International Journal of Engineering and Geosciences
https://dergipark.org.tr/en/pub/ijeg
e-ISSN 2548-0960

# Economic analysis of land consolidation project: Kızılcabölük neighborhood, Tavas-Denizli-Turkey Province

**Tayfun CAY**[*1], **Ramazan Yoldas SATILMIS**[2]

[1] *Konya Technical University, Department of Surveying Engineering, Türkiye, tcay@ktun.edu.tr*
[2] *Pamukkale University, Department of Architecture and Urban Planning, Türkiye, rsatilmis@pau.edu.tr*

Cite this study: Cay, T., & Satilmis, R. Y. (2024). Economic Analysis of Land Consolidation Project: Kızılcabölük Neighborhood, Tavas-Denizli-Turkey Province. International Journal of Engineering and Geosciences, 9 (3), 334-344

https://doi.org/ 10.26833/ijeg.1429522

**Keywords**
Land Consolidation
Economic Analysis
Benefits of Consolidation
Development of Agriculture

**Research Article**

Received: 31.01.2024
Revised: 24.05.2024
Accepted: 03.07.2024
Online Published: 17.11.2024

**Abstract**

In this study, the land consolidation project in Denizli Tavas District Kızılcabölük Neighborhood, the economic effects of the consolidation on the neighborhood, were examined by making economic analyzes. The data to be used in the economic analyzes were obtained from the consolidation maps and lists, and at the end of the interviews with farmers. While making the analysis, vegetable production variable, labor input variable, water input variable and fertilizer input variables were used. The economic profitability of consolidation was found by bringing together the obtained variables. The agricultural areas, which were 1292 hectares with consolidation, decreased to 1255 hectares with the cuts made On the other hand, consolidation led to an annual profit of approximately 2.5 million dollars in the project area. It is seen that the most important factor in increasing profitability in the project area is the change in product variety. With the land consolidation, the irrigation system was came to the agricultural areas. Farmers that provide easy and more convenient access to water have turned to corn with high profitability. This situation has led to an increase in the plant production value in the project area.

## 1. Introduction

The global population has grown exponentially in recent decades, reaching 8 billion individuals worldwide [1]. In Turkey, the population has also increased rapidly, reaching approximately 85 million [2]. In conjunction with the observed population growth, there will be an accompanying increase in the demand for water and food [3]. Agriculture is therefore an indispensable part of the world and Turkish economy [4]. One of the primary objectives of the agricultural sector is to achieve the highest possible quality yield while minimizing the input of labor and production costs [5]. The unplanned use of soil and natural resources in numerous countries around the globe, including Turkey, has led to a significant threat to these resources [6]. At this juncture, it is of paramount importance to prioritize land consolidation efforts [7]. With land consolidation, agricultural areas are protected and agriculture is strengthened [8]. Moreover, it ensures food security for nations [9]. Moreover, agriculture is a crucial sector for rural development and a significant component of national progress [10]. For this reason, many consolidation projects have been carried out in European [11]. The process of land consolidation in Turkey commenced in 1961, with numerous projects being implemented in the subsequent decades [12].

Land consolidation is the process of reorganizing fragmented, scattered, and geometrically distorted lands to meet the demands of the present era, with the goal of enhancing the welfare of farmers [13,14]. Consolidation brings infrastructure services such as roads, water and drainage to agricultural lands and reduces costs [15]. Moreover, the primary objective of land consolidation is to enhance the efficiency of agricultural production [16].

As with every investment, consolidation investments have a certain cost and return [17]. For this reason, economic analysis is important in consolidation projects, as in every investment. Following the land consolidation, an economic analysis can be conducted, allowing for the clear identification of the project's economic benefits

[18]. While the return of agricultural activities to the national economy is 9%, this figure is 8% when the costs are also taken into account [19]. This situation reveals the importance of consolidation.

