a complete lack of linkages would show the strength of block interdependence. That is, when differences between actual and counterfactual (or simulated) values of gross domestic outputs and total backward linkages turn out to be sufficiently small (large), one can conclude that the block interdependence is weak (strong) (Sayan & Demir, 1998).

Such an analysis would, however, be partial as it looks only at the demand-side, and must be repeated using the supply-side variant of the traditional IO model. Letting $\ddot{\mathbf{A}}$ and VA' represent the $n \times n$ matrix of output coefficients $\ddot{a}_{ij}=X_{ij}/X_i$, and a $1 \times n$ vector of sectoral value-added payments, respectively, the supply-side equivalent of Eq. (1) would be (Ghosh, 1958):

$$\mathbf{X}'.\ddot{\mathbf{A}} + VA' = \mathbf{X}' \tag{2}$$

where prime (′) is the transpose operator. Then, for any given VA', the solution of the system would be:

$$\mathbf{X}' = VA'.(\mathbf{I} - \ddot{\mathbf{A}})^{-1} \tag{3}$$

where $(\mathbf{I} - \ddot{\mathbf{A}})^{-1}$ is the supply-side version of the Leontief inverse. Within this framework, the $\ddot{a}_{ij}$'s show the supply generation capacity of sector i following an increase in the amount of primary factors available for production of i. This will also affect production in other sectors, since the resulting increase in sector i's output will relax the input constraint facing other sectors that use i as an intermediate input. This supply multiplier effect is measured through the sum of all coefficients along row i of $(\mathbf{I} - \ddot{\mathbf{A}})^{-1}$ representing total forward linkages of sector i.[5]

The supply-side IO models will generate the same solution as in Eq. (1) for the base year (Bon & Bing, 1993). There, however, is no assurance that the gross domestic outputs projected by the demand-side model in response to a change in F would be matched by those projected by the supply-side model in response to a change in VA'. The results from the counterfactual experiment described must therefore be obtained also by using the supply-side IO model before deciding how strongly the agricultural block is linked to the rest of the economy. This requires partitioning the $(\mathbf{I} - \ddot{\mathbf{A}})$ matrix into four blocks (i.e. the sub-matrices S_{AA}, S_{AN}, S_{NA} and S_{NN}) as before, and solving the system again after setting all of the coefficients in the S_{AN} (S_{NA}) block equal to 0, i.e. after converting S_{AN} (S_{NA}) into a null matrix.

To observe the change in demand- and supply-side results over time, the experiments were repeated using Turkish input-output tables for 1979, the year just preceding the introduction of structural adjustment program, and 1990, the last year for which an IO table was available. The analysis was carried out using 10-sector aggregated versions of the 64-sector transaction matrices showing total IO flows for Turkey.[6] The first three sectors represent the agro complex containing primary agriculture, food (Sugar, Canned food etc.) and non-food agro processing sectors (Processed tobacco, Wood products, Ginning, Textiles, etc.), whereas non-agricultural sectors are Mining, Chemicals, Construction and other manufacturing, Metal products, Machinery, Utilities and Services (see Appendix). Tables 2 and 3 present results in terms of the means (calculated over individual sectors) of percentage deviations of gross domestic outputs and multipliers under counterfactual assumptions from actual values.

Both the demand- and supply-side IO models yield interesting results when they are solved for sectoral gross domestic outputs under the counterfactual assumption of block independence. When agro input purchases of non-agricultural sectors are assumed to be zero or negligible, sizable reductions are observed in the gross domestic outputs of agro (non-agro) sectors under the demand-side (supply-side) model. If non-agricultural sectors had not purchased inputs from agricultural sectors ($D_{AN} = O$), changes in the final demands for non-agricultural sectors would have no impact on agricultural sectors under the demand-side model. Then, the gross domestic outputs of agricultural sectors would, on the average, have been 7.04% and 11.30% lower than they actually were in 1979 and 1990, respectively (Table 2). Under $S_{AN} = O$, the supply-side equivalent of this assumption, on the other hand, changes in the primary factor use by agricultural sectors would have no effect on non-agricultural sectors. Then, the gross domestic outputs of non-agricultural sectors would, on the average, have been about 4% lower than they actually were in both 1979 and 1990 (Table 3).

In contrast, when non-agro input purchases of agricultural sectors are assumed to be zero or negligible, the sectors to face sizable reductions in gross domestic

Table 2. Deviations of Gross Domestic Outputs and Multipliers from Actual Values after Simulated Changes in Linkages between Agricultural and Non-agricultural Sectors in Turkey (Demand-Side Analysis).

Years	Percentage Deviations in Sectoral Gross Domestic Outputs* under the Counterfactual Assumption that				Percentage Deviations in Sectoral Multipliers* under the Counterfactual Assumption that			
	D_{AN} = O: Changes in the final demands for non-agricultural sectors have no impact on agricultural sectors		D_{NA} = O: Changes in the final demands for agricultural sectors have no impact on non-agricultural sectors		D_{AN} = O: Changes in the final demands for non-agricultural sectors have no impact on agricultural sectors		D_{NA} = O: Changes in the final demands for agricultural sectors have no impact on non-agricultural sectors	
	Agro Sectors	Non-agro Sectors	Agro Sectors	Non-agro Sectors	Agro Sectors	Non-agro Sectors	Agro Sectors	Non-agro Sectors
1979	7.04	1.22	0.93	15.38	0.92	4.32	20.77	1.01
1990	11.30	1.32	0.98	11.12	0.98	3.41	22.34	0.80

* Arithmetic means calculated over sectors contained within each block.

Table 3. Deviations of Gross Domestic Outputs and Multipliers from Actual Values after Simulated Changes in Linkages between Agricultural and Non-agricultural Sectors in Turkey (Supply-Side Analysis).

Years	Percentage Deviations in Sectoral Gross Domestic Outputs* under the Counterfactual Assumption that				Percentage Deviations in Sectoral Multipliers* under the Counterfactual Assumption that			
	$S_{AN} = O$: Changes in the primary factor use by agricultural sectors have no impact on non-agricultural sectors		$S_{NA} = O$: Changes in the primary factor use by non-agricultural sectors have no impact on agricultural sectors		$S_{AN} = O$: Changes in the primary factor use by agricultural sectors have no impact on non-agricultural sectors		$S_{NA} = O$: Changes in the primary factor use by agricultural sectors have no impact on agricultural sectors	
	Agro Sectors	Non-agro Sectors	Agro Sectors	Non-agro Sectors	Agro Sectors	Non-agro Sectors	Agro Sectors	Non-agro Sectors
1979	0.82	4.00	23.30	1.19	8.68	1.04	1.07	11.94
1990	1.66	4.03	49.63	2.06	14.97	1.65	1.70	11.17

* Arithmetic means calculated over sectors contained within each block.

outputs would be non-agro (agro) sectors under the demand-side (supply-side) model. The demand-side model reveals that counterfactually assuming that $D_{NA} = O$ lowers the gross domestic output of the average non-agro sector 15.38% (11.12%) below its actual value in 1979 (1990) (Table 2). The average output reductions resulting from the corresponding supply-side assumption that $S_{NA} = O$, on the other hand, are 23.30% and 49.63% of actual outputs produced by agricultural sectors in 1979 and 1990, respectively.

Considering the time dimension, percentage deviations in gross domestic outputs in agriculture would be expected to have become larger over time, if agricultural sectors have indeed become better integrated into the non-agricultural economy. The results from both demand- and supply-side models are in line with this expectation: Errors in agricultural gross domestic outputs considerably increase from 1979 to 1990 in all scenarios except for $D_{NA} = \mathbf{O}$ where the growth in errors from 0.93% to 0.98% remains at a modest 6.5 points.[7] The disaggregated results reported in Table 4 provide additional evidence to this effect.

As for the impacts on multipliers, total backward linkages are found to be pretty sensitive to both assumptions (particularly to $D_{AN} = O$ for non-agro sectors, and to $D_{NA} = O$ for agro sectors). Average errors in demand-side output multipliers increasing from 20.77% to 22.34% under $D_{NA} = O$ signal a strong and increasing interdependence between agricultural and non-agricultural blocks over the 1979–1990 period. This implies that following a change in the final demand for the output of an agricultural sector, total input requirements of this

Table 4. Deviations of Agricultural Gross Domestic Outputs from Actual Values after Simulated Changes in Linkages between Agricultural and Non-agricultural Sectors in Turkey.

	$D_{AN} = 0$: Changes in the final demands for non-agricultural sectors have no impact on agricultural sectors			$S_{NA} = 0$: Changes in the primary factor use by non-agricultural sectors have no impact on agricultural sectors		
		Agricultural Processing			Agricultural Processing	
Years	Primary Agriculture[a]	Food[b]	Non-Food[c]	Primary Agriculture[a]	Food[b]	Non-Food[c]
1979	3.82	7.47	12.14	15.29	27.91	33.56
1990	7.83	11.38	16.25	41.78	57.19	55.50

[a] Crops, Livestock, Fishery, and Forestry.

[b] Sugar, Canned food, etc.

[c] Processed tobacco, Wood products, Textiles, etc.

sector from others are significantly distorted when linkages between agricultural and non-agricultural blocks are ignored.

Turning to the supply-side again, the average downward bias in the agricultural gross domestic outputs under S_{NA} = O rises from 23.30 in 1979 to 49.63% in 1990, clearly illustrating the increasing level of interdependence of agro sectors as users of inputs supplied by non-agro sectors (e.g. Chemicals, Petroleum products, Machinery, Utilities). A closer look at the disaggregated results in Table 4 shows that the percentage errors in the gross domestic outputs go as high as 57.19% in 1990, large enough to cause alarm for partial equilibrium researchers treating these sectors in isolation. Moreover, errors in gross domestic outputs over the 1979–1990 period more than double pointing to an increasing degree of dependency, e.g. stronger forward linkages between agro and non-agro sectors.

To summarize, the results indicate that both the total linkages and sectoral gross domestic outputs are underestimated if agro and non-agro sectors are assumed not linked, with the extent of underestimation visibly increasing from 1979 to 1990. Thus, the analysis of the direction and magnitude of the change in the strength of linkages between agricultural and non-agricultural blocks over the 1980s leads to the conclusion that the structural reforms Turkey undertook during this decade induced an increased degree of integration and interdependence between primary agriculture and the rest of the economy. This often overlooked aspect of the consequences of the reforms of the 1980s has a wide range of policy implications. Given that the supply-side input-output model points to stronger and more diffused linkages than the demand-side model, one can conclude, for example, that more attention needs to be paid to the supply enhancing ability of agricultural sectors. In other words, an increase in the use of primary factors by these sectors will lead to a significant expansion in the outputs of other sectors that heavily use agricultural inputs.[8] Likewise, the implications of results should carefully be evaluated in the light of the fact that the Customs Union Agreement Turkey signed with the EU in 1996 does not cover agriculture. A particularly important question in this respect would be whether strengthening linkages of Turkish agriculture to non-agricultural sectors would facilitate or hinder the adjustment of the latter group of sectors to the EU. Similarly, the effects of this increased interdependence on trade and growth prospects of the country or sectors within each block need to be investigated.

Having pointed to a number of directions for future research hinted by the results presented above, we now focus on the implications of the current degree of integration between agriculture and other sectors for overall water consumption in Turkey. This is an important issue that has not yet been satisfactorily addressed in the literature and is taken up in the next section.

4. A GENERAL FRAMEWORK FOR ANALYZING OVERALL WATER CONSUMPTION IN TURKEY

As noted before, the growth of cultivated area in Turkey stopped prior to 1990 with the only sizable expansion after the 1950–1960 period coming through the fallow reduction program of the 1980s. The increased use of capital (e.g. tractors and harvesters) and material inputs also appears to have reached its limits following the intensification in the 1970s of agricultural mechanization and the increased use of imported inputs such as fertilizers in the 1980s. So, in the absence of a new "Green Revolution" or similar event to shift the agricultural production possibility frontier outwards significantly, the most feasible way for Turkey to achieve sizable gains in total agricultural output and yields is to speed up the efforts to enlarge its irrigation capacity.[9]

The major initiative Turkey undertook for this purpose was the launching of the Southeastern Anatolia Project (SAP), one of the largest irrigation and power generation projects in the world. SAP aims to put more than 50 billion cubic meters (that is roughly equal to 50 billion tons) of water carried annually by Euphrates and Tigris rivers into productive use primarily through the creation of new capacity for irrigation and hydropower generation (MFA, 1999).[10] While the allocation of the water carried by Euphrates and Tigris rivers between upstream Turkey and downstream countries (Iraq and Syria) is admittedly a controversial and politically sensitive issue, a discussion of this issue is beyond the scope of this paper.[11]

The SAP region covers the provinces of Batman, Diyarbakir, Gaziantep, Kilis, Mardin, Sanliurfa, Siirt and Sirnak, all in the economically lesser developed southeastern part of Turkey,[12] which borders Syria in the south and Iraq in the southeast. With an area of about 75,000 square kilometers, it makes up 9.7% of Turkey's total land mass, and a considerable part of Turkey's land stock suitable for irrigation lies in the SAP region encompassing vast plains in lower Euphrates and Tigris basins (MFA, 1999).

Once completed, the SAP is expected to open 1.7 million hectares (roughly 4.3 million acres) of land into irrigation that is mostly under rainfed cultivation currently. This area corresponds to about 20% of the total land stock that is economically worth irrigating, and to about half of the land actually irrigated in Turkey (MFA, 1999; Akder & Cakmak, 1998).

While Turkey's water resources are not as large as those of such major water-surplus countries as Australia, Brazil, Canada, Colombia or the U.S., it is relatively better endowed than other countries in the Middle East and North Africa region (see Table 5). Current surface water potential of Turkey is about 186 billion cubic meters a year including the waters of Euphrates and Tigris rivers (which constitute about 28.5% of this water potential). Coupled with the underground reserves of about 10 billion cubic meters, Turkey's per capita water resources slightly exceed 3,000 cubic meters, although this figure is expected to fall to about 2,000 cubic meters per capita by the year 2010, due to population growth. It should also be noted that since only about half of that water potential is readily available for consumption, Turkey may still face difficulties especially in years of severely reduced precipitation or draught (Bagis, 1994).

While the expanded irrigation capacity brought about by SAP would definitely help, SAP alone is unlikely to cause a major boom in agricultural exports. Recent estimates indicate that the completion of SAP will enable Turkey to maintain its net-exporter status and to avoid becoming a net-importer of agricultural produce but not to experience a burst of growth in farm exports. The projected growth in domestic demand due to an increasing population with ever-growing purchasing power for more nutritious food and better balanced diets is offered as the major reason underlying the low likelihood of SAP to generate an export boom (Akder & Cakmak, 1998).

Given that water is an essential input for the production of all agricultural products, food or non-food alike, however, increasing the land area to be irrigated would not only help Turkey remain self-sufficient in feeding a growing population but also maintain the volume of Turkey's primary food exports. At least as importantly, expansion of the area under irrigation would also help Turkey satisfy the input needs of its rapidly growing manufacturing sector, particularly the agro-based industries. As the production in these sectors requires inputs produced by primary agriculture, increased availability of water would mean the relaxation of a constraint (indirectly) affecting the outputs of these sectors as well. This implies that a complete evaluation of the potential water use in the country requires that consideration be given to the direct and indirect water requirements of Turkish economy as a whole. Once this is done, projections on the future growth prospects of individual sectors can be used to present more accurate estimates on the potential demand for water in Turkey.

In this paper, direct and indirect water requirements of the sectors in Turkish economy are calculated based on Turkish input-output data for 1990. This analysis makes it possible to rank sectors by total amounts of water used in their production. Then, the input-output framework is used again to compare the amounts of water exported in the form of an embodied input in merchandise exports of Turkey in 1979 and 1990. Results of the latter analysis allow for an observation of the direction and magnitude of the change in the indirect water exports of Turkish economy as it gradually moved from a predominantly

Table 5. Water Resources and Use in the Middle East and North Africa, 1996 and 1998.*

		Annual freshwater withdrawals				
Countries	Freshwater Resources (in m^3/capita)	Total (billion m^3)	As % of Total Resources	% Used for Agriculture	% Used for Industry	% Used for Domestic Consumption
Algeria	**483** (485)	**4.5** (4.5)	**32.4** (31.5)	60	15	25
Egypt	**47** (949)	**55.1** (55.1)	**1967.9** (94.5)	85	9	6
Israel	**299** (184)	**1.9** (1.7)	**108.8** (155.5)	79	5	16
Jordan	**158** (198)	**0.5** (1.0)	**66.2** (51.1)	75	3	22
Morocco	**1,110** (1,080)	**10.9** (11.1)	**36.2** (36.8)	92	3	5
S. Arabia	**124** (116)	**17.0** (17.0)	**709.2** (708.3)	90	1	9
Syria	**483** (2,926)	**14.4** (14.4)	**205.9** (32.2)	94	2	4
Tunisia	**385** (439)	**3.1** (2.8)	**87.2** (69)	89	3	9
Turkey	**3,126** (3,213)	**31.6** (35.5)	**16.1** (17.4)	72	11	16

* The figures in bold are the values for 1996 when freshwater resources were reported by considering the internal renewable water resources including river flows and groundwater from rainfall within the country but not flows of rivers from other countries. The figures in parentheses are the values for 1998 and refer to total renewable resources including river flows and groundwater from rainfall within the country and flows of rivers from other countries. Annual withdrawals refer to total water withdrawals excluding evaporation losses from storage basins, but may include water from desalination plants.
Source: World Bank (1999, pp. 206–207; 2001, pp. 290–291).

agricultural, inward-looking economy to an outward-looking industrial economy over the 1979–1990 period. The findings of this section could generate further discussion on the magnitude of potential demand for water in Turkey, and its implications for the countries of the Middle East and North Africa and regional trade patterns – see also Sayan (2000).

Identification and Ranking of Sectors by Water Use

Overall water use by major sectoral blocks of agriculture and industry (including the services), and "household industry" varies across countries depending upon the commodity composition and structure of the economy in question. For example, while only 3% of fresh water is consumed by agriculture in England, agriculture's share is as high as 59%, 62% and 63% in Italy, Spain and Greece, respectively. The ratio for Turkey is 72% with the remaining 28% shared by industry and services (11%) and households (16%) (World Bank, 1999).[13] By further decomposing the use of water by blocks, average water requirements by sectors can be calculated. Once these values are obtained, water transaction matrices, W^d and W^s, can be derived by pre- or post-multiplying the appropriate inverse matrix with the diagonal water requirement matrix for each of the demand-side or supply-side models. Mathematically, water transaction matrices for the demand and supply sides are respectively given by:

$$W^d = \text{diag} - \mathbf{W}.(\mathbf{I} - \mathbf{A})^{-1} \tag{4}$$

and

$$W^s = (\mathbf{I} - \ddot{\mathbf{A}})^{-1}\ \text{diag} - \mathbf{W} \tag{5}$$

where diag – **W** is a diagonalized $n \times n$ matrix showing average water requirements, with the j^{th} element showing the amount in cubic meters of fresh water directly required to produce one billion TL worth of output by sector j.

Given Eq. (4), the sum of all elements in column j of the water transaction matrix W^d would represent the amount of water directly and indirectly needed by all sectors supplying inputs to sector j for this sector to deliver a billion TL worth of output to final demand. Similarly, the sum of row i elements of the water transaction matrix W^s shows the amount of direct and indirect water consumption (by all sectors demanding inputs from sector i) induced by a billion TL worth of increase in the availability of primary factor inputs for the production in sector i.

The information on sectoral amounts of water needed for the construction of the diag – **W** matrix in Eqs (4) and (5) was gathered by drawing upon a large number of published and unpublished studies carried out at a variety of institutions, including the State Institute of Statistics (SIS), the General Directorate for Rural Services and the State Hydraulic Works Authority (SHWA). The Leontief inverse matrix for the demand-side was then calculated using a 32-sector version of the 1990 IO table so as to allow for a more disaggregated sectoral analysis than in Section 3. The demand-side results from Eq. (4) are presented in Table 6.

Table 6. Ranking of Production Sectors in Turkey in Terms of Water Requirements from the Demand Side.

Rank	Sectors	Total (Direct and Indirect) Water Use (billions of m^3)	Total Water Use per Billion TL Worth of Delivery to Final Demand (m^3)	Sectoral Total Use/ Direct Use Ratios
1	Crops	16.71	489	1.10
2	Livestock	3.74	192	13.94
3	Services	3.62	20	3.55
4	Other food processing	2.52	195	23.32
5	Construction	1.92	31	5.79
6	Textiles	1.25	90	30.40
7	Cereal processing	1.08	376	30.47
8	Tobacco processing	1.00	202	13.56
9	Utilities	0.88	298	1.09
10	Sugar	0.75	371	5.17
11	Shoes and apparel	0.75	61	20.34
12	Fruit and vegetable proc.	0.60	325	3.61
13	Machinery and vehicles	0.46	31	5.07
14	Vegetable and livestock oil	0.38	187	9.86
15	Ginning	0.37	403	28.56
16	Slaughtering	0.34	156	4.58
17	Fishery	0.24	100	1.17
18	Printing, etc.	0.19	80	3.43
19	Non-alcoholic drinks	0.17	203	1.75
20	Alcoholic drinks	0.16	95	2.88
21	Rubber and plastics	0.15	62	3.22
22	Furniture	0.13	87	1.87
23	Wood products	0.13	63	2.78
24	Chemicals	0.10	39	3.40
25	Leather and furs	0.08	154	1.97
26	Glass and cement	0.07	55	3.17
27	Steel and metal	0.07	47	7 74
28	Paper products	0.04	129	2.14
29	Forestry	0.01	26	1.16
30	Petroleum products	N	28	4.58
31	Fertilizers	N	125	1.66
32	Mining	N	43	1.52

Note: N: Negative because of large imports.

The fourth column of the table shows total (direct and indirect) cubic meters of water required per billion TL worth of output delivered to final demand by each of the 32 sectors ranked according to overall amount of water used by each sector (the third column). The overall amounts were obtained by multiplying the numbers in the fourth column by the value (in billions of TL) of final demand for each sector in 1990. The heavy users of water in descending order are crops, livestock, services, other food processing, construction, and textiles. Those that require the least water are forestry, paper, and steel and metal industries. It must be noted, however, that sectors differ widely in terms of their backward linkages. The crops sector, for example, ranks first in its total use of water but most of this is directly consumed by the sector itself. When one looks at the numbers in the last column showing total direct and indirect water use for each cubic meter of direct use, the crops sector's ratio of 1.1 implies that this sector requires a relatively small amount of water embodied in the inputs purchased from other sectors. So, the ratios listed in this column can be viewed as indicators of the degree of intensity with which a sector is linked backwardly (in terms of water requirements) to other sectors, thereby facilitating spotting the sectors that demand inputs whose production requires relatively large volumes of water. For example, textiles, with a ratio of 30.4, stands out as a sector that requires relatively heavy amounts of indirect water consumption. The other sectors that need to be watched if water is to be conserved are cereal products, ginning, other food processing, and shoes and apparel, all with total to direct water consumption ratios exceeding 20.0.

Turning to the supply-side, the rankings of sectors by their use of water were estimated by using the 32×32 output inverse matrix and sectoral water requirement coefficients as in Eq. (5). As shown in Table 7, the results differ considerably from those of the demand-side. The third column of the table shows total (direct and indirect) water consumption created by each billion TL worth of additional value added. While the crops sector dominates the list again, the followers this time are services, utilities, mining, petroleum products, and chemicals. The sectors ranking on top in the demand-side analysis are now generally close to the bottom. This is explained by the differing nature of linkages in backward and forward directions, and by the fact that the sectors that stand out as heavy users of water by the demand-side approach generally have a relatively small supply generation capacity in the forward sense. So, the sectors with the highest ratios of total to direct water consumption (the last column) are also the ones that are key input suppliers for the majority of other sectors in the economy. This implies that an increase in the productive capacity of these sectors would relax the input constraints for other sectors making it possible for them to produce larger amounts and hence, use higher amounts of water.

Table 7. Ranking of Production Sectors in Turkey in Terms of Water Requirements from the Supply Side.

Rank	Sectors	Total (Direct and Indirect) Water Use (billions of m^3)	Total Water Use per Billion TL Worth of Delivery to Final Demand (m^3)	Sectoral Total Use/ Direct Use Ratios
1	Crops	23.07	490	1.12
2	Services	5.10	27	4.64
3	Utilities	2.80	334	1.22
4	Mining	1.42	229	8.08
5	Petroleum products	1.04	89	14.39
6	Chemicals	0.62	100	8.72
7	Livestock	0.51	38	2.75
8	Fertilizers	0.39	749	9.89
9	Machinery and vehicles	0.31	27	4.42
10	Steel and metal	0.28	32	5.29
11	Forestry	0.22	77	3.46
12	Paper products	0.21	122	2.03
13	Fishery	0.18	88	1.03
14	Rubber and plastics	0.17	71	3.68
15	Glass and cement	0.16	28	1.62
16	Construction	0.16	6	1.11
17	Wood products	0.13	44	1.92
18	Textiles	0.09	10	3.48
19	Leather and furs	0.09	94	1.21
20	Non-alcoholic drinks	0.07	125	1.08
21	Other food processing	0.07	16	1.96
22	Alcoholic drinks	0.06	40	1.22
23	Fruit and vegetable proc.	0.06	100	1.11
24	Furniture	0.04	51	1.11
25	Tobacco processing	0.04	15	1.03
26	Vegetable and livestock oil	0.04	36	1.88
27	Slaughtering	0.04	53	1.56
28	Printing, etc.	0.04	33	1.40
29	Sugar	0.03	83	1.16
30	Cereal processing	0.02	22	1.78
31	Shoes and apparel	0.02	4	1.35
32	Ginning	0.01	23	1.63

Water Exports by Turkish Economy

Given that some of the sectors identified as top water users are also the leading export sectors of Turkish economy, one can conclude that Turkey already sends abroad considerable amounts of water embodied in its merchandise exports. This point can be illustrated by considering the textiles industry example. In the total output of textiles delivered in 1990, a total of about 1.25 billion cubic meters of water was embodied directly and indirectly. A rough estimation would indicate that one-third to half of that water must have been exported as an embodied input in the textiles exports. Therefore, heavily exporting sectors whose outputs require large amounts of direct and indirect water consumption may be viewed essentially as water exporters in disguise.[14] So, the structural transformation of Turkish agriculture following 1980 could be argued to have caused the amount of water exported by Turkish economy to increase, as the process leading to the increased outward orientation and higher volume of exports went together with strengthening linkages of agriculture to the rest of the economy. To test the validity of this reasoning, the water contents of Turkish exports in 1979 and 1990 have been calculated using Eq. (6).

$$\boldsymbol{E}^{W} = \text{diag} - \mathbf{W}.(\mathbf{I} - \mathbf{A})^{-1} E \tag{6}$$

where $\boldsymbol{E}^{W}$ is the water export vector and E is the export vector.

The results in Table 8 indicate that between 1979 and 1990, total amount of water contained in Turkish exports increased by about 153.2%. By comparison, total fresh water use in Turkey increased by only 25% (from 30.0 to 37.5 billion cubic meters) during the same period. This implies that the share of water going into the production of exported merchandise in total use of water increased exports significantly.[15]

The rate of increase in direct and indirect water contents of exports was 93.4% for primary agriculture, 130.3% for agro-processing, and an impressive 534.5% for non-agricultural exports. So, water sent abroad through primary agricultural exports grew in absolute value but at a slower rate than other sectors. This is an observation that is broadly consistent with the previously discussed changes in the relative position of sectors within Turkish economy, especially with respect to the value of primary agricultural exports. Given that a substantial part of water embodied in agro-processing exports came from primary agricultural inputs used in their production, the faster rate of increase in water contents of agro-processing exports than exports of primary agriculture itself is also a notable finding pointing to the increasing strength of linkages between primary agriculture and other sectors.

Table 8. Sectoral Composition of Water Exports by Turkey, 1979 and 1990.

Sectors	1979 Total (Direct and Indirect) Water Exports (millions of m^3)	1979 Totals by Blocks (millions of m^3)	1990 Total (Direct and Indirect) Water Exports (millions of m^3)	1990 Totals by Blocks (millions of m^3)
Crops	514.61		1,001.9	
Livestock	28.66	Primary	65.98	Primary
Forestry	0.43	Agriculture	0.68	Agriculture
Fishery	13.65		9.27	
		557.35		1,077.80
Slaughtering	9.05		40.63	
Fruit and vegetable proc.	161.64		479.04	
Vegetable and livestock oil	23.37		81.67	
Cereal processing	22.01		62.30	
Sugar	1.17		2.99	
Other food processing	284.70		432.67	
Alcoholic drinks	2.80		29.75	
Non-alcoholic drinks	0.09		19.79	
Tobacco processing	109.51		22.97	
Ginning	225.18		123.97	
Textiles	101.50		534.25	
Shoes and apparel	18.45		299.40	
Leather and furs	0.38		61.37	
Wood products	0.45	Agro-	4.16	Agro-
Furniture	0.13	Processing	5.26	Processing
Paper products	2.89		15.52	
Printing, etc.	0.29		3.93	
		963.63		2,219.67
Mining	23.62		21.95	
Fertilizers	0.00		20.61	
Chemicals	5.64		55.60	
Petroleum products	0.64		21.64	
Rubber and plastics	0.42		16.95	
Glass and cement	11.74		42.90	
Construction	3.16	Non-agricultural	11.43	Non-agricultural
Steel and metal	10.30	Sectors	175.12	Sectors
Machinery and vehicles	7.04		56.82	
Utilities	12.76		34.16	
		145.23		921.51
Services	69.90		464.33	
TOTAL	1,666.21		4,218.21	

5. CONCLUSIONS

Three major conclusions can be drawn from the foregoing discussion in this paper. The first conclusion concerns the changing role of primary agriculture within the national economy during the 1980s and 1990s. The structural reforms of the 1980s aimed at transforming the predominantly agricultural, inward-looking economy of Turkey into an outward-looking and competitive industrial economy. During this transformation process, relative contributions of primary agriculture to national output and exports diminished considerably, and this was followed by a decline, though to a lesser extent, in the sector's share in civilian employment. While losing its position as the leading producer/employer and exporter within the national economy, the sector assumed a new role. It ceased to be a sector that primarily serves final demand. Instead, it became a major supplier of inputs to the rapidly growing agro-processing sector, which in turn has become a leading exporter.

The second conclusion concerns future demand for water in the Turkish economy. Demand will continue to increase as a result of the growing population and income, thus increasing both the direct consumption of water by households, and the indirect consumption through the demand for food (processed and primary). What is perhaps less obvious is that population and income growth are equally likely to increase the demand for non-food products some of which require substantial amounts of water to produce.[16] Furthermore, the rate of growth of total (direct and indirect) water consumption should be expected to increase as the agricultural complex becomes better integrated with the non-agricultural economy. Our results suggest that the Turkish agriculture as a whole is now linked more strongly to the rest of the economy and the process seems to be continuing. In the absence of major technical improvements to increase the efficiency in the use of water by non-agricultural sectors, one may expect a declining share for primary agriculture and an increasing share for industry as compared to the current composition of water use among sectors. In fact, this view is supported by the differing rates of growth of water use by sectors over the 1979–1990 period as calculated in Section 4.[17]

The final conclusion of the study relates to the structural transformation of the Turkish economy in the 1980s. This transformation led to significant increases in the water content in Turkish exports from 1979 to 1990. The end of inward-looking, import substitution-based development policies could be argued to have cleared the way for this country to export the commodities in which it has a comparative advantage. Our results appear to provide supporting evidence for this view as they reveal significant increases in both the total amount of water embodied in Turkish exports and the share of exports in total water consumption. To be more precise, total amounts of water contained in Turkish exports increased by about 153.2% between 1979 and 1990 – from 1.666 billion cubic meters in 1979 to 4.219 billion cubic meters in 1990 (Table 8). The first amount corresponded to about 5.56% of total water consumption in 1979 whereas the latter represented about 11.25% of 37.5 billion cubic meters of water consumed in Turkey that year. Our estimates based on the share of the Middle East as a destination for sectoral exports point to the same pattern. The amount of water sold to this region by Turkey increased from 345 million cubic meters (or about 1.15% of total water consumption) in 1979 to 850 million cubic meters (about 2.27% of total water consumption). These numbers imply that Turkey already exports significant amounts of water to its trade partners in the form of agricultural and industrial merchandise. Moreover, even if the projected pipelines through which Turkey wants to export water directly to the countries in the Middle East do not become a reality (Bagis, 1994), hundreds of millions of tons of water embodied in Turkish exports are being sent to the Middle Eastern countries, enabling Turkey to share its water resources with its regional neighbors.

It can be argued in conclusion that in regions such as the Middle East where water is relatively scarce, and politically sensitive, free trade provides a means to peacefully share regional water resources. For relatively water-scarce countries in the region, imports of merchandise produced by sectors heavily using water could help alleviate some of the pressures created by water shortages, if these countries could identify and act according to their comparative advantages on the basis of water endowments. In that case, welfare gains would be likely for all parties involved.

NOTES

1. A more detailed, technical description can be found in Sayan and Demir (1998).
2. For sectors $i, j \in \{1, 2, \ldots, k, k+1, \ldots, n\}$, the IO coefficient a_{ij} shows the amount of commodity i required to produce one unit of commodity j (both measured in domestic currency terms). In other words, for X_{ij} representing the value of purchases by sector j from sector i and X_j representing the value of output produced by sector j, $a_{ij} = X_{ij}/X_j$.
3. Since a_{ij}'s and hence, the elements of $(\mathbf{I} - \mathbf{A}.)^{-1}$ are fixed, $dX = (\mathbf{I} - \mathbf{A}.)^{-1}.dF$.
4. When partitioned into agricultural and non-agricultural blocks, **A** would look like

$$A^{n \times n} = \left[\begin{array}{c|c} A_{AA}^{k \times k} & A_{AN}^{k \times (n-k)} \\ \hline A_{NA}^{(n-k) \times k} & A_{NN}^{(n-k) \times (n-k)} \end{array}\right]$$

where A_{AA} is a $k \times k$ matrix of IO coefficients representing flows within the agricultural complex/ block, A_{NN} is an $(n - k) \times (n - k)$ matrix showing the IO coefficients for flows within the non-agricultural block, and rectangular matrices A_{NA} and A_{AN} represent the delivery of inputs from non-agro to agro sectors, and from agro to non-agro sectors, respectively. Then $(\mathbf{I} - \mathbf{A})$ would be of the form

$$(\mathbf{I} - \mathbf{A})^{n \times n} = \left[\begin{array}{c:c} D_{AA}^{k\times k} & D_{AN}^{k\times(n-k)} \\ \hdashline D_{NA}^{(n-k)\times k} & D_{NN}^{(n-k)\times(n-k)} \end{array}\right]$$

where the diagonal elements of matrices D_{AA} and D_{NN} are of the form $(1 - a_{ij})$, with $-a_{ij}$'s elsewhere. Now, the counterfactual assumption that changes in the final demands for non-agro (agro) sectors have no impact on agro (non-agro) sectors can be simulated by setting all a_{ij}'s in D_{AN} (D_{NA}) equal to zero so that $D_{AN} = \mathbf{O}$ ($D_{NA} = \mathbf{O}$), i.e. the null matrix. With the a_{ij}'s set equal to 0 for all $i \in \{1, 2, \ldots, k\}$ and $j \in \{k + 1, k + 2, \ldots, n\}$ and *vice versa*, the experiment seeks an answer to what the gross domestic outputs and total backward linkages would have been, had there been no IO linkages across different blocks.

5. Note that total differentiation of Eq. (3) yields $\mathrm{d}\boldsymbol{X}' = \mathrm{d}VA'.(\mathbf{I} - \ddot{\mathbf{A}})^{-1}$ implying that the row total of the i^{th} shows the rise (fall) in total supply by all sectors, in response to a unit increase (decrease) in primary factor use by sector *i*.

6. The IO coefficients used here are based on total flows covering both domestically produced and imported products. While there are alternative views concerning this treatment (Miller & Blair, 1985), the unavailability of import matrices for 1979 made this choice necessary. Moreover, a test comparing multipliers under total vs. domestic flows for 1990 did not yield significant differences.

7. Coupled with the reduction in mean percentage deviations in gross domestic outputs of non-agro sectors (from 15.38% in 1979 to 11.12%) in 1990 under the same assumption, the results seem to indicate that the relative importance for non-agricultural sectors of input purchases by agro sectors did not grow at the same rate as that for the agro complex of input demands by non-agro sectors.

8. Stronger and more diffused nature of the supply-side linkages is essentially a legacy of the development strategy of the decades prior to the 1980s when import substitution policies pushed for the creation and protection of basic intermediate good industries such as iron and steel.

9. The State Hydraulic Works Authority (SHWA) sources estimate that the value added on one hectare of irrigated land is about 2.5 times that on a hectare of non-irrigated land.

10. 27 billion kWh of electricity will be generated annually, with an installed capacity over 7,500 MW following the completion of SAP.

11. For this issue and various other aspects of the use of water in the Middle East, the readers may see the relevant papers in Bagis (1994).

12. Carried out under the coordination of the SHWA, the project envisages the construction of 22 dams and 19 hydroelectric power plants on the Euphrates and Tigris rivers and their branches. As one of the most ambitious regional development projects ever launched in the world, however, the SAP goes beyond power generation and irrigation. It also aims to develop the infrastructure necessary for improvements in the existing communications and transportation networks and in the quality of health

services, education, tourism etc., as well as for new residential and industrial development. As such it is more of an integrated regional development project than simply an investment to expand capacity for power generation and water use in agriculture.

13. In our calculations in the next sub-section, we use a slightly different but more precise estimate of the sectoral composition of water use. By this, 76.5% of water is used by agriculture (as estimated based on irrigation requirements and crop pattern data), with the rest either being used by industry with a share of 10.4% or going to household consumption (13.1%).

14. This argument reminds one of the Leontief Paradox (Leontief, 1954).

15. Although non-agricultural sectors recorded the fastest increase, the share of non-agricultural exports in total water use remained the lowest in 1990 as in 1979.

16. The sectors that heavily use so-called industrial crops could be used to illustrate this point. Even the production of footwear, which seemingly has little to do with water, may require significant amounts of water indirectly – with hides coming from cows that feed on hay and grass.

17. Alternatively, such a change in the sectoral composition of water use may result from an increase in the efficiency of water use in agriculture but this efficiency is not likely to increase in a marked way any time soon, since the water used for irrigation appears to be underpriced in Turkey. Currently, farmers who use SHWA's infrastructure are charged a price based on the accounting cost of repair and maintenance of the irrigation system per unit of irrigated area. The amount charged is clearly lower than the economic cost, with the difference acting as an input subsidy to farmers.

REFERENCES

Akder, H. (1998). Agricultural mechanization and labor in Turkey. In: T. Bulutay (Ed.), *Agricultural Structure and Employment in Turkey* (pp. 381–402). Ankara: SIS.

Akder, H., & Cakmak, E. (1998). Implications of international agreements and GAP for labor in agriculture. In: T. Bulutay (Ed.), *Agricultural Structure and Employment in Turkey* (pp. 295–318). Ankara: SIS.

Bagis, A. I. (Ed.) (1994). *Water as an Element of Cooperation and Development in the Middle East*. Ankara: Hacettepe University and Friedrich Naumann Foundation.

Bon, R., & Bing, X. (1993). Comparative stability analysis of demand-side and supply-side input-output models in the U.K. *Applied Economics*, *25*, 75–79.

Bulutay, T. (1998). General introduction. In: T. Bulutay (Ed.), *Agricultural Structure and Employment in Turkey* (pp. X–LI). Ankara: SIS.

Ghosh, A. (1958). Input-output approach to an allocative system. *Economica*, *25*, 58–64.

Gurkan, A. A., & Kasnakoglu, H. (1991). The political economics of agricultural price support in Turkey: An empirical assessment. *Public Choice*, *70*, 277–298.

Kotan, Z., & Sayan, S. (2002). A comparative investigation of the price competitiveness of Turkish and South East Asian exports in the European Union Market: 1990–1997. *Emerging Markets Finance and Trade*, *38*, 57–83.

Leontief, W. (1936). Quantitative input-output relations in the economic system of the United States. *Review of Economics and Statistics*, *18*, 105–125.

Leontief, W. (1954). Domestic production and foreign trade: The American capital position reexamined. *Economia Internazionale 7* [Reprinted in American Economic Association, 1968. Readings in International Economics. Richard D. Irwin, Homewood.]

MFA (1999). Republic of Turkey Ministry of Foreign Affairs World Wide Web Site at http://www.mfa.gov.tr/grupd/dc/dcd/gap.htm

Miller, R. E., & Blair, P. D. (1985). *Input-Output Analysis: Foundations and Extensions*. Englewood Cliffs:Prentice Hall.

Muthoo, M. K., & Onul, T. (1996). *Agriculture in Turkey*. Ankara: FAO.

Sayan, S. (2000). Could free trade lead to a more efficient use of scarce water resources in the MENA region?: An innovative application of the Heckscher-Ohlin framework. Paper presented at the Seventh Annual Conference of the ERF, Amman, Jordan, October 26–29. (This paper is available at http://www.erf.org.eg/html/trade10.pdf).

Sayan, S., & Demir, N. (1998). Measuring the degree of block interdependence between agricultural and non-agricultural sectors in Turkey. *Applied Economics Letters*, *5*, 329–332.

SPO (1997). *Economic and Social Indicators: 1950–1998*. State Planning Organization, Ankara.

United Nations (1997). *World Population Prospects: The 1996 Revision*. New York: UN.

World Bank (2001). *World Development Report 2000/2001*. New York: The World Bank.

World Bank (1999). *World Development Report 1998/1999*. New York: The World Bank.

Yildirim, T., Furtan, W. H., & Guzel, A. (1998). A theoretical analysis of wheat policy in Turkey. In: T. Yildirim, A. Schmitz & W. H. Furtan (Eds), *World Agricultural Trade* (1999, pp. 113–128). Boulder: Westview Press.

APPENDIX

Table A1. Sector Coverage of the Input-Output Model.

10-Sector Model	Activities Included by Sector*
Agro Sectors	
1. Primary agriculture	1. Crops
	2. Livestock
	3. Forestry
	4. Fishery
2. Agricultural processing (Food)	11. Slaughtering
	12. Fruit and vegetable processing
	13. Vegetable and livestock oil
	14. Cereal processing
	15. Sugar
	16. Other food processing
	17. Alcoholic drinks
	18. Non-alcoholic drinks
3. Agricultural processing (Non-food)	19. Tobacco processing
	20. Ginning
	21. Textiles
	22, 24. Shoes and apparel
	23. Leather and furs
	25. Wood products
	26. Furniture
	27, 28. Paper products, printing, etc.
Non-Agro Sectors	
4. Mining	5–10. Various mining sectors
5. Chemicals	29. Fertilizers
	30–31. Medicines and chemicals
	32–33. All petroleum products
	34–35. Rubber and plastic products
6. Construction and other manufacturing	36–38. Glass and cement
	49,52. Construction
	53. and other manufacturing
7. Metal products	39–41. Steel and metal products
8. Machinery	42–48. All machinery and vehicles
9. Utilities	50–51. Electricity, gas and water
10. Services	54–64. All services

* According to the SIS classification.

This article has been cited by:

1. I. Durusoy, M. F. Turker, S. Keleş, K. Kaygusuz. 2011. Sustainable Agriculture and the Production of Biomass for Energy Use. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects* **33**:10, 938-947. [CrossRef]
2. Kamil Kaygusuz. 2010. Sustainable energy, environmental and agricultural policies in Turkey. *Energy Conversion and Management* **51**:5, 1075-1084. [CrossRef]