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# RESOURCE USE EFFICIENCY OF ORGANIC WHEAT PRODUCTION IN TURKEY

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***Abstract***

*Intensive cropping techniques, over-mechanized agricultural production, inefficient agricultural chemical use have negatively affected world valuable cropland, which is very important to the mankind. About 38% of Earth's land cover is occupied by agriculture. If unsustainable agricultural methods are pursued, they contribute to inefficient resource use. Organic farming is a good alternative in order to provide sustainability and efficient resource use. Yet, its production is not robust enough to play a significant role in feeding the world. Globally, 1.9 billion adults are overweight and, of those, 600 million are obese, while 793 million people are undernourished. Organic agriculture is discussed if it is the most appropriate option for sustainable agriculture. The current paper seeks to find organic wheat production and its positive impacts to the Turkish economy. In Turkey, there is no organic wheat production yet. We revealed the economic benefits when organic wheat production is partially preferred by examining the resource use efficiency. In other words, the nature of organic farming and conventional farming, what those methods demand from nature and restore to the environment, and their unit economic values constitute the subject of this study.*

***Key words***: *economic efficiency, organic wheat, Turkey*

## INTRODUCTION

The many issues related to agriculture, food, nutrition and human health bring complicated questions and discussions to the world agenda. Some of these discussions include matters such as the pressures on human resources, sustainable natural resource management and sustainable agriculture. Therefore, each unit of land allocated to any sector and, each unit of production input to be employed has become important nowadays. Sustainable agriculture is the focus of all these discussions. Such an agricultural system is a suitable model for both developing and developed countries dominated by industrial agriculture because sustainable agriculture is a concept that takes into account methods of sustainable land use and processing. The consumption of natural resources and the level of use of non-nature-friendly production inputs concern policy-makers and social planners. The consumption of natural resources and / or environmental pollution are topics that directly and indirectly affect the costs of agricultural production in the national economy. For this reason, a large number of studies are conducted which examine the situations in which the environment is involved in production inputs. Numerous investigations are of interest not only to developed countries but also to less developed countries. Indeed, the cost of environmental disasters (yield losses, product damage, etc.) is reflected in the cost to government and is shared by all households. However, household income distribution is not equal. Therefore, the cost of environmental problems imposes more significant costs to low-income individuals.

The current paper examines organic wheat production and its positive impacts to the Turkish economy. At present, there is no organic wheat production in Turkey. The paper seeks to find the optimal cultivated land requirement which should be allocated to organic wheat production. It contributes to the available literature by measuring the environmental and social effects by using the proxy values of regular wheat production in the country.

## MTERIALS AND METHODS

In this study, it is accepted that the farmers of the country maximize their revenues with their production decisions. They make their decisions in a single production direction. However, the externalities created by the conventional agricultural system have not been internalized yet. This model tells us the allocation requirement of a certain part of the land of the country to organic production due to sustainable agriculture. In fact, social planner thinks that a mixture agriculture system including conventional / organic production will ensure sustainable agriculture, and wonder which part of the organic farming system should be allocated. If the agro-environmental performances of the products produced by conventional agriculture from field to table can be taken into account, the internalization of the externality will be through the transition to the organic farming system. One study suggests that the monetary value paid to organic agricultural products in a country is the value of the externality created by conventional agriculture in that country [3]. The science of economics offers ideas for understanding the conditions of sustainable agriculture. The optimal of the marginal benefits. Such investigations reveal how land should be used in the most efficient way. In fact, inefficient land allocations may cause losses in general welfare.

The social opportunity cost of converting land to organic agriculture is equal to the difference between the marketable conventional product value and the externality of this production system to the environment. In other words:

$$B^o - [B^c - B^e] > 0 \qquad (1)$$

must be realized by the sustainable agricultural system. In the equation, $B^o$ indicates the benefits of the organic farming system, $B^c$ indicates the benefits of the conventional agricultural system and $B^e$ is the negative environmental externalities of the conventional agricultural system.