It is standard practice to undertake cost calculations at the inception of land consolidation projects. It is similarly crucial to ascertain the extent to which the economic return has been altered as a consequence of the consolidation process. The principal objective of this study is to ascertain the profit that farmers will realize from consolidation. A technical examination has been conducted on the selected project site to ascertain the amount of the observed decrease in costs and increase in profitability.

Literature studies were examined while determining the criteria to be used in the analysis.

Wojewodzic et al. [20] stated in their study that there are many factors affecting the economic evaluations of land consolidation studies.

Pašakarnis et al. [21] aimed to create a decision support system that prioritizes by determining a set of criteria to determine priority in consolidation. In the study, they conducted a survey with experts, including scientists. Project selection criteria determined by the survey study; "average land fragmentation index", "average distance from farms to fields", "average parcel size", "irrigation infrastructure status", "number of wealthy farmers".

Liao et al. [22] examined the situation before and after consolidation in their research on 447 farmers. They stated that there was a decrease in the number of parcels after consolidation, a decrease in water consumption, an improvement in the microclimate, and the economic returns of agricultural enterprises increased accordingly.

Bahar and Kirmikil [23] stated that in a consolidation area, the road length for each farmer decreased by 343.5 km, resulting in 151.14 L fuel and 163.254 USD cost savings.

Tunca and Deliktas [24] measured agricultural efficiency in OECD countries between 1966 and 2007 with Dynamic Data Envelopment Analysis. Efficiency measurement was made with economic data. For this, land input variable, tractor input variable, labor input variable, fertilizer input variable and fertilizer input variables were used.

Özlem and Kenan [25] stated that in a project with a consolidation rate of 47%, 80.6% of the existing farmers in social and economic terms improved their living conditions and 83.9% increased their income.

In their study, Heinrichs et al. [26] examined the economic effects of parcel sizes and farm distances in organic and traditional agricultural systems in Germany. The study employed a business perspective on agriculture. The researchers concluded that both traditional and organic agricultural activities influence the costs associated with parcel sizes and farm distances.

Janus [27] posited that the distance between the parcels of farmers in a land consolidation study is a crucial factor in determining the success of consolidation. He posited that the distance between parcels is of particular significance when conducting economic analysis.

In this research has yielded the creation of a novel methodology, which effectively integrates the methods employed in the aforementioned studies. Furthermore, by incorporating the perspectives of the farmers at the project site, more comprehensive and tangible outcomes have been achieved. The economic profitability and costs were analyzed before and after the land consolidation of farmers based on the agricultural data from the project area and the technical information provided by the project. The economic analysis was conducted in accordance with the classical method.

The economic efficiency of implementing land consolidation projects in the selected site has been demonstrated. The study is based on interviews with farmers. Detailed research and calculations were conducted. The study distinguishes itself from other literature by providing concrete evidence of the economic benefits of consolidation and demonstrating its profitability in Denizli Province.

## 2. Method

### 2.1. Analysis method

Tavas District, Kızılcabölük Neighborhood was determined as the research area. Kızılcabölük neighborhood was visited and investigations were made about the project. These examinations can be listed as the observation of the land consolidation in the field, the examination of the parcels, roads and irrigation systems in the field. In addition, interviews and surveys were carried out with the headman of Kızılcabölük, the President of Kızılcabölük Irrigation Cooperative and the farmers of the neighborhood. In the light of the data obtained, the economic analysis of the land consolidation of the project area was carried out with classical methods by making use of the project area data.

While analyzing;

- Crop production variable
- Labor input variable
- Fertilizer input variable
- Water input variable

Were utilized.

The first step was to calculate the crop production variable. At this stage, the profit obtained from herbal products was calculated separately before and after consolidation. To do this, land consolidation lists were used, and interviews with farmers were conducted. Product profitability was then calculated based on the productivity per decare of each product variety planted in the project area. In addition, while calculating profitability and cost, real sales prices for May 2022 were taken into account.

While calculating the labor input variable, the cost differences of tractor diesel before and after consolidation were calculated. For this purpose, the road lengths from the village center to the fields have been calculated. During the calculation, the distances to the village center for each parcel were determined by taking into account the shape of the road network. In this process, the road distances from their homes to their fields have been determined for each farmer. LiCAD software was used when determining the road distances.

The found road distances were multiplied by the commuting distances to the variable parcels according to the product types and the total distance traveled was found. The total cost was calculated by multiplying the found distance by the diesel price.

The calculation of the fertilizer input variable was performed. Fertilizer costs were calculated separately for the situation before and after consolidation, using land consolidation lists and farmer interviews. The cost of fertilizer was determined based on the cost per decare of each product type planted in the project area.

The water input variable was calculated next. Irrigation costs were then calculated separately for the situations before and after consolidation. To make these calculations, land consolidation lists and farmer interviews were used. Water costs were determined based on the cost per decare of each product type planted in the project area.

To determine the profitability of the project area, the crop production variable was subtracted by the labor input variable, fertilizer input variable, and irrigation input variable. The profitability of the project area was calculated for both the pre-consolidation and post-consolidation situations. By analyzing the difference between the profitability of the two situations, the effect of land consolidation on profitability was determined.

## 2.2. Study area

Kizilcabölük is located in the Denizli province of Turkey and is connected to the Tavas district. The location of Kızılcabölük is 37° 36' 50.9976'' North and 29° 0' 55.0008'' East coordinates. Kızılcabölük is 7 kilometers away from Tavas town center to which it is affiliated. Kızılcabölük district is 55 km from Denizli and 130 km from Aydın. All of the roads to reach the neighborhood are asphalt. The closest district to the neighborhood is Tavas District.

Denizli-Tavas Plain 1st Section AT and TİGH Project, whose construction started with the decision of the Council of Ministers no 2007/11687, Kızılcabölük neighborhood was used in the study. The project AT and TİGH projects, which are the subject of the research, were completed in 2016.

There are a total of 1079 field owners in the project area. The number of parcels, which was 1406 before Consolidation, decreased to 993. Consolidation rate is 29.37%. As the consolidation rate increases, the success of the consolidation increases [28].

Figure 1 shows the status of parcels before and after consolidation of Kızılcabölük neighborhood.

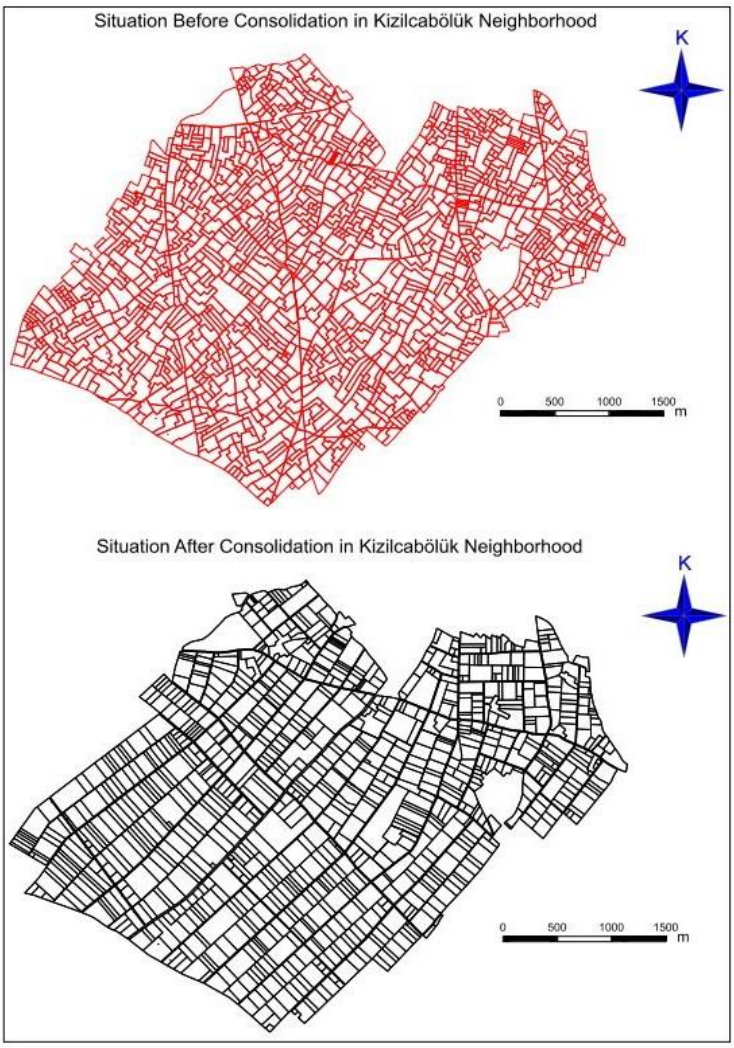


**Figure 1.** Situation map of Kızılcabölük before and after consolidation

### 2.3. Data sources

The project area data were obtained from the twenty-first Regional Directorate of State Hydraulic Works and the contractor company. The files obtained from the administration and the contractor company include computer-aided design (CAD) files pertaining to the project site and consolidation lists. The analyses in the study were conducted using computer-aided design (CAD) files and land consolidation lists.

## 3. Results

When the situations before and after consolidation are examined technically, it is expected that the number of parcels will decrease and the average parcel sizes will increase. The fact that the parcels are as large as possible will affect the labor input variable by causing a decrease in the number of parcels. On the other hand, since it will cause a decrease in the length of the parcel's boundaries, it will cause a decrease in the loss of 30 cm wide unused area at the boundaries of the parcels.

Table 1 shows the ratio of parcel sizes before and after consolidation in Kızılcabölük district. When the table is examined, it is seen that the number of small-sized parcels decreased and the number of large-sized parcels increased with consolidation. For example, while the number of parcels in 1-2 daa size was 111 before consolidation, it decreased to 33 after consolidation.

**Table 1.** Parcel sizes before and after consolidation

| Parcel Size (daa) | Before Consolidation | | After Consolidation | |
|---|---|---|---|---|
| | Number of Parcels | (%) | Number of Parcels | (%) |
| 0-1 | 23 | 1.64 | 13 | 1.31 |
| 1-2 | 111 | 7.89 | 33 | 3.32 |
| 2-5 | 307 | 21.83 | 132 | 13.29 |
| 5-10 | 461 | 32.79 | 324 | 32.63 |
| 10-20 | 412 | 29.30 | 335 | 33.74 |
| 20-30 | 73 | 5.19 | 102 | 10.27 |
| 30-40 | 14 | 1.00 | 30 | 3.02 |
| 40-50 | 2 | 0.14 | 11 | 1.11 |
| 50-60 | 1 | 0.07 | 8 | 0.81 |
| 60< | 2 | 0.14 | 5 | 0.50 |
| Total | 1406 | 100 | 993 | 100 |

Table 2 shows, the total of the parcels, which was 1293 ha before consolidation, decreased to 1255 ha after consolidation. The said area was used for the construction of roads and irrigation lines. The difference of 38 hectares is the income obtained by the public from consolidation.

After consolidation, the number of parcels decreased from 1,406 to 993. Average parcel area increased from 9,194 $m^2$ to 12,641 $m^2$. The average size of farmer's fields decreased from 11,981 $m^2$ to 11,634 $m^2$.

Some parcel owners in the project area are not engaged in farming. The owners of small and inherited parcels do not sell them due to their spiritual value. The consolidation project has not benefited the mentioned parcel owners, who are in the minority. However, it has led to a decrease in the number of parcels owned by farmers who make their living from agriculture, resulting in increased profitability. However, due to the parcels with shares, the Average Number of Farmer Parcels is seen as 0.92 in Table 2.

**Table 2.** Average field sizes of farmers before and after consolidation

| | Before Consolidation | After Consolidation |
|---|---|---|
| Project Area ($m^2$) | 12,927,188 | 12,552,686 |
| Number of Parcels | 1,406 | 993 |
| Average Parcel Area ($m^2$) | 9,194 | 12,641 |
| Number of Farmers | 1,079 | 1,079 |
| Average Farmer Field Size ($m^2$) | 11,981 | 11,634 |
| Average Number of Farmer Parcels | 1,30 | 0,92 |

### 3.1. Agricultural status

Opinions of farmers were consulted to examine the agricultural situation in the project area. In the interviews, it was seen that 30% of the agricultural lands in the neighborhood were planted with tobacco, 40% with cereals, 15% with sunflowers and 15% with corn. After consolidation, it was observed that 10% of the agricultural lands were planted with tobacco, 10% with cereals, 20% with sunflowers and 60% with corn. In other words, there has been a change in the variety of crops planted after consolidation and corn planting has increased. The arrival of water in the project area was effective in observing this situation. Corn is more profitable for farmers in terms of yield and product value. However, corn is a plant that needs plenty of water [29].

The crops planted before and after consolidation are shown in Table 3.

**Table 3.** Crops planted before and after consolidation

| | Before Consolidation | After Consolidation |
|---|---|---|
| Tobacco | % 30 | % 10 |
| Cereals | % 40 | % 10 |
| Sunflower | % 15 | % 20 |
| Sweetcorn | % 15 | % 60 |

Table 4 provides information on the yields of agricultural products. Looking at the table, we can see that the productivity of the products has increased after the consolidation. In this case, it can be said that the introduction of irrigation systems in the project area is effective.

**Table 4.** Product yields before and after consolidation

| | Before Consolidation | After Consolidation |
|---|---|---|
| Tobacco | 100 kg | 140 kg |
| Cereals | 700 kg | 850 kg |
| Sunflower | 250 kg | 350 kg |
| Sweetcorn | 1500 kg | 2100 kg |

During interviews with farmers, information was gathered on the average market values of agricultural products, including the selling prices which may vary depending on the quality and the farmer. As of May 2022, farmers reported a prices of;

- Tobacco → 34 TL ($ 2.078)
- Cereals → 4 TL ($ 0.245)
- Sunflower → 20 TL ($ 1.223)
- Sweetcorn → 4 TL ($ 0.245)

was determined.

During the interviews with farmers, they were asked how often they visit their fields on average for the crops planted. It was noted that an exact figure for the round trip was not possible to provide. For instance, some farmers stated that they stayed in the field by setting up a gazebo, while others stated that they came and went. However, they generally provided information on how many times they had to visit their fields with the tractor. The information provided by the farmers is summarised below;

- Tobacco → Planting Phase 6 times
  After Planting 10 times
- Cereals → 7 times
- Sunflower → 12 times
- Sweetcorn → 8 times

It has been seen that they have made an expedition.

Prior to consolidation, Kızılcabölük Neighborhood lacked an irrigation system, forcing farmers to either find their own water resources or engage in agriculture without water. However, with the implementation of land consolidation, the neighborhood now benefits from a covered irrigation system. This has resulted in increased product diversity and yield. On average, farmers pay 1.70 TL ($0.104) per ton of irrigation in Kızılcabölük Neighbourhood. Prior to consolidation, farmers were responsible for their own irrigation. Based on the responses received, it was found that... The cost of self-irrigation is approximately 2.40 TL ($0.147) per ton. Farmers were surveyed regarding the cost of irrigation for tobacco, grains, sunflower seeds, and corn.

For 1000 m2 field;

- Tobacco → 200 ton
- Cereals → 150 ton
- Sunflower → 350 ton
- Sweetcorn → 350 ton

Irrigation was observed.

Fertiliser costs are a significant economic factor in agriculture. In recent years, rising fertiliser costs have posed economic challenges for agricultural enterprises. While these costs vary for each enterprise, the estimated fertiliser costs for 2022 are as follows;

For 1000 m2 field;

- Tobacco → 500 TL ($ 30.56)
- Cereals → 700 TL ($ 42.59)
- Sunflower → 1000 TL ($ 61.12)
- Sweetcorn → 1000 TL ($ 61.12)

It has been found to be.

### 3.2. Crop production variable

Land consolidation works aim to bring together scattered and fragmented agricultural lands into larger and fewer parcels with a regular shape. The introduction of irrigation systems can increase crop yield and change crop variety, both of which affect crop production.

Additionally, there may be losses associated with using the areas on the borders of the parcels during agriculture. The reason for this is that 30 cm wide gaps are left on the parcel boundaries [30]. As the length of the parcel boundaries increases, so does the unusable area on the parcel boundaries. Bringing these unusable areas into agriculture will affect the crop production variable.

Firstly, the yield of the situation before consolidation was calculated. Prior to consolidation, tobacco and cereals were the primary crops cultivated, with less emphasis on sunflower and corn. The total cultivated area was approximately 1293 hectares. Table 5 displays the crop yields and returns from the pre-aggregation period. The cultivated area was divided based on the percentage of crop variety cultivation, and each crop was calculated using its own parameters. To calculate the total profit, the yield value per decare was multiplied by the cultivation area. The resulting total yield was then multiplied by the product price. Finally, the profits from each crop were summed to determine the overall profit of the project area.

The efficiency of the pre-consolidation state was calculated. After consolidation, especially corn cultivation is quite high compared to other products. This situation depends on the arrival of the irrigation system to the project site. It was observed that the profitability of corn was higher than that of other products. Additionally, the cultivated area decreased from approximately 1293 hectares to 1255 hectares. After the consolidation, the introduction of the irrigation system led to an increase in product yields per decare. This increase varied according to product groups, with the lowest increase observed in cereals and the highest increase observed in corn. Table 6 shows the product yield and yield of the post-consolidation situation.

Then, the direction in which the lost areas on the parcel boundaries changed after consolidation was also calculated. For this, the boundary lengths of all parcels before and after consolidation are needed. There are 2399 parcels in total in the project area. The total side lengths of each plot were determined by determining all the side lengths one by one. LiCAD software was used because of the convenience it offers while determining the lengths. While the sum of the parcel boundary lengths was 791,023.04 m before consolidation, it decreased to 600,200.71 m after consolidation.

If the sum of the parcel boundary lengths before consolidation is subtracted from the sum of the parcel boundary lengths after consolidation, the result is 190,822.33 m. By multiplying this result by 0.3 m, which is the unusable width at the parcel boundaries, the amount of unusable area is found. The result is presented in the Calculation 1.

$$190{,}822.33 \times 0.3 = 57{,}246.70 \text{ m2} \quad (1)$$

After consolidation, the area gained from the parcel boundaries, 57,245 m2, was divided according to the planting rates of the product groups, and the gained area profit was calculated in the light of the information

provided by the farmers. As seen in Table 7, the area profit gained was found to be 415,382 TL ($ 25390). This amount is a profit to be obtained as the fields are planted each year.

**Table 5.** Product efficiency before consolidation

| Area (m²) = 12,927,188 | Tobacco | Cereals | Sunflower | Sweetcorn |
|---|---|---|---|---|
| Sowing Rate (%) | 30 | 40 | 15 | 15 |
| Planting Area (Decares) | 3878 | 5170 | 1939 | 1939 |
| Yield per Decare (Kg) | 100 | 700 | 250 | 1500 |
| Total Yield (Kg) | 387,815 | 3,619,612 | 484,769 | 2,908,617 |
| Kilogram Unit Price (TL) | 34 | 4 | 20 | 4 |
| Total Profit (TL) | 13,185,731 | 14,478,450 | 9,695,391 | 11,634,469 |
| **Project Area Total Profit (TL)** | | | **48,994,043** | |

**Table 6.** Product efficiency after consolidation

| Area (m²) = 12,552,686 | Tobacco | Cereals | Sunflower | Sweetcorn |
|---|---|---|---|---|
| Sowing Rate (%) | 10 | 10 | 20 | 60 |
| Planting Area (Decares) | 1255 | 1255 | 2510 | 7531 |
| Yield per Decare (Kg) | 140 | 850 | 350 | 2100 |
| Total Yield (Kg) | 175,737 | 1,066,978 | 878,688 | 15,816,384 |
| Kilogram Unit Price (TL) | 34 | 4 | 20 | 4 |
| Total Profit (TL) | 5,975,078 | 4,267,913 | 17,573,760 | 63,265,537 |
| **Project Area Total Profit (TL)** | | | **91,082,290** | |

**Table 7.** Yield from parcel boundaries after consolidation

| Area (m²) = 57,247 | Tobacco | Cereals | Sunflower | Sweetcorn |
|---|---|---|---|---|
| Sowing Rate (%) | 10 | 10 | 20 | 60 |
| Planting Area (Decares) | 5.72 | 5.72 | 11.45 | 34.35 |
| Yield per Decare (Kg) | 140 | 850 | 350 | 2100 |
| Total Yield (Kg) | 801 | 4865 | 4007 | 72,130 |
| Kilogram Unit Price (TL) | 34 | 4 | 20 | 4 |
| Total Profit (TL) | 27,249 | 19,463.88 | 80,145.38 | 288,523 |
| **Project Area Total Profit (TL)** | | | **415,382** | |

In order to calculate the total crop production variable after consolidation, the crop production value after consolidation and the yield gained from the parcel boundaries are added. This result is demonstrated in the Calculation 2.

415,382 TL ($ 25,390) +91,082,290 TL ($ 5,567,377) = 91,497i672 TL ($ 5,592,767) (2)

The result is $5,592,767 for the date 26.05.2022.

Kumbasaroğlu and Dağdemir [31] determined that the value of plant production was 1618.3 TL, animal production value was 2834.8 TL, and other agricultural incomes were 270.8 TL.

### 3.3. Labor input variable

The study calculated the labor input variable by considering the differences in distances between agricultural holdings and their parcels. Prior to land consolidation, the roads leading to the parcels were narrow and more curved. However, following consolidation, they became wider and straighter. Additionally, the decrease in the number of parcels led to a decrease in commuting distances for the holdings.

The LiCAD program was used to measure the distance from the agricultural holdings to the village center for a total of 2399 parcels. Table 8 displays a selection of the measured distances and project totals, with measurements taken separately for each enterprise. The labor input variable is directly affected by the reduction in the number of enterprise parcels. The distance before consolidation was 5.119 km, which decreased to 3.558 km after consolidation. According to Hamza et al. [32], the road distance shortened by approximately 16% after consolidation.

The fuel that farmers spend while traveling to and from their fields is one of the most important expenses. Other factors affecting the labor costs of farmers are the diesel price and the diesel consumption of their tractors. Diesel consumption of tractors varies according to horsepower and traction. Accordingly, the fuel burned by the tractor in 1 km on a straight road was accepted as approximately 0.8 l. The diesel price was taken as 25 TL ($ 1.528) according to the data of May 2022.

Labor input variables before and after consolidation were calculated separately. This is because the number of trips to and from the farmers' fields changes depending on the plant species planted after consolidation. The total distance was divided according

to the planting rates of the crops and then multiplied by the number of farmers going to the field and by two. The purpose of this calculation is to determine the round trip distance and corresponding diesel consumption. The diesel consumption is calculated by multiplying the round trip distance by the fuel consumption rate per liter. The total cost is then found by multiplying the diesel consumption by the price of diesel fuel. Table 8 shows that the total diesel cost is 2,170,582 TL ($132,676), which is a significant expense.

Table 9 calculates the labor input variable after consolidation. The total round-trip distance to the fields has changed due to consolidation, as well as a change in product diversity affecting the round trip distance to and from the farmers' fields. Upon examination of the table, the total diesel cost is 1,352,098 TL ($82,646).

The difference between the labor input variables of the post-consolidation situation and the pre-consolidation situation was calculated. The result is presented in the Calculation 3.

2,170,582 TL ($ 132,676) – 1,352,098 TL ($ 82,646) = 818,484 TL ($ 50,029) (3)

The amount in question remained in the country's economy after the consolidation works and relieved the farmers.

**Table 8.** Labor input variable before consolidation

| Distance (m) =5,119,297 | Tobacco | Cereals | Sunflower | Sweetcorn |
|---|---|---|---|---|
| Sowing Rate (%) | 30 | 40 | 15 | 15 |
| Road Length (Km) | 1,535 | 2,047 | 767 | 767 |
| The Number of Farmers Going to Their Fields | 16 | 7 | 12 | 8 |
| Total Round Trip Distance (Km) | 49,145 | 28,668 | 18,429 | 12,286 |
| Diesel Consumption per 1 Km (L) | | | 0.8 | |
| Total Diesel Consumption (L) | 39,316 | 22,934 | 14,743 | 9,829 |
| 1L Diesel Price (TL) | | | 25 | |
| Total Cost (TL) | 982,904 | 573,361 | 368,589 | 245,726 |
| Project Area Cost (TL) | | | 2,170,582 | |

**Table 9.** Labor input variable after consolidation

| Distance (m) =3,558,154 | Tobacco | Cereals | Sunflower | Sweetcorn |
|---|---|---|---|---|
| Sowing Rate (%) | 10 | 10 | 20 | 60 |
| Road Length (Km) | 355 | 355 | 711 | 2134 |
| The Number of Farmers Going to Their Fields | 16 | 7 | 12 | 8 |
| Total Round Trip Distance (Km) | 11,386 | 4,981 | 17,079 | 34,158 |
| Diesel Consumption per 1 Km (L) | | | 0.8 | |
| Total Diesel Consumption (L) | 9,108 | 3,985 | 13,663 | 27,326 |
| 1L Diesel Price (TL) | | | 25 | |
| Total Cost (TL) | 227,721 | 99,628 | 341,582 | 683,165 |
| Project Area Cost (TL) | | | 1,352,098 | |

### 3.4. Fertilizer input variable

To enhance product yields, farmers apply fertilizers, which constitute a significant agricultural expense. The types of fertilizers used by farmers for different crops vary, and they often mix them. In interviews with farmers, it was found that the cost of fertilizer has remained stable. However, the consolidation of product variety has led to changes in fertilizer costs.

Fertilizer variables before and after consolidation were calculated separately. In the pre-consolidation and post-consolidation cases, separate calculations were made according to the product variety. When Table 10 is examined, the area before consolidation is divided according to product variety. The obtained areas were multiplied by the fertilizer costs per decare of each product. The total cost of the project site was found by the sum of the fertilizer costs of each product. The project cost before consolidation was 9,436,847 TL ($ 576,824). This cost is an important item for farmers.

The calculation of the fertilizer input variable after consolidation was made in Table 11. Although fertilizer costs remained the same after consolidation, the project area cost also changed due to the change in product diversity. When the fertilizer cost after consolidation is considered, it is seen that it is 11,548.471 TL ($ 705,897). Compared to the situation before consolidation, the cost of farmers increased by approximately 2,111,624 TL ($ 129,072) after consolidation on 26.05.2022. Bayramoğlu and Cennet [33] stated in their study that approximately 15% was saved from the use of fertilizers by consolidation.

**Table 10.** Fertilizer input variