VIRTUAL LAND RESOURCES IN TÜRKİYE'S CROP TRADE

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Abstract

Virtual land refers to implicit land resources displaced between countries in the trade of agricultural products. Virtual land flows can be measured using trade volume and country and year-specific yield data of products. This study aims to measure and reveal the long-term changes in virtual land flows in Türkiye's crop trade from 1986 to 2020. The results show that Türkiye's net virtual land imports in crop trade had increased from approximately -670 thousand hectares in 1986 to 7 million hectares in 2020. Turkey's annual average net virtual land import is 1.8 million hectares.

Key words: *Virtual Land Trade, Crop Trade, Türkiye, Embodied Land, Arable Land Flows.*

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INTRODUCTION

In international trade, there are implicit flows of production factors involved in the production processes of tradable goods as well as final goods flows. In addition to final goods flows between countries or regions, international trade also results in the exchange of resources such as water and land involved in the production processes of these goods. Since these resources are not tangible in tradable goods but are embedded in production processes, these resource transfers are called virtual resource trade (Zhang et al., 2016). In addition to the ever-increasing and diversifying commodity flows associated with international trade activities, the globalization process has also led to significant increases in the volume of virtual resource flows. Both national and global trade policies focus primarily on tangible commodity flows, which leads to neglect of embedded resource flows in tradable goods. In this context, it is possible to state that current trade policies are far from regulating the virtual resource flows in international trade. However, virtual resource flows have significant economic, socio-economic, and environmental impacts in the context of both exporting and importing countries (Würtenberger et al., 2006; Qiang et al., 2013; Kastner and Nonhebel, 2010). For all these reasons, there is a need to redesign existing trade policies by taking into account virtual resource flows both on a national and global scale. Quantitative measurement of these virtual resource flows is a preliminary stage for the relevant efforts.

Virtual resource flows are discussed in the literature mainly through trade in agricultural products and in the context of water (Allan, 1993,1999; Ioris, 2004; Xiong vd., 2020) and land (Kastner vd., 2011; Meyfroidt vd., 2013; Qiang vd., 2020; Wang vd., 2021) resources. The main reason for this situation is that agricultural production is closely tied to water and land resources. On the other hand, these resources have become increasingly scarcer on a global scale due to economic, demographic, and environmental factors (Qiang et al., 2013; Würtenberger et al., 2006; Chen and Han, 2015).

There is a fairly heterogeneous structure in the spatial and temporal distribution of water and arable land resources on a global scale. For this reason, especially for countries where water and land resources are scarce and the population is dense, international trade in agricultural products is very important in meeting local food demand and ensuring sustainable food security. In this context, trade in agricultural products functions as a bridge connecting countries or regions with resource supply deficit and surplus (Qiang et al., 2013; Chen and Han, 2015) and partially balances the heterogeneity in resource distribution. This balance is mainly achieved through embedded resource flows in agricultural trade (Zhang et al., 2016).

Virtual resource flows were first mentioned in the literature by Borgstrom (1965) in the context of land resources. The author expressed the embedded land resources in the trade of agricultural products with the concept of "ghost acreage". However, the interest in virtual resource flows in the literature is mainly based on Allan's (1993) studies on water resources. For this reason, it is possible to state that the theoretical foundations of the virtual land concept have developed predominantly within the framework of the virtual water concept. The concept of virtual water is defined by Allan (1993) as water resources embedded in agricultural products and transferred between countries as a result of trade activities. Based on this definition, Würtenberger et al. (2006) defined the concept of virtual land as productive land resources embedded in exported and imported agricultural products.

The term virtual water first emerged as a global solution alternative to the water problem in the MENA region (Middle East and North African Countries), which suffers from severe water scarcity and where food demand is mainly met through imports (Yang and Zehnder, 2007). Both virtual water and virtual land approaches are essentially based on the view that it is possible to protect and save these resources on a global scale if flows in international agricultural trade occur according to positive yield differences between countries. Positive yield differences between countries are closely related to the agricultural production techniques and methods applied by these countries (Yang et al., 2006). The virtual resource trade approach also enables countries to reduce the pressure on scarce local resources and benefit from extraterritorial resources. For this reason, the virtual resource approach is also described by Allan (1993) as a potential solution alternative for political conflicts that may arise due to resource scarcity, especially in regions where this problem is severe.