We consider Hartwick's optimal land use paper in this study in order to understand optimality conditions of the wheat production [2]. Although Hartwick's work is related to forestry / agricultural conversion, it can also be applied to this study. The discounted marginal rent value of the organic field ($MB^o$), will be converted until the discounted value of the remaining conventional / organic area is equal to the discounted future marginal rent value ($MB^l$). If the marginal utility of sustainable agriculture is ( $MB^l$ ), the environmental externality of conventional agriculture is ( $MC_j^{ce}$ ) and ( $MB_m^o$ ) is considered to be the marginal benefit of the area to be left to organic agriculture following equality follows the Hartwick rule:

$$MB_j^l = MB_j^c - MC_j^{ce} = MB_m^o \qquad (2)$$

In short, the current model, with its current agricultural land of a country, attempts to maximize the economic values of the conventional and organic wheat agricultural system for period *t* inside investigated time period *T*. If we formulate what is described;

$$V = \int_{t=0}^{T} W_0(t)e^{-rt}dt + W_c(T)e^{-rT} \qquad (3)$$

$W_0$ : Economic and social benefit flow of organic wheat farming
$W_c$ : Economic and social benefit flow of conventional wheat farming
r: Discount rate

Eqyation 3 is assumed to be $dW_0/dt > 0$ because the soil that purified of agricultural chemicals and inorganic fertilization will increase its efficiency over the years. Part of the increase in the benefit is due to the increase in the price that will be generated by the additional demand for such goods by the adoption of the organic agriculture movement. It will also contribute to the value of social welfare by protecting natural resources and public health effects. If we say $\bar{f}$ to total cultivated wheat field and $f$ is the amount of land allocated to conventional wheat production, we can formulize the net present value of the social benefits of sustainable agriculture as follows:

$$NPV(T,f) = (\bar{f} - f)\int_{t=1}^{T} W_0(t,f)e^{-rt}dt + f\int_{t=1}^{T} W_c(t,f)e^{-rt}dt \quad (4)$$

Equation 4 is maximized by deriving the first-order conditions for country-level, and re-arrange:

$$B^c + fB_f^c = B^o - (\bar{f} - f)B_f^o \quad (5)$$

The benefit function of conventional wheat production is under the effect of health expenditures caused by pesticides, production value loss caused by decreasing pollination (risk premium) and the cost of the treatment of water pollution caused by agricultural chemicals and greenhouse gas ($CO_2$ or its equivalent) emission arising from agricultural production. They are considered in calculating the values of USD/year. Therefore annual benefits and annual cultivated areas are helpful to estimate per hectare values of the conventional wheat production. These three components has been linked to the conventional wheat production amount as a damage cost that has been imposed to the society. Thus, the data set belonging to 1980-2016 has been considered as panel data.

Health problems caused by pesticide use is very important and must be considered. At this study, impacts of pesticides' on humans are considered although it has impacts on other species as well. However the economics of health is a troublesome process because it is closely related with keeping and accessing data. In developed countries such as UK many studies has been performed about this issue, but data sharing and studies in this issue are limited developing countries [5] [6]. We used benefit transfer method by taking account other researches' results. Following general formula was used to do this:

$$I_j = (Y_i / Y_j)^E * I_i \quad (6)$$

$I_j$: Impact value for country j
$Y_i$: Income in country i
$Y_j$: Income in country j
E: Income elasticity of demand for environmental benefits
$I_i$: Impact value for country I

We transformed the calculated value to cultivated areas in related year in Turkey, the inquiring value is 0.0957 USD/Ha.

In this study pesticide use has been monetized as a "damage risk". In pollination damage value calculation, need for insect pollination coefficients are used [1]. In the related study agricultural products that need pollination has been classified and 0.1, 0.5 and 0.9 coefficients were determined ranked from the products that have minimum pollination need to the products that need maximum amount of pollination. The pollination dependency coefficients has been used as 0.1 for vegetables and 0.5 for fruits for Turkey. Following formula we produced was used to calculate pesticide damage risk in Turkey, and was found 176.8 USD/Ha:

$$\left(\sum_{i=1}^{n}(V_{vi} * P_{vc_i} + V_{fi} * P_{fc_i})\right) / (wheat\ harvested\ area_i / total\ ag.area_i) \quad (7)$$

where $V_{vi}$ is vegetable production value and $P_{vc_i}$ is pollination dependency coefficients of vegetables. Likewise, $V_{fi}$ is fruits production value and $P_{fc_i}$ is pollination dependency coefficients of fruits. Annual biological purification cost of water in Turkey was declared, in a report, by Ministry of Environment and Urbanization as 0.1412 USD/Tones. By using this data, pesticides purification cost was calculated with following formula:

*Gross water purification costs = Average annual per capita water consumption (Tonnes/person)/Year * Total population (Persons) * Purification costs of water in Turkey (USD/Tonnes)* (8)

The data in the above formula has been compiled by using different reports published by Turkey's "State Water Hydraulics". Gross water purification cost was estimated as 2,257,788,000 USD/Year with an average per capita water consumption of 205 $m^3$/Year, total population and purification costs of water in Turkey of 0.1412 USD / Tons. Pesticide active ingredients value was employed to calculate the amount of cost allocated to conventional wheat production. This value is 0.47 kg / Hectare in Turkey [4]. Thus, water purification cost charged to conventional wheat production is estimated as 519,291,240 USD/year by using following formula:

WPC= (Pesticides active ingredients*cultivated wheat area / Turkey's cultivated area) X (Gross water purification costs (9)

where: the WPC is water purification cost charged to conventional wheat production which is calculated as 45.35 USD/Ha in Turkey.

Finally, we consider greenhouse gas ($CO_2$) emission arising from agricultural production externality. We used the amount of $CO_2$ emission (or equivalent) needed to produce 1 ton of wheat and the cost of disposal of this emission for necessary for calculations.

Therefore cultivated annual conventional wheat production value minus its externalities mentioned above were considered in the statistical analysis in order to find the optimal land amount. Organic wheat production's externality was only arising $CO_2$ emission. In this study, farm gate prices has been used to calculate the yearly wheat production value. It has been assumed that 50% yield loss will occur when production transitions to organic wheat and the organic wheat price will be 20% more than the conventional wheat. And the value of the $CO_2$ emission reduction has been determined by using the data from the carbon market. According to this, the disposal cost of 1 kg $CO_2$ is considered to be 0.02 USD [7].

## RESULTS AND DISCUSSIONS

Ordinary Least Squares estimator was used to estimate the model parameters related to equation 5.

Model coefficients have statistical significance. Model parameters are accepted to robust when examined the $R^2$ values (Table 1).

Optimality condition in equation 5 is satisfied at 18.13 point. It is stated that conventional wheat production area must be %18.13 of current cultivated area in Turkey.

Table 1. Numerical model results of two models

| | B | Std. Errors | Significancy |
|---|---|---|---|
| Constant_organic | -80,888.96* | 8,292.29 | 0.000 |
| ln_land_organic | 44,101.73* | 2,209.64 | 0.000 |
| *$R^2$ for model organic* | *0.803* | | |
| *St_Er_of_org_mod_est.* | *20,403.87* | | |
| Constant_conventional | -1,462,011.70* | 193,515 | 0.000 |
| ln_land_conventional | 635,882.19* | 51,565.87 | 0.000 |
| *$R^2$ for model conventional* | *0.608* | | |
| *St_Er_of_conv_mod_est.* | *478,159.89* | | |

**Statistical significancy at %1 level*
Source: Authors' own estimation.

Conventional wheat production amount in Turkey is approximately 7.6 million hectare annually. However, the model suggests to be 1.3 million hectares. If we take into account the annual negative externality of wheat production which is 227.5 USD/Ha and the total annual external cost would be 1,416,061,536 USD annually.

The results numerically demonstrate the importance of organic farming. Wheat is still an important nutrient for Turkey, and is the leader in Europe with 150 kg of bread consumption per capita. In addition, the importance of sustainability in wheat production is obvious when considering a significant portion of the per capita income is allocated to food expenditure. Although the productivity of organic wheat production is low, scientific studies should be focused on how to increase the efficiency in this field and sufficient budget should be allocated such studies. The fact that the portion of Turkish agricultural land allocated for wheat production to be reduced to 18% is not theoretically possible, it can be said that it is the target to be reached.

## CONCLUSIONS

In this study, the optimal production area of conventional and organic wheat production in Turkey is calculated. In determination of the optimality conditions, the effect of healthcare expenditures caused by pesticides, production value loss caused by decreasing pollination (risk premium) and the cost of the treatment for water pollution caused by agricultural chemicals and for greenhouse gas ($CO_2$ or its equivalent) emissions arising from agricultural production. The optimal area of land for conventional wheat production is that which makes the marginal benefit of this production equal to the marginal benefit of organic wheat production. According to the results, the conventional wheat production area should be reduced by to 18.13 % of the current production area for conventional wheat production in Turkey.

The model only addresses the optimal conditions with available data. If additional data on externality is obtained, a more extensive model can be developed. In a further study, drought and climate change conditions may be included in the model and their externality effects can then be analyzed. In order to reduce the negative externalities of wheat production in Turkey, prevention of food wastes, reduction of post-harvest losses, guaranteeing the use of certified seed, along with the re-design of many policies and creation of new ones such as a restriction on the use of agricultural chemicals must be realized. There is no doubt that the implementation cost of all these policies will be less than 1,416,061,536 USD/year.

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