An Assessment of Sustainable Agriculture in the OECD Countries with Special Reference to Turkey

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Jel classification: O13, O52, Q01, Q56

Abstract

The purpose of this paper is to measure and assess, in a comparative way, the efficiency of the Turkish agricultural sector with the OECD countries in the context of sustainability for the 1990-2005 periods. An empirical method is used to make the comparison, and hence, data envelopment analysis (DEA) is applied for 23 OECD countries including Turkey. The study shows that a limited number of OECD countries like Belgium, Denmark, the Netherlands and Slovakia succeeded in making agricultural production efficiently from 1990 to 2005. Therefore, it can be proposed that the production structures of these countries are environment friendly thus allowing sustainability in their agricultural sectors with respect to other OECD countries. However, the picture does not seem so optimistic for Japan, Poland and Turkey since their efficiency performance decelerated recently. Therefore, in order to reach agricultural sustainability, Japan, Poland and Turkey should improve the efficiency level of their production process. Moreover, Turkey can be ranked within the worst performers among the 23 OECD countries in the context of sustainable agriculture. What is more alarming is the deterioration in the efficiency performance of the country from 1995 onwards. To reverse the ongoing trend, Turkey should radically change the current structure of its agricultural production. In this context, the heavy use of both labour and machinery should be reduced to minimum. Alternatively, the country may concentrate on the supply side of the economy without ignoring further declines in the greenhouse gas emissions.

Key words: Sustainable development, Sustainable agriculture, Food security, Pollution, Data envelopment analysis, Turkish economy

Résumé

L'objectif de ce travail est de mesurer et évaluer, d'une manière comparative, l'efficience du secteur agricole en Turquie par rapport aux autres pays de l'OCDE, sur le plan de la durabilité, pour la période 1990-2005. Une méthode empirique a été utilisée pour réaliser cette comparaison et de ce fait, on a appliqué une analyse de l'enveloppement des données (DEA) à 23 pays de l'OCDE, y compris la Turquie. L'étude a confirmé l'efficience de la production agricole de 1990 à 2005 pour un certain nombre de pays de l'OCDE à savoir, la Belgique, le Danemark, les Pays-Bas et la Slovaquie. En effet, les structures de production de ces pays sont respectueuses de l'environnement et cela permet d'assurer une agriculture durable. Toutefois, la situation ne semble pas être si favorable au Japon, en Pologne et en Turquie vu la décélération enregistrée récemment en terme d'efficience. Afin d'atteindre un niveau durable de leur production agricole, le Japon, la Pologne et la Turquie devraient améliorer le niveau d'efficience de leur processus de production. En plus, sur le plan de durabilité agricole, la Turquie peut être classée parmi les pays les moins performants dans l'ensemble des 23 pays de l'OCDE. Ce qui est alarmant en Turquie est la réduction de l'efficience dans le pays à partir de 1995. Pour inverser cette tendance, la Turquie devrait changer radicalement la structure de sa production agricole. A cette fin, il serait nécessaire de minimiser l'emploi de la main-d'œuvre et des machines qui est aujourd'hui très important. Par ailleurs, le pays pourrait se concentrer sur le côté de la demande sans pour autant ignorer la réduction des émissions de gaz à effet de serre.

Mots-clés: *Développement durable, agriculture durable, Sécurité alimentaire, Pollution, Analyse de l'enveloppement des données, Economie turque*

1. Introduction

Even though the efforts to investigate "sustainable development" by the path breaking book "*Our Common Future*" provides a generic framework for that concept (UN, 1987), to measure and assess sustainability, more operational definitions and related indicators might be presented. The same problem could further be encountered with the measuring of sustainable agriculture. In this respect, the structure of investigations, scale and time dimensions together with the choice of indicators necessitate attentive evaluations (Becker, 1997; Dale and Beyeler, 2001; McSorley and Porazinska, 2001; Raman, 2006; vanLoon *et al*., 2005; Yunlong and Smith, 1994; Zhen and Routray, 2003; Zinck *et al*., 2002).

The chief feature of sustainable development is to guarantee the efficient use of existing resources without ignoring the needs of the future generations. Hence, efficiency in the use of the current resources seems to be vital for sustainability. Alike, sustainable agriculture emphasizes long-term endurance of efficiency in the factors of production from environmental, economic and social perspectives and concentrates on the supply of nutritional needs of the mankind (Hansen 1996; Rao and Rogers, 2006). Additionally, sustainable agriculture focuses on the best channels of preserving the environment and natural resources. In other words, stewardship of the natural habitat is as much crucial as the production and profitability in the frame of sustainable agriculture (Smith and McDonald, 1998). Moreover, sustainable agriculture declines the dependency of the production process on the inputs destructive for the environment, and therefore, agriculture-based environmental pollution is reduced to minimum (De Koeijer *et al*., 2002; Gomes *et al*., 2008).

An economy can be both efficient and sustainable; but efficiency does not directly lead to sustainability (Bishop, 1993). However, efficiency can be considered as a precondition for sustainability. According to De Koeijer *et al*. (2002), the efficient use of pollution-creating inputs should be concerned with to reach sustainability. In other words, sustainability is argued as a necessary but not sufficient condition to ensure sustainability. Furthermore, De

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Koeijer *et al.* (2002) observed a positive correlation between technical and sustainable efficiency. Nevertheless, in order to reach sustainability in an agricultural system, all the resources necessary for production should not only be used in the most efficient way, but output per input should be maximized as well. Moreover, agricultural efficiency might be attained through rationing outputs to inputs (van-Loon *et al.*, 2005).

In the light of the above considerations, sustainability relations between inputs and outputs can be categorized depending on the Table 1 below.

Table 1 - *Probability of Sustainability According to the Trends in Input-Output Systems.*

	Inputs		
Outputs	**Diminishing**	**Constant**	**Increasing**
Diminishing	Indeterminate	Unsustainable	Unsustainable
Constant	Sustainable	Sustainable	Unsustainable
Increasing	Sustainable	Sustainable	Indeterminate

Sources: Monteith (1990).

According to Table 1, if inputs and outputs are moving in the same direction through time, system becomes indeterminate, and therefore direct inferences about sustainability could not be proposed. On the other hand, if outputs are constant and increasing while inputs are kept constant or diminishing, the system will be definitely sustainable. Controversially, if the inputs are constant and outputs diminishing, system will no longer be sustainable. Similarly, if the inputs are rising together with diminishing and constant outputs, the system turns out to be unsustainable.

In the current study, sustainability of the OECD countries' agricultural sector is evaluated based on the efficiency principles. While the inputs are constant, the rise in the outputs such as food security and agricultural production together with the decline of the greenhouse gas emissions originating from the agricultural production which have adverse effects on the environment provide valuable information in order to assess the determination of the sustainable agricultural systems of the countries under investigation.