There are many studies in the literature on measuring virtual water and land flows in local, national, and regional trade of agricultural products (Wichelns, 2001; Kumar et al., 2005; Yang et al., 2006; Fader et al., 2011; Dalin et al., 2012; Chen and Chen, 2013; Cao and Yuan, 2022; Fan et al., 2022). Although the term virtual land was introduced to the literature earlier than the concept of virtual water, it is seen that studies on the virtual water trade occupy a larger place in the literature. This situation is mainly because the water problem is more visible than the land problem. At the same time, the effects of the drought problem have become more felt day by day due to global warming and climate change. This situation has led researchers to focus their attention mainly on virtual water trade. On the other hand, as mentioned before, the theoretical foundations of the virtual land approach have developed mainly within the framework of the concept of virtual water. For this reason, techniques and methods for calculating embedded land flows in agricultural products have been developed mainly based on water resources. For all these reasons, there is a particular need for contributions from different disciplines toward the development of both the theoretical dimension and the calculation techniques and methods of virtual land trade (Yang ve Zehnder, 2007).

In this study, the virtual land area hidden in Türkiye's crop trade was quantified from 1986 to 2020. To quantify the virtual land export and import in primary crops we use the trade volumes and country and year-specific yield data of these products. We use the conversion factors for processed crop products to convert them into primary crop equivalents (Qiang vd., 2013). In this study, virtual land export and import amounts were calculated for 339 different crop products (178 primary crops and 161 crop products). Conversion factors of crop products were quantified using the caloric equivalent approach (Gerbens-Leenes et al., 2002; Kastner and Nonhebel, 2010; Qiang et al., 2013; Qiang et al., 2020). In this approach, the conversion factors are calculated by comparing the caloric contents of the processed product to the caloric contents of the primary product in the same amount. The caloric contents of crops were provided from the FAO's (2001) International Food Balance Sheets.

Best of our knowledge, there isn't any specific study in the literature on virtual land trade conducted in the context of Türkiye. In the limited number of studies (Fader vd., 2011; Qiang vd., 2013, 2020) conducted on a global scale, it is seen that Türkiye is included only in terms of total virtual land flows based on certain product groups or in short time intervals. For this reason, this paper aims to fill the gap observed in the literature. At the same time, it aims to reveal in detail the current situation regarding Türkiye's virtual land trade in the context of primary and processed crop products and the changes observed in the net virtual land flows over the years. On the other hand, quantitative calculation of virtual land flows constitutes the first stage of studies on both sustainable land management and the protection of arable land resources. However, it is possible to obtain more detailed and comprehensive results if virtual resource flows are considered based on specific product groups and the calculations are carried out in the context of both water and land resources.

1. Conceptual Framework and Literature Review

Due to economic, demographic, and environmental factors, arable lands are scarce resource that is decreasing day by day on a global scale (Qiang et al., 2020). According to World Bank (2023) data; Türkiye's per capita arable land area, which was approximately 0.81 hectares in 1961, decreased to 0.23 hectares by 2021. On a global scale, the arable land area per capita, which was 0.36 hectares in 1961, decreased to 0.18 hectares in 2021. This data shows that there has been a serious decrease in arable land area per capita both in Türkiye and in the world. Although the arable land area per capita in Türkiye is slightly above the global average, it is quite likely that soon, existing agricultural land resources will be insufficient to meet the food demand of the rapidly increasing population and ensure sustainable food security.

The fact that agricultural production is closely tied to arable land resources makes trade in agricultural products a necessity, especially for countries and regions where arable land resources are scarce. International trade in agricultural products plays a very important role in reducing the effects of existing resource scarcity in these countries (Qiang et al., 2013). On the other hand with global agricultural trade, local arable lands not only meet local consumption demands but also cross-border consumption demands. Countries where arable land resources are limited and food demand is high have to choose to meet the balance between low supply and high demand in arable land resources by renting or purchasing land from abroad or by importing more agricultural products (Wang et al., 2021). In this context, trade in agricultural products makes it possible for countries with scarce arable land resources to benefit from land resources outside their national borders (Würtenberger et al., 2006). Meeting consumption demand through imports shifts domestic land demand towards foreign land resources. This situation opens the door to cross-border environmental and ecological impacts (Meyfroidt et al., 2013). As a result of consumption and trade activities, the use of local land resources exceeds national borders, and this situation reveals the need to reorganize land use and management decisions from an international perspective.

The effects of trade in agricultural products on the protection and savings of water and land resources have been extensively discussed in the literature. Empirical findings show that international trade flows contribute significant savings to global water and land resources if these flows occur from countries with higher productivity levels to lower ones (Fader et al., 2011; Dalin et al., 2012). China's trade in agricultural products from 1986 to 2009 contributed to global land savings an annual average of 3.27 million hectares (Qiang et al., 2013). On the other hand the annual average land saving in international grain products trade is approximately 50 million hectares, which corresponds to a land area roughly the size of Spain (Zhang et al., 2016). In addition, the volume of arable land area included in international trade has also expanded significantly in parallel with the increase in trade in agricultural products and has reached one-third of the total arable land area on a global scale (Chen and Han, 2015). However, some studies in the literature (Fader vd., 2011; Kumar vd., 2005; Ioris, 2004) state that the mentioned increase in international trade of agricultural products may also lead to an increase in the dependency levels of importing countries on other countries and foreign resources. For this reason, the mentioned countries unintentionally remain outside the virtual land market. Yang and Zehnder (2007) oppose this view and state that the basis of virtual land trade is the arable land scarcity problem of importing countries and argue that agricultural trade is a necessity rather than an alternative for the mentioned countries.

The virtual land trade approach is mainly based on differences in land use efficiency between countries (Yang et al., 2006). The absence of a global market for water and land resources causes the prices of these resources to be determined well below their real value. It is also possible to say that the agricultural, economic and trade policies followed by countries are very effective in this regard. This situation makes it difficult to determine the actual efficiency levels of countries in resource use (Burke et al., 2009). Another important limitation of the virtual land approach is that productivity levels in agricultural production are directly related to input use (Yang and Zehnder, 2007). If the land requirement level is the only parameter taken into account, empirical findings show that the most suitable alternative to meet food demand is intensive agricultural practices targeting high productivity levels (Kastner and Nonhebel, 2010). However, there are many undesirable environmental and ecological impacts caused by intensive agricultural production systems, especially eutrophication, pesticide pollution, and biodiversity loss (Matson et al., 1997). Another important criticism of the virtual land approach is that it focuses mainly on product yields and trade amounts when measuring the virtual land export and import amount of agricultural products. An implicit assumption is made that other variables affecting the trade in agricultural products, other these variables remained constant throughout the research period. This assumption leads to neglect of other variables related to demand, while variables related to product supply have an important place in measurements. In reality, increases in trade volume and productivity levels of agricultural products may lead to an increase in the demand for food products, especially those with high demand elasticity. This situation may lead to an increase in the absolute demand for arable land resources, contrary to the expectations underlying the virtual land approach (Ewers et al., 2009; Rudel et al., 2009).

Criticisms of the virtual land approach generally focus on the theoretical foundations of the concept. This is mainly because the theoretical foundations of the concept are not yet sufficiently developed (Yang and Zehnder, 2007). Cao and Yuan (2022) point out that the virtual land trade approach is not a comprehensive solution alternative for all problems related to the scarcity of arable land resources. However, the authors particularly state that this approach plays a very important role in both ensuring efficiency in resource distribution and reducing the pressure on scarce local resources.

The fact that indirect land flows related to consumption and trade flows have become equal or even more important than local direct land use brings to the agenda the need to re-evaluate land use policies from a virtual perspective (Chen and Han., 2015). In this context, monitoring embedded land flows in agricultural trade is very important in terms of including sustainability issues in global trade policies. It also allows undesirable environmental and socio-economic impacts associated with international trade flows to be taken into account in designing national and international trade policies (Würtenberger et al., 2006).

2. Method

There are serious differences between crops and livestock products in terms of both production methods and techniques and land use types and requirements. Conversion factor calculations also show significant differences in the context of crop and livestock products. For these reasons, calculations of the virtual land export and import amount were made only for crop and crop products. This study considers 339 different crop products, 178 primary crops, and 161 crop products. The number of products in export and import are 148 and 191, respectively.

The virtual land export and import amount in the trade of agricultural products is calculated using the trade and yield data of the primary crops. The product caloric equivalent approach (Gerbens-Leenes et al., 2002; Kastner and Nonhebel, 2010; Qiang et al., 2013; Qiang et al., 2020) was used to calculate the conversion factors showing the primary crop equivalent of crop products. In this approach, the conversion factor of crop products is calculated by dividing the caloric content of the processed product by the caloric content of the same amount of primary crop. Caloric contents of crops and crop products taken from the FAO's (2001) Food Balance Tables Sheets.

Crop products that are re-exported after value-added processes (such as processed coffee and cocoa products) are not included in the scope of the study. It is very difficult to determine the country of origin for the mentioned crop products. However, some countries import primary crops from other countries and then re-export them to different countries. This situation leads to deviations in the redistribution of local land resources and calculation results. Since these products constitute a very small part of the total trade volume, their impact on the calculation results is quite low (Qiang et al., 2020).

2.1 Calculation of Virtual Land in Crop Trade

Virtual land area in crop trade is calculated based on the trade volume and yield data of the primary crops. Yield is calculated by dividing the production amount of primary crops by the harvested area in a certain year. Virtual land export and import in Türkiye's crop trade can be calculated as follows: (Qiang et al., 2013):

$$\text{VLI}= \text{Cp} \sum_{h=1}^{n} \sum_{i=1}^{n} \frac{I\ h,i,j}{Y\ h,i,j} \tag{1}$$

where VLI denotes the virtual land import amount per hectare area, and Cp denotes the conversion factor. I h,i,j shows Türkiye's import amount (kg) of product i from country h in year j, and Y h,i,j shows the yield value (kg/ha) of product i in country h in year j.

$$\text{VLE}= \text{Cp} \sum_{i=1}^{n} \frac{E\ i,j}{Y\ \ i,j} \tag{2}$$

where VLE refers to the virtual land export amount per hectare area. Ei,j shows the export amount (kg) of Türkiye's product i in year j, and Yi,j shows the yield value of product i in Türkiye in year j (kg/ha).

The net balance of virtual land incorporated in Türkiye's crop trade can be calculated as follows:

$$\text{NVLT}= \text{VLE} - \text{VLI} \tag{3}$$

A positive value of NVLT indicates that Türkiye has a net virtual land export (ha), while a negative value indicates a net virtual land import (ha).

2.2 Calculation of Conversion Factor

The conversion factor allows processed products to be expressed in terms of the primary product, or in other words, it shows how much primary product is needed to obtain a certain amount of processed product. Although there are different methods and approaches in the literature about the calculation of the conversion factor, in this study, a caloric equivalent approach based on the caloric contents of primary crops and crop products was adopted. This approach avoids the problem of double counting. Conversion factor for crop products can be calculated as follows (Qiang vd., 2013; Kastner ve Nonhebel, 2010; Kastner vd., 2011):

$$\mathrm{Cp}=\frac{kcal\ a}{kcal\ p} \tag{4}$$

where Cp refers to the conversion factor of the crop product p, kcala refers to the caloric content of the primary crop, and kcalp refers to the caloric content of the crop product p.

3. Results

Total virtual land exports were 33,203,382 hectares, and total virtual land imports were 86,918,271 hectares in Türkiye's crop trade from 1986 to 2020. The annual average virtual land export was 948,668 hectares, and the annual average virtual land import was 2,483,379 hectares. As can be seen from Figure 1, it is noteworthy that Türkiye mainly imports net virtual land in crop trade and the amount of net virtual land import has increased significantly, especially since 2001.

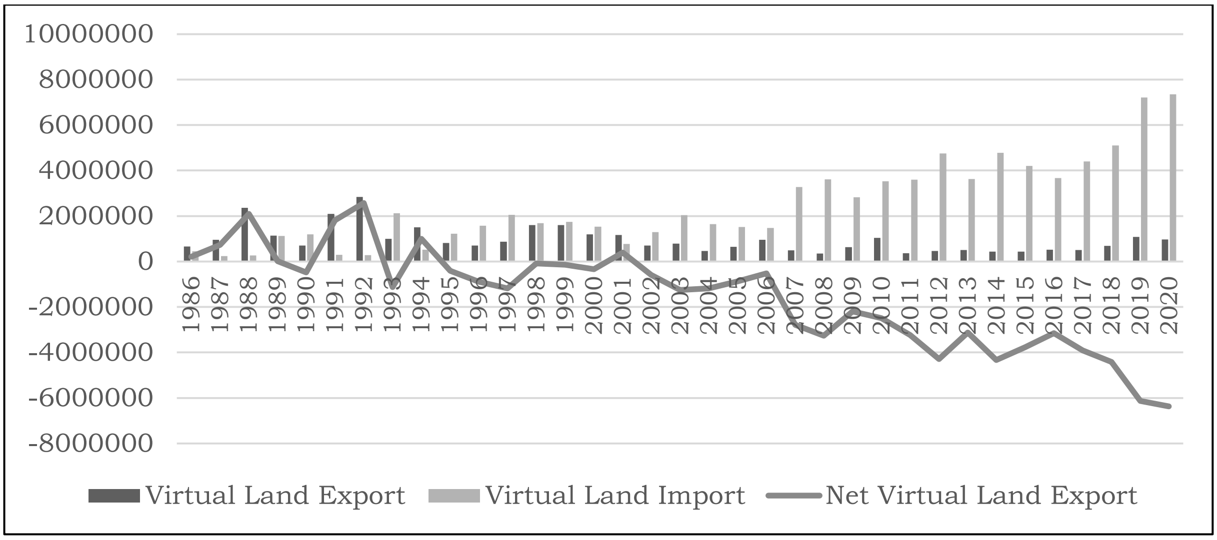

Fig. 1. Virtual Land Trade of Türkiye's Primary Crop Trade (1986–2020)

Source: *Authors' own calculations based on the FAOSTAT database.*

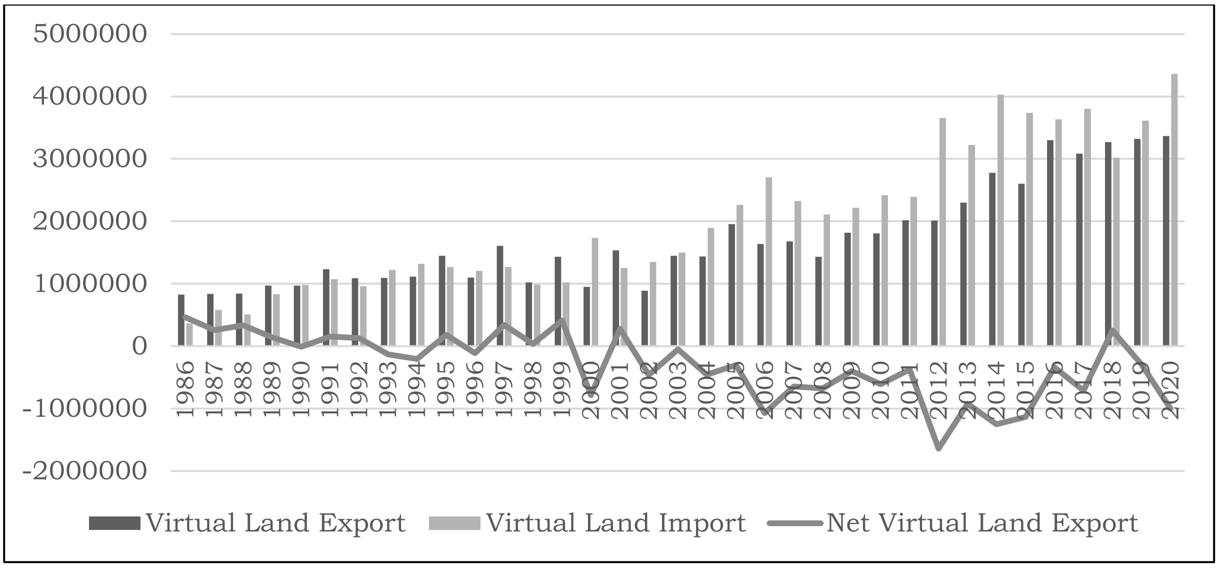

Fig. 2. Virtual Land Trade of Türkiye’s Processed Crop Trade (1986–2020)

Source: *Authors' own calculations based on the FAOSTAT database.*

Türkiye's net virtual land export in crop products trade between 1986 and 1999 turned into net virtual land import in 2000. From 1986 to 2020, Türkiye's total virtual land exports in crop products trade were 60,218,526 hectares, and total virtual land imports were 70,825,088 hectares. Net virtual land import is 10,606,563 hectares. The annual average exported and imported virtual land area is 1,720,529 and 2,023,574 hectares, respectively.

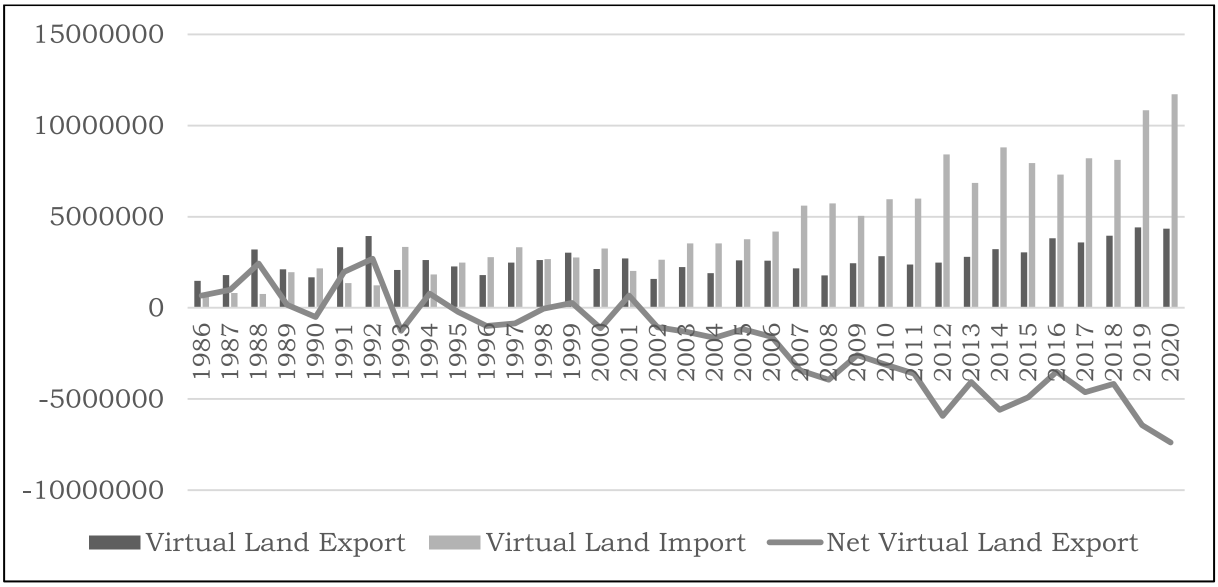

Fig. 3. Total Virtual Land Trade of Türkiye’s Crop Trade (1986–2020)

Source: *Authors' own calculations based on the FAOSTAT database.*

Total virtual land export and import amounts in Türkiye's crop trade are approximately 93 million hectares and 158 million hectares, respectively from 1986 to 2020. According to Figure 3, the difference between Türkiye's virtual land exports and imports in crop products trade started to increase in the 2000s, and this difference gradually increased until 2020. In the years except 1986–1989, 1991, 1992, 1994, 1999, and 2001, Türkiye imported net virtual land in the trade of crop products.

4. Conclusion

Total virtual land export and import amounts in Türkiye's crop trade are approximately 93 million hectares and 158 million hectares, respectively from 1986 to 2020. During the examined period, Türkiye's total net virtual land import is 64,321,451 hectares, and the annual average is 1,837,756 hectares. This finding shows that to meet the current demand for crop products, Türkiye needs an annual arable land area of 1,8 million hectares in addition to national land resources. As mentioned before, products that are re-exported after some value-added processes, such as processed coffee and cocoa products, and livestock and livestock products are not included in the virtual land calculations. For this reason, Türkiye's annual extraterritorial land requirement is expected to be well above the mentioned area. On the other hand, according to World Bank (2023) data, Türkiye's loss rate in arable land per capita was 71.6 % in the period 1961–2021. This ratio is very important as it reveals the seriousness of the current situation. In addition to the downward trend observed over the years in Türkiye's per capita arable land equipment, some economic, environmental, and ecological developments may cause the current situation to become even more critical. In addition to environmental factors such as climate change (Dalin et al., 2012) and drought caused by the global warming process, excessive fertilizer use, inefficient irrigation techniques, and intensive agricultural production practices can lead to serious deterioration in soil structure and quality (Kastner and Nonhebel, 2010). It is quite likely that all these developments will negatively affect land use efficiency in agricultural production processes and further increase Türkiye's current demand for external land resources.

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