Nonetheless, real facts exhibit alarming signals with respect to environmental pollution. In the last few decades, agriculture has largely been affected by the rapid technological improvements, and therefore, the use of labour saving technology in agricultural production boosted productivity. Consequently, cultivation of land and livestock witnessed drastic changes via the influence of modern techniques leading to unprecedented rises in agricultural production. Such rapid agricultural transformations, however, conduced to serious environmental damages especially in the developed countries. Table 2 can be considered as a summary document of environmental destruction originated from the agricultural activities in the case of the OECD countries.

As Table 2 indicates, in the period 1990-92 to 2002-04, the highest increase in total GHG emissions was realized in Turkey with 43 per cent. In countries like Spain, Portugal, Greece, Ireland and Canada, GHG emissions were also raised and attained unacceptably high levels. As for the GHG originated from the agricultural activities, the highest increase is observed in Mexico with 43 per cent in the turn of the new millennium. Among the other OECD countries, high increases in agricultural GHG emissions occurred in Spain, Canada and New Zealand during the 1990-92 to 2002-04 period. Although Turkey experienced the highest increase in total GHG emissions, it succeeded in decreasing agricultural GHG emissions by 21 per cent in the same period. Similarly, Czech Republic, Slovak Republic and Hungary achieved significant reductions in their agricultural GHG emissions with 4%3, 41% and 35%, respectively.

On the other hand, the share of agriculture in total national GHG emissions is the highest in New Zealand with 49 per cent. Ireland, Australia and France follow in this respect. The main reason for New Zealand to have such high share of agriculture in total GHG emissions can be related to large number of livestock and relatively high share of agricultural production in GDP (OECD, 2008).

Most importantly, excluding Mexico and Korea, United States has the lion's share in agricultural GHG emissions among the OECD countries. US are solely responsible for 39 per cent of total OECD countries' emission of agricultural GHG into the atmosphere. Meanwhile, the contribution of EU 15 countries is around 35 per cent in this context.

In the light of the above concerns, the main aim of this paper is to measure and evaluate, in a comparative way, the efficiency of the Turkish agricultural sector with the OECD countries in the context of sustainability for the 1990-2005 periods. An empirical method is employed to make the comparison, and hence, data envelopment analysis (DEA) is used for 23 OECD countries including Turkey.

The organization of the paper is as follows: the next section focuses on the quantitative method and the data set used in the current study. The third section presents the main findings of DEA. Section four is devoted to some policy recommendations depending on the empirical findings. As usual, the final section concludes with the main remarks.

2. The Model and Data Set

In this section, the methodology and the model are briefly presented together with the data set used in the study.

2.1. The Method and Model

The empirical model used in this study is DEA. The origin of DEA studies goes back to Farrell's famous work. After pointing out the major weaknesses of the contemporary methods attempting to measure efficiency, Farrell (1957) tried to find a new method through including all the inputs in the computational process and arrived to obtain satisfactory measure of productivity efficiency (Cooper *et al.*, 2004). DEA approach, however, was constructed more

Table 2 - *Agricoltural Gross Greenhouse Gas Emission of the OECD Countries.*

	Average		Change in Agricultural GHG Emissions[1]		Change in Total GHG Emissions	Share of Agriculture in National Total GHG Emissions	Share in Total OECD Agriculture GHG Emissions	Kyoto Reduction Commitment
	"000" tones CO_2 Equivalent		"000" tones CO_2 Equivalent	%	%	%	%	%
Country	1990-92	2002-04	1990-92 to 2002-04		1990-92 to 2002-04	2002-04	2002-04	2008-2012
Spain	39,737	47,003	7,625	18	41	11	4	+15
Canada	44,781	52,823	8,043	18	23	7	5	-6
New Zealand	32,322	36,990	4,668	14	19	49	3	0
Portugal	7,909	8,400	490	6	36	10	1	+27
Australia	90,707	96,081	5,374	6	22	18	8	+8
Poland	27,114	28,099	985	4	-21	7	2	-6
United States	440,855	445,661	4,806	1	14	6	39	-7
Ireland	19,376	19,059	-316	-2	24	28	2	+13
Norway	4,468	4,321	-147	-3	10	8	0	+1
Sweden	9,223	8,659	-564	-6	-3	12	1	+4
Luxembourg	486	458	-28	-6	-9	4	0	-28
Italy	41,520	38,591	-2,929	-7	12	7	3	-6.5
France	105,794	97,625	-8,169	-8	-3	17	9	0
Switzerland	6,640	6,037	-603	-9	-3	12	1	-8
Greece	13,309	12,005	-1,304	-10	26	9	1	+25
Belgium	12,874	11,641	1,233	-10	-1	8	1	-7.5
Iceland	554	497	-57	-10	6	15	0	+10
Germany	72,572	64,556	-8,066	-11	-14	6	6	-21
Austria	9,079	8,004	-1,074	-12	15	9	1	-13
United Kingdom	52,808	45,896	-6,912	-13	-11	7	4	-12.5
Finland	6,654	5,732	-922	-14	12	7	1	0
Japan	32,287	27,676	-4,611	-14	10	2	2	-6
Netherlands	22,391	18,291	-4.100	-18	0	8	2	-6
Turkey	18,930	15,000	-3,930	-21	43	6	1	..
Denmark	12,846	10,096	-2,750	-21	-3	14	1	-21
Hungary[2]	16,447	10,665	-5,782	-35	-32	13	1	-6
Czech Rep.	13,718	8,060	-5,658	-41	-18	6	1	-8
Slovak Rep.	6,943	4,004	-2,939	-42	-22	8	0	-8
Korea[3]	4,798	4,527	-271	-6	5	3	..	..
Mexico[4]	38,863	55,674	16,811	43	..	8	..	..

1. Gross GHG emissions from agriculture include emissions of CH_4, N_2O and CO_2 (fossil fuel combustion only), but exclude CO_2 emissions from soils and agriculture land use change.
2. Data for the period 1990-92 refer to 1990. Change for Hungary is -35%.
3. Data for the period 1990-92 and 200-2002 refer to the year 1990 and average 1999-2001.
4. Data for the period 1990-92 and 2000-2002 refer to the year 1990 and 1998.
Source: OECD (2008).

than two decades later by the seminal works of Charnes, Cooper and Rhodes (Charnes *et al.*, 1979, 1978). Consequently, DEA approach has been widely used to evaluate the performance of various decision making units in different fields of study. Although DEA method has been largely employed in various fields of economics, its use remained limited to environmental economics. In recent years, however, several studies attempting to assess environmental sustainability of agricultural production activities preferred to use DEA methods[1]. As mentioned before, the current paper targeting to evaluate relative efficiency of Turkish and OECD countries agricultural sectors in the context of agricultural sustainability also endeavours to use DEA method.

One of the principal aims of sustainable agriculture is to minimize the use of non- renewable resources and environmental degradation while preserving the current stages of productivity and profitability (Abay *et al.*, 2004). Therefore, to determine efficiency level of input use in agriculture becomes crucial with respect to sustainability. From this perspective, the use of pollution creating inputs like fertilizer and undesirable output like greenhouse gas emissions that lead global warming are included in the model to represent environmental effects of agricultural production. Furthermore, labour, land and machinery are used as significant input variables to resolve efficiency level of agricultural productivity. In this study, depending on the cross section data for 1990, 1995, 2000 and 2005, DEA is performed. The rationale of using DEA method is to determine efficient and inefficient decision making units (DMU), and hence, to predict necessary changes of inefficient DMU to reach efficient ones. CCR model which is one of the basic models of DEA and proposed by Charnes Cooper and Rhodes in 1978 is used for this purpose.

At this stage, it would be better to present analytic structure of the CCR model. The mathematical statement to maximize output/input ratio for n DMU which have m input and s output item is presented as follows:

$$\max h_k = \frac{\sum_{r=1}^{s} u_{rk} Y_{rk}}{\sum_{i=1}^{m} v_{ik} X_{ik}} \qquad (1)$$

In this statement while the parameter of $X_{ij}>0$ indicates i input quantity used by j decision-unit, the parameter of $Y_{rj}>0$ shows r output quantity used by j decision-unit. The variables for this decision problem are the weights of k decision units for i inputs and r outputs. The weights are presented as v_{ik} and u_{rk} respectively.

Furthermore, the below statement provides the constraint of not exceeding 100 per cent efficiency level for other decision units when they use the same weights of k decision units.

$$\frac{\sum_{r=1}^{s} u_{rk} Y_{rj}}{\sum_{i=1}^{m} v_{ik} X_{ij}} \le 1 \ ; \quad j=1,\ldots,n.$$

Finally, the constraint which prevents negative sign for the weights of inputs and outputs used in the study is presented as follows:

$$u_{rk} \ge 0 \ ; \qquad r=1,\ldots,s$$

$$v_{ik} \ge 0 \ ; \qquad i=1,\ldots,m$$

From this point onwards, it is sufficient to transform the above set of inequalities into a linear programming to reach a solution in the form of simplex or similar algorithms and to make it a constraint through equalizing the denominator of the maximization function to 1. CCR model specification formed as a result of such transformation is presented below:

$$\max h_k = \sum_{r=1}^{s} u_{rk} Y_{rk} \qquad (2)$$

s.t.:

$$\sum_{j=1}^{n} \lambda_{kj} Y_{rj} \ge Y_{rk} \ ; \qquad r=1,\ldots,s$$

$$-\sum_{j=1}^{n} \lambda_{kj} X_{ij} + q_k X_{ik} \ge 0 \ ; \qquad i=1,\ldots,m$$

$$\lambda_{kj} \ge 0 \ ; \qquad j=1,\ldots,n$$

$$-\infty \le q_k \le +\infty$$

For n item decision unit, the above model should be solved n times with their own parameters. In addition, the dual CCR model which especially helps the determination of efficient reference sets is shown in the following way:

$$\text{Min } w_k = q_k \qquad (3)$$

s.t.:

$$\sum_{j=1}^{n} \lambda_{kj} Y_{rj} \ge Y_{rk} \ ; \qquad r=1,\ldots,s$$

$$-\sum_{j=1}^{n} \lambda_{kj} X_{ij} + q_k X_{ik} \ge 0 \ ; \qquad i=1,\ldots,m$$

$$\lambda_{kj} \ge 0 \ ; \qquad j=1,\ldots,n$$

$$-\infty \le q_k \le +\infty$$

In this model λ dual variable is used to determine efficient reference sets. In the primal model of k decision units, all λ_{kj} dual variables having positive values correspond to efficient decision units. The set formed from these decision units is called as the "reference set" of the k decision unit. In general, if k is efficient, then it will be the only decision unit in the reference set, and the value of λ_{kk} dual variable will be equal to 1.0. The reference set for inefficient decision units will provide an answer to the question of how many outputs should be increased (or inputs should be reduced) to attain efficiency level (Ulucan, 2000).

[1] The works of Abay et al. (2004), De Koeijer et al. (2002), Ehrmann (2008), Gomes et al. (2008), Kim (2001), Lilienfield and Asmild (2007), Piot-Lepetit et al. (1997), Zhou et al. (2008), Zhou et al. (2007) can be cited among others.

2.2. The Data Set

The present paper uses two main categories of variables, namely input and output variables. In determining the variables, sustainability perspective is taken into account. For a system to be sustainable, it should at least be efficient, and furthermore, outputs should be increased while inputs are diminishing or constant.

The current study also depends on the efficiency analysis; and hence, variables are chosen to reflect agricultural sustainability. For example, the amount of fertilizer used for agricultural purposes taken as input variable in the model generates adverse effects on the environment. Therefore, a system producing more agricultural output using a lower amount of fertilizer will be more sustainable. Furthermore, greenhouse gas emissions are chosen as output variable to monitor environmental effects originating from agricultural production. Last but not least, there is a close association between food security and sustainability. A system which produces less environmental pollution alongside with ensuring the necessary calorie requirements of the society will undoubtedly be more sustainable.

2.2.1. Output Variables

1. Value of agricultural production: Agricultural production volume is expressed in 1999-2001 international dollars ('000000').

2. Food Security[2]: Food security is commonly defined as economic, social and physically easy and permanent access to sufficient, secure and nutritious food for human beings in order to maintain healthy life and perform quotidian activities (FAO, 2005).

To achieve food security variable, various steps are pursued. Firstly, it should be noted that the data set is mainly arranged focusing on the agricultural production sufficiency of the countries. At the first stage, population data according to sex and age distribution for all the countries are obtained from EUROSTAT and United Nations Population Division. Secondly, in order to remove age distribution differentials among the countries, population data is aggregated by using adult equivalent scale[3]. After the aggregation procedure, total equivalent population is attained. Consequently, by using average daily calorie requirements for men and women, the need for one day calorie requirement of the total population is computed for all the countries. Afterwards, each country's average annual calorie requirement is obtained. The distribution of the basket of foods necessary for per capita daily calorie requirement is presented in the Appendix (Table 6).

Unfortunately, the data for certain foods namely rice, olive and liquid oil are not available for the majority of the countries included in the quantitative analysis. Therefore, these foods are eliminated from the basket. The amount of calorie requirement for the eliminated foods is redistributed for the remaining foods in the basket. Calorie redistributed new basket of foods is presented in the Appendix (Table 7).

Relying on the quantity of calories in Table 7, new basket of foods is established according to annual calorie requirement of the total adult equivalent population. Evidently, necessary amount of food materials providing the annual calorie requirement of the constructed basket of foods are procured. Consequently, the amount of food materials is transformed to raw material commodities using by technical transformation values (DİE 2003). As for raw material commodity, bread, flour and dough are transformed to bovine wheat, white cheese and yoghurt to milk, sugar to sugar beet and sugar cane and jam to cherries, plums, sloes and strawberries. Table 8 is constructed to present the sufficiency level in the calorie requirement of every OECD country in each raw material commodity. In the Table 8 located at the Appendix, positive signs indicate that production quantity is sufficient for the necessary calorie requirement. On the contrary, negative signs state that production level fails to meet necessary calorie requirement. For certain commodities, production level is insufficient to satisfy necessary calorie requirement for benchmark years specified in the table with the last two numbers of the particular year of the analysis period (1990-2005).

Turning back to the calculation procedure of the food security, minimum production quantities providing necessary annual calorie requirement of the total population are achieved for all the countries. Afterwards, current production amounts at the commodity level rationed to minimum production quantities necessary for the calorie requirement[4]. The values obtained for each commodity are aggregated once again depending on the weighted average of their quantity of calories. Table 3 is constructed to show how many times are the countries have the production level above their minimum calorie requirement[5].

Basing on the values presented in Table 3, Australia produces more than 15 times above the minimum production level necessary to provide annual calorie requirement of its population in 2005. Denmark and Canada also have higher values with respect to food security and succeeded to produce more than 10 times above the minimum level necessary to provide yearly calorie requirement of their population within the two recent decades. On the other hand, the lowest value among the 23 OECD countries belongs to Japan. Japan could not even meet necessary annual calorie requirement of Japanese people throughout the analysis period. Also, Portugal started to face with some difficulties in

[2] The method of calculating food security is similar to the method used by Mollavelioğlu et al. (2010).

[3] While age of 18 years and above is multiplied by 1.0, 0-6 age interval is multiplied by 0.2, 7-12 by 0.3 and 13-18 by 0.5 depending on the Deaton and Muellbauer's (1986) method.

[4] Current production amounts for the commodities are obtained from the Food Balance Sheets of FAO.

[5] Due to data problems, only 23 OECD countries could be included into the empirical analysis. The commodity values are unavailable for Iceland, Korea, Luxembourg, New Zealand, Norvay and Switzerland. On the other hand, Mexico is excluded from the analysis because CO2 values could not be obtained.

Table 3 - *Food Security.*

COUNTRIES	1990	1995	2000	2005
Australia	11.79	12.94	13.06	15.39
Austria	3.65	3.34	3.44	3.49
Belgium	3.37	3.75	4.01	3.68
Canada	12.17	9.94	10.84	10.03
Czech Republic	5.20	5.00	4.96	4.71
Denmark	11.01	11.21	10.89	10.83
Finland	2.99	2.30	2.50	2.86
France	8.43	7.48	8.11	7.62
Germany	3.53	3.40	4.00	3.87
Greece	4.13	4.31	4.19	3.66
Hungary	8.25	5.95	4.89	5.81
Ireland	6.09	5.97	5.88	5.40
Italy	3.19	3.06	3.13	2.98
Japan	0.81	0.72	0.66	0.64
Netherlands	4.52	4.41	4.43	4.10
Poland	7.03	5.55	5.31	4.22
Portugal	2.08	2.04	1.94	1.51
Slovakia	4.82	4.95	3.29	3.63
Spain	3.68	2.88	4.02	3.08
Sweden	3.90	2.90	3.75	3.47
Turkey	6.58	6.30	5.52	5.25
UK	3.51	3.43	3.73	3.34
USA	4.44	3.85	3.82	3.40

meeting calorie requirements of its population in the last decade. In the meantime, Turkey has the actual production level of approximately 5 times above the minimum calorie requirement. Even though this value is higher than OECD countries' average, it shows regular decline since the beginning of the analysis period.

3. Greenhouse Gas Emission: In this work, greenhouse gas emission is used in the model as "undesirable output". The concentration of the greenhouse gas emissions in the atmosphere is commonly studied as one of the most important factors in global warming and climate change. Greenhouse gases are especially significant for agriculture because agricultural production is at the same time one of the sources of the emissions and functions as absorptive as well. The most crucial component of the greenhouse gases is undoubtedly carbon dioxide (CO_2) emissions. More than 80 per cent of the greenhouse gas emissions are composed of CO_2. However, agriculture only generates 5 per cent of total CO_2 emissions. Meanwhile, being another important source of greenhouse gas, methane (CH_4) constitutes 10 per cent of the total emissions. Nevertheless, agriculture based CH_4 gas emissions forms 40 per cent of the total methane emissions. The share of nitrogen oxide (N_2O) in total greenhouse gas emissions is less than 10 per cent. Eventually, agricultural sector produces almost 60 per cent of the total N_2O emissions (OECD, 2001: 279). Even if non-agricultural sectors like industry and transportation play a paramount role in the formation of greenhouse gas emissions, the contribution of agricultural sector should not be dismissed at all. Additionally, absorptive feature of the agricultural sector should also be concerned in the struggle to overcome greenhouse gas emission problem (OECD, 2001).

In the present study, following OECD's approach, total gross agricultural emission values of CO_2, CH_4 and N_2O is calculated as "*CO_2 equivalent*". The equivalent CO_2 value of the three agricultural greenhouse gas depicted in metric tons is computed using with the following formula (OECD, 2001):

$$E_{CO2eq} = 1 \times E_{CO2} + 21x\, E_{CH4} + 310 \times E_{N2O}$$

In the above formula, E_{CO2eq} represents CO_2 equivalent of total gross agricultural emissions. E_{CO2} is the total gross agricultural emission of the CO_2. E_{CH4} and E_{N2O} are for total gross agricultural emissions of CH_4 and N_2O respectively.

2.2.2. Input Variables

1. Land: This variable embraces both arable land and permanent crops. In the current study, the variable of land is measured as hectares ('000').

2. Machinery: Number of agricultural tractors in use ('000').

3. Fertilizer: This input variable covers the sum of nitrogen, phosphate and potash fertilizers used for agricultural purposes. It is measured as '000' metric tons. Data is taken from the International Fertilizer Industry Association (IFA) database.

4. Labour: The variable comprehends economically active population in agriculture ('000').

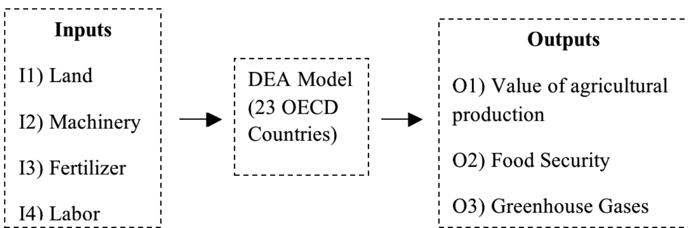
Descriptive statistical information about the variables is summarized in Table 4.

Table 4 - *Descriptive Statistical Information on the Variables.*

Variable	Unit	1990		1995		2000		2005	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Value of agricultural production	1999-2001 international dollars ('000000')	18830.59	29774.30	18239.97	30736.12	19883.29	35115.19	20118.88	36662.71
Food Security	Weighted Ratio	5.44	3.06	5.03	2.97	5.06	2.99	4.91	3.28
Greenhouse Gas Emission	'000' Ton	46830.87	78291.90	45843.80	81906.98	45921.75	81905.29	45001.73	84017.54
Land	'000' Hectare	18919.09	39456.18	18221.78	38566.41	18172.00	37616.87	17976.43	37173.74
Labour	'000' Number	1625.43	2436.22	1426.91	2285.96	1250.57	2069.75	1111.17	1931.42
Machinery	'000' Number	771.34	1008.85	733.04	971.43	736.12	995.61	740.33	995.59
Fertilizer	'000' Ton	2146.62	3892.69	2058.14	4084.48	1965.06	3824.74	1888.45	3911.30

3. Empirical Findings

The model takes into consideration food security as representative for "sustainable agriculture" and greenhouse gas emissions for "undesirable output". As a natural outcome of agricultural activities, value of agricultural production is added as a last output variable. Meanwhile, land is included in the model as uncontrollable input variable. The structure of the model can be described as "output-oriented CCR model". In modelling undesirable output, observation values are rearranged as "(maximum value +1)-observed value" following the arrangement made by Zhou (2003:107).



Efficiency values of DEA for the whole period under investigation are presented in Table 5. The *DEA-Solver* program is used for the computations. The values of 1.000 in Table 5 indicate efficient situation. On the other hand, the values below 1.000 represent inefficient situations. Furthermore, projection results for the final year of the analysis period (2005) are presented in Table 9 and evaluated in the following section of the paper.

Table 5 - *Efficiency Values for OECD Countries.*

COUNTRIES	1990	1995	2000	2005
Australia	**1.0000**	**1.0000**	0.8893	0.8981
Austria	0.8132	0.8698	0.9688	**1.0000**
Belgium	**1.0000**	**1.0000**	**1.0000**	**1.0000**
Canada	0.9014	0.8394	0.8847	0.9454
Czech Republic	0.8114	0.7580	0.6675	0.6522
Denmark	**1.0000**	**1.0000**	**1.0000**	**1.0000**
Finland	0.9331	1.000	0.8432	0.9405
France	0.6555	0.6134	0.6787	0.7258
Germany	0.5899	0.5378	0.5791	0.6485
Greece	0.4628	0.7296	0.6870	0.7360
Hungary	**1.0000**	0.9101	0.6893	0.7163
Ireland	0.7382	0.6597	0.5992	0.5230
Italy	0.7169	0.7083	0.6110	0.7422
Japan	0.5169	0.5325	0.4452	0.4375
Netherlands	**1.0000**	**1.0000**	**1.0000**	**1.0000**
Poland	0.7254	0.5825	0.4393	0.3154
Portugal	0.6334	0.7579	0.8429	**1.0000**
Slovakia	**1.0000**	**1.0000**	**1.0000**	**1.0000**
Spain	0.5875	0.4557	0.4740	0.4793
Sweden	0.8396	0.7985	0.8702	0.9742
Turkey	0.6225	0.6870	0.5246	0.4810
UK	0.7111	0.6404	0.5942	0.5999
USA	0.9826	0.8459	0.8776	0.9278
Average	0.7931	0.7794	0.7463	0.7714

According to the efficiency scores obtained from the output-oriented CRR model, Belgium, Denmark, Netherlands and Slovakia appear as the most efficient countries among 23 OECD countries. Furthermore, some countries seem to be only efficient for certain benchmark year of the analysis period. In this context, Australia was efficient for 1990 and 1995 but lost its efficiency for the consecutive years. Similarly, although Hungary achieved to be an efficient country in the start of the analysis period (1990), the efficiency disappeared for the recent periods. The opposite trend can be observed for Austria and Portugal. These two countries arrived to be efficient at the final phase of the analysis. Moreover, the countries like Japan, Poland and Turkey showed their worst performance in the ultimate year of the analysis period.

Average efficiency value for all the OECD countries was 0.7931 in 1990. This score gradually declined in 1995 and 2000; it showed slight rise at the end of the analysis period. The average efficiency value in 2005, however, remained below that of 1990. This rather pessimist long-run trend should be reversed. Furthermore, the same trend also indicates that there is still some room to improve the efficiency level of the countries.

4. Policy Recommendations

This section concentrates on the policy implications basing on the empirical findings of the current study. In doing so, the emphasis is given to the last year projection of the countries for performing efficiently while considering the slacks. To improve the efficiency level of the countries, reduction ratios of the inputs or the rising rates of the outputs while keeping inputs constant are calculated and presented in Table 9[6]. Depending on the main findings obtained from Table 5 and Table 9, the following policy recommendations can be proposed for the OECD countries:

1) Australia should either decline to great extent the use of fertilizers or increase agricultural production level while decreasing greenhouse gas emissions. The rationale of this suggestion is related with the fact that the country has the potential to raise the current level of production with its existing resources.
2) Canada should either decline the use of machinery and fertilizer at a rate of 32.53 per cent or largely reduce

[6] For the details of the projection results, see Table 9 in the Appendix. In Table 9, the "*data*" represents real values of the variables used in the current study. The "*projection*" values show the values necessary for a country to reach the highest efficiency level. The "*difference*" refers to the gap between real and projection values. Among the variables, greenhouse gas emissions are tranformed since they are considered as "undesirable output". The transformation is made as "(maximum value +1)-observed value". In this way, the value of the country having the highest greenhouse gas emission is assumed as 1, and therefore, the country having the smallest greenhouse gas emission is introduced into the empirical analysis as the biggest value. In doing so, rising values of the greenhouse gas emission variable which is represented as "undesirable output" is interpreted as the declining values.

greenhouse gas emissions together with rising agricultural production level while taking input use as constant.

3) For Czech Republic, the use of labour and machinery seems to be efficient; hence there are no slacks in this respect. Nevertheless, the inefficiency in this case originates from the heavy use of fertilizers in the production process. Therefore, in order to be efficient, the country should diminish the use of fertilizer at a rate of 18.94 per cent. Alternatively, Czech Republic might increase agricultural production and decline seriously greenhouse gas emissions.
4) Controversially, the inefficiency in the case of Finland can be attributed to the excessive use of machinery in the production process. In order to show an efficient performance, the country should either decline the use of machinery at 54.48 per cent or elevate agricultural production whereas declining greenhouse gas emissions at a rate of 6.33 per cent.
5) The inefficiency of France rooted from the excessive use of fertilizer and machinery. To improve efficiency performance, the country should reduce the use of machinery 14.25 per cent and that of fertilizer 9.68 per cent respectively. In an alternative manner, France might greatly diminish emissions and rise agricultural production to attain efficiency.
6) The current position of Germany with respect to efficiency resembles to that of France. Germany should choose between declining the use of fertilizer (1.13 per cent) and reducing greenhouse gas emissions together with raising the level of production while keeping the use of fertilizer as constant.
7) The inefficiency of Greece originates from the heavy use of labour in the production process. Efficiency performance can be ameliorated either from reducing the use of labour at a rate of 51.45 per cent, or decreasing greenhouse gas emissions from 35.86 per cent and elevating production again by the same proportion collectively.
8) Comparing to other countries, efficiency position of Hungary seems to be slightly complex. In order to develop its efficiency performance, the country should decline the use of fertilizer at a rate of 18.80 per cent. Alternatively the country may improve the efficiency both by declining greenhouse gas emissions by 82.79 per cent and increase the value of food security together with the value of agricultural production at a rate of 39.61 per cent.
9) For Ireland, the efficiency problem is closely related with declining the use of fertilizer by 3.32 per cent or gas emissions by 91.20 per cent together with raising the value of food security and agricultural production 91.20 and 132.17 per cent respectively. On the other hand, Italy should tremendously decrease the use of machinery in the production process or to improve the value of food security; she could raise agricultural output whereas diminishing emissions. In either of the above ways, the country could attain efficiency level higher than the existing one.
10) The efficiency performance of Japan merits special concern since the country is one of the worst country in the sample. Additionally, the country exhibits the sole example of not meeting minimum annual calorie requirement of its total population among the 23 OECD countries (See Table 3). Under these circumstances, efficiency performance of the country might be improved either through decreasing the use of machinery (71.86 per cent) and labour (55.49 per cent) or boosting food security, and largely reducing undesirable output - greenhouse gas emissions-without changing the level of current inputs.
11) Poland displays similar efficiency problems with Japan. In fact, the efficiency performance of the country is the worst among the OECD countries. Alike Japan, Poland should decline heavy use of machinery and labour. Alternatively, the country should improve food security, and therefore, increase the value of its agricultural production while radically decline greenhouse gas emissions. The same trends seem to be valid for Spain. The only prominent difference can be associated with the fact that Spain does not need to reduce its labour use.
12) As for Sweden, the country should either enhance agricultural production by nearly 30 per cent or decline the use of machinery by 57.80 per cent in the production process to advance its efficiency level.

To become more efficient, UK should decrease the use of fertilizers by 21.10 per cent or promote agricultural production together with food security while diminishing emissions.

13) The inefficiency of USA production mainly originates from the excessive use of machinery and fertilizer at rates of 11.47 and 34.93 per cent respectively. Therefore, the attempt to reduce the mentioned inputs with cited ratios will eventually lead to advancement in the efficiency performance of the country. The country may also prefer to largely decline greenhouse gas emissions or increase the value of food security rather than restricting input use.
14) From the input side, the inefficiency of Turkey mainly depends on the excessive use of labour and machinery in the production process. Therefore, the efficiency of the country might be ameliorated via decreasing labour by 84.27 per cent and machinery by 14.62 per cent. When the attention is turned to the output side, it can be alternatively intimated that the efficiency performance could be upgraded through tremendously declining greenhouse gas emissions and heavily increasing agricultural production, and hence, securing the sufficiency of the food production.

5. Conclusion

At first glance, one should mention that the data on food security provides valuable information for assessing sustainability of the agriculture sector. According to the findings of the present study, Australia produces approximately 15 times above the minimum production level necessary to provide annual calorie requirement of its population in 2005. Denmark and Canada also performed well in this context and achieved to produce more than 10 times above the minimum level necessary to provide calorie requirement of their population. Controversially, Japan could not even be able to fulfil necessary calorie needs of Japanese people during the whole analysis period. Meanwhile, Turkey attained a production level 5 times higher than the minimum calorie requirement of its population. Nevertheless, gradual and secular decline in Turkey's food security values should be closely concerned for the welfare of the next generations.

When the focus of analysis shifts on the findings of DEA, it can be inferred that limited number of OECD countries like Belgium, Denmark, Netherlands and Slovakia succeeded to make agricultural production efficiently from 1990 to 2005. Therefore, it can be proposed that the production structure of these countries are environment friendly, and thus allow sustainability in their agricultural sectors relative to other OECD countries. Additionally, Australia, Austria, Hungary and Portugal arrived at efficient production performance for particular benchmark years. It can be suggested that these OECD countries showed advancement on the path towards sustainable agriculture.

However, the picture does not seem so optimistic for Japan, Poland and Turkey since their efficiency performance decelerated recently. Moreover, efficiency performance of these countries remained far below the average values of the OECD countries during the analysis period. Therefore, in order to reach agricultural sustainability, Japan, Poland and Turkey should improve the efficiency level of their production process. Even though acceleration is observed in its efficiency performance from the turn of the new millennium, Spain also needs to ameliorate sustainability of its agricultural sector.

According to the findings of the present study, Turkey can be ranked within the worst performers among the 23 OECD countries in the context of sustainable agriculture. What is more alarming is the deterioration in the efficiency performance of the country from 1995 onwards. To reverse the ongoing trend, Turkey should radically change the current structure of its agricultural production. In this context, the heavy use of both labour and machinery should be reduced to minimum. Under the threat of raising unemployment originated from the recent global economic crisis, however, diminishing agricultural labour does not seem an easy arrangement for Turkey. Alternatively, the country may concentrate on the supply side of the economy and attempt to raise its agricultural production without ignoring further declines in the greenhouse gas emissions.

In fact, as Table 2 indicates, Turkey successfully achieved to reduce agriculture-based greenhouse gas emissions in the last two decades. If the same trends could be maintained in combination with the acceleration in the production sphere, efficiency performance of the country might be improved. Under these circumstances, sufficiency of the food production could further be developed. Therefore, it can be argued that to overcome efficiency problems of Turkish agricultural production, output-oriented solutions appear to be more rational than the input-oriented ones.

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APPENDIX

Table 6 - *Basket of Foods Necessary for Daily Calorie Requirement of an Adult.*

Name of the Food	Quantity (in Gram)	Quantity of Calorie
Bread	350	1 000
Flour	60	210
Dough	60	210
Rice	60	211
Meat	120	300
Liquid Oil	30	270
White Cheese	30	70
Egg	50	70
Yoghurt	350	210
Dry Pulses	50	180
Onion	50	20
Potatoes	150	115
Fresh Fruit	300	150
Fresh Vegetables	250	125
Sugar	60	240
Olive	20	29
Jam	30	90
TOTAL	2 020	3 500

Source: Baysal (1991: 147).

Table 7 - *Calorie Redistributed New Basket of Foods.*

Name of the Food	Quantity (in Gram)	Quantity of Calorie
Bread	358	1 036
Flour	68	246
Dough	68	246
Meat	128	336
White Cheese	38	106
Egg	58	106
Yoghurt	358	246
Pulses	58	216
Onion	58	56
Potatoes	158	151
Fruit	308	186
Vegetables	258	161
Sugar	68	276
Jam	38	126
TOTAL	2 020	3 500

Table 8 - *Sufficiency Level of the OECD Countries in the Annual Calorie Requirement.*

Countries	Wheat	Bovine Meat	Milk	Egg	Pulses	Onion	Potatoes	Fruit	Vegetable	Sugar Beet & Sugar Cane	Cherries, Plums and Sloes, Strawberries
Australia	+	+	+	+	+	+	+	+	+	+	+
Austria	+	+	+	+	+	+	+	+	+	+	+
Belgium	+	+	+	+	-	-	+	+	+	+	+
Canada	+	+	+	+	+	-(90,05)	+	-(90;00;05)	+	-	-
Czech Republic	+	-(00;05)	+	+	+	+	+	+	+	+	+
Denmark	+	+	+	+	+	-(90;00)	+	-	+	+	-(00;05)
Finland	+	+	+	+	-	-		-		-(95;00;05)	-(95)
France	+	+	+	+	+	-(90,95)	+	+	+	+	+
Germany	+	+	+	+	-(90;95;05)	-	+	+	+	+	+
Greece	+	-	+	+	-	+	+	+	+	-(05)	+
Hungary	+	-	+	+	-(00;05)	+	+	+	+	-(00)	+
Ireland	+	+	+	+	-(90;00;05)	-	+	-	+	+	-(95;00;05)
Italy	+	+	+	+	-	+	+	+	+	-(90;95;00)	+
Japan	-	-	-	-	-	+	+	-(00;05)	+	-	+
Netherlands	+	+	+	+	-(95;00;05)	+	+	+	+	+	+
Poland	+	-(95;00;05)	+	+	+	+	+	+	+	+	+
Portugal	-	-	+	+	-	+	+	+	+	-	+
Slovakia	+	-(95;00;05)	+	+	+	+	+	+	+	-(00)	-(05)
Spain	+	+	+	+	-(95)	+	+	+	+	-	+
Sweden	+	+	+	+	-(95)	-	+	-	+	+	-
Turkey	+	-	+	+	+	+	+	+	+	+	+
UK	+	-(00)	+	+	+	-(90;95)	+	-	+	-	-
USA	+	+	+	+	+	+	+	+	+	-(90;95;00)	+

Tab. 9 - *Projection Results for the Year 2005*.

	I/O	Data	Projection	Difference	%
1	Australia	1.1135			
	Machinery	315000.00	315000.00	0.00	0.00%
	Fertilizer	2215.10	801.23	-1413.87	-63.83%
	Labor	446.00	446.00	0.00	0.00%
	Agricultural Prod.	16897590.00	18814700.50	1917110.50	11.35%
	Food Security	15.39	17.13	1.75	11.35%
	Converted CO_2	321254234.78	998278417.13	677024182.35	210.74%
2	Austria	1.0000			
	Machinery	331528.00	331528.00	0.00	0.00%
	Fertilizer	180.90	180.90	0.00	0.00%
	Labor	171.00	171.00	0.00	0.00%
	Agricultural Prod.	3640685.00	3640685.00	0.00	0.00%
	Food Security	3.49	3.49	0.00	0.00%
	Converted CO_2	402977456.24	402977456.24	0.00	0.00%
3	Belgium	1.0000			
	Machinery	95010.00	95010.00	0.00	0.00%
	Fertilizer	301.00	301.00	0.00	0.00%
	Labor	68.00	68.00	0.00	0.00%
	Agricultural Prod.	4693802.00	4693802.00	0.00	0.00%
	Food Security	3.68	3.68	0.00	0.00%
	Converted CO_2	400889489.93	400889489.93	0.00	0.00%
4	Canada	1.0578			
	Machinery	733050.00	494610.88	-238439.12	-32.53%
	Fertilizer	2326.00	1566.97	-759.03	-32.63%
	Labor	354.00	354.00	0.00	0.00%
	Agricultural Prod.	23100910.00	24435381.00	1334471.00	5.78%
	Food Security	10.03	19.14	9.12	90.90%
	Converted CO_2	349243014.31	2086983521.12	1737740506.81	497.57%
5	Czech Republic	1.5334			
	Machinery	87039.00	87039.00	0.00	0.00%
	Fertilizer	383.80	311.12	-72.68	-18.94%
	Labor	371.00	371.00	0.00	0.00%
	Agricultural Prod.	3701839.00	5676235.55	1974396.55	53.34%
	Food Security	4.71	7.23	2.51	53.34%
	Converted CO_2	403060909.36	705232998.18	302172088.82	74.97%
6	Denmark	1.0000			
	Machinery	113402.00	113402.00	0.00	0.00%
	Fertilizer	305.00	305.00	0.00	0.00%
	Labor	90.00	90.00	0.00	0.00%
	Agricultural Prod.	5513338.00	5513338.00	0.00	0.00%
	Food Security	10.83	10.83	0.00	0.00%
	Converted CO_2	400896392.64	400896392.64	0.00	0.00%
7	Finland	1.0633			
	Machinery	175232.00	79758.19	-95473.81	-54.48%
	Fertilizer	270.00	270.00	0.00	0.00%
	Labor	117.00	117.00	0.00	0.00%
	Agricultural Prod.	1888589.00	4078225.04	2189636.04	115.94%
	Food Security	2.86	3.92	1.06	37.20%
	Converted CO_2	405222774.20	430862940.16	25640165.96	6.33%
8	France	1.3779			
	Machinery	1176425.00	1008782.65	-167642.35	-14.25%
	Fertilizer	3538.60	3195.91	-342.69	-9.68%
	Labor	722.00	722.00	0.00	0.00%
	Agricultural Prod.	36169630.00	49837133.00	13667503.00	37.79%
	Food Security	7.62	39.05	31.43	412.69%
	Converted CO_2	313235223.59	4256503113.70	3943267890.11	999.90%

9	Germany	1.5419			
	Machinery	833200.00	833200.00	0.00	0.00%
	Fertilizer	2485.90	2457.91	-27.99	-1.13%
	Labor	820.00	820.00	0.00	0.00%
	Agricultural Prod.	29285100.00	45155595.10	15870495.10	54.19%
	Food Security	3.87	29.77	25.90	668.91%
	Converted CO_2	358024587.24	3156162872.30	2798138285.06	781.55%
10	Greece	1.3586			
	Machinery	259766.00	259766.00	0.00	0.00%
	Fertilizer	370.00	370.00	0.00	0.00%
	Labor	723.00	351.02	-371.98	-51.45%
	Agricultural Prod.	6862724.00	9324015.22	2461291.22	35.86%
	Food Security	3.66	4.97	1.31	35.86%
	Converted CO_2	399193115.99	542362287.77	143169171.78	35.86%
11	Hungary	1.3961			
	Machinery	120479.00	120479.00	0.00	0.00%
	Fertilizer	466.90	379.13	-87.77	-18.80%
	Labor	384.00	384.00	0.00	0.00%
	Agricultural Prod.	5536952.00	7730209.85	2193257.85	39.61%
	Food Security	5.81	8.11	2.30	39.61%
	Converted CO_2	401427272.92	733786236.84	332358963.92	82.79%
12	Ireland	1.9120			
	Machinery	174800.00	174800.00	0.00	0.00%
	Fertilizer	555.10	536.66	-18.44	-3.32%
	Labor	161.00	161.00	0.00	0.00%
	Agricultural Prod.	3732342.00	8665355.14	4933013.14	132.17%
	Food Security	5.40	10.32	4.92	91.20%
	Converted CO_2	392157887.44	749788492.71	357630605.26	91.20%
13	Italy	1.3474			
	Machinery	1860000.00	531031.03	-1328968.97	-71.45%
	Fertilizer	1278.00	1278.00	0.00	0.00%
	Labor	1025.00	877.71	-147.29	-14.37%
	Agricultural Prod.	26063090.00	35118334.60	9055244.60	34.74%
	Food Security	2.98	15.05	12.06	404.19%
	Converted CO_2	373583818.83	1440845671.79	1067261852.96	285.68%
14	Japan	2.2855			
	Machinery	1910724.00	537762.41	-1372961.59	-71.86%
	Fertilizer	1294.20	1294.20	0.00	0.00%
	Labor	1997.00	888.83	-1108.17	-55.49%
	Agricultural Prod.	15560370.00	35563496.59	20003126.59	128.55%
	Food Security	0.64	15.24	14.60	999.90%
	Converted CO_2	383993687.99	1459109912.70	1075116224.71	279.98%
15	Netherlands	1.0000			
	Machinery	144600.00	144600.00	0.00	0.00%
	Fertilizer	348.00	348.00	0.00	0.00%
	Labor	239.00	239.00	0.00	0.00%
	Agricultural Prod.	9562739.00	9562739.00	0.00	0.00%
	Food Security	4.10	4.10	0.00	0.00%
	Converted CO_2	392342952.88	392342952.88	0.00	0.00%
16	Poland	3.1709			
	Machinery	1437183.00	765798.28	-671384.72	-46.72%
	Fertilizer	1843.00	1843.00	0.00	0.00%
	Labor	3366.00	1265.74	-2100.26	-62.40%
	Agricultural Prod.	15971280.00	50644045.91	34672765.91	217.09%
	Food Security	4.22	21.70	17.48	413.83%
	Converted CO_2	377877951.20	2077839259.09	1699961307.89	449.87%

17	Portugal	1.0000			
	Machinery	176394.00	176394.00	0.00	0.00%
	Fertilizer	166.00	166.00	0.00	0.00%
	Labor	602.00	602.00	0.00	0.00%
	Agricultural Prod.	3185973.00	3185973.00	0.00	0.00%
	Food Security	1.51	1.51	0.00	0.00%
	Converted CO_2	402762234.08	402762234.08	0.00	0.00%
18	Slovakia	1.0000			
	Machinery	21837.00	21837.00	0.00	0.00%
	Fertilizer	127.10	127.10	0.00	0.00%
	Labor	216.00	216.00	0.00	0.00%
	Agricultural Prod.	1540024.00	1540024.00	0.00	0.00%
	Food Security	3.63	3.63	0.00	0.00%
	Converted CO_2	407590614.19	407590614.19	0.00	0.00%
19	Spain	2.0863			
	Machinery	980808.00	744485.21	-236322.79	-24.09%
	Fertilizer	1803.40	1803.40	0.00	0.00%
	Labor	1195.00	1195.00	0.00	0.00%
	Agricultural Prod.	23251970.00	48510662.33	25258692.33	108.63%
	Food Security	3.08	23.87	20.79	674.19%
	Converted CO_2	365947425.85	2053979678.19	1688032252.33	461.28%
20	Sweden	1.0265			
	Machinery	159590.00	67345.09	-92244.91	-57.80%
	Fertilizer	237.00	237.00	0.00	0.00%
	Labor	130.00	130.00	0.00	0.00%
	Agricultural Prod.	2705250.00	3515350.09	810100.09	29.95%
	Food Security	3.47	3.74	0.27	7.78%
	Converted CO_2	402272714.59	412939625.95	10666911.36	2.65%
21	Turkey	2.0791			
	Machinery	1006196.00	859123.45	-147072.55	-14.62%
	Fertilizer	2067.60	2067.60	0.00	0.00%
	Labor	9028.00	1419.99	-7608.01	-84.27%
	Agricultural Prod.	27326810.00	56815859.64	29489049.64	107.91%
	Food Security	5.25	24.34	19.09	363.80%
	Converted CO_2	395002118.04	2331058302.82	1936056184.78	490.14%
22	UK	1.6670			
	Machinery	444500.00	444500.00	0.00	0.00%
	Fertilizer	1598.50	1261.25	-337.25	-21.10%
	Labor	499.00	499.00	0.00	0.00%
	Agricultural Prod.	15110240.00	25188472.25	10078232.25	66.70%
	Food Security	3.34	15.20	11.86	354.51%
	Converted CO_2	364991992.15	1584856005.88	1219864013.74	334.22%
23	USA	1.0778			
	Machinery	4470905.00	3958284.26	-512620.74	-11.47%
	Fertilizer	19273.30	12540.19	-6733.11	-34.93%
	Labor	2833.00	2833.00	0.00	0.00%
	Agricultural Prod.	181432900.00	195552074.50	14119174.50	7.78%
	Food Security	3.40	153.21	149.81	999.90%
	Converted CO_2	1.00	16701763602.65	16701763601.65	999.90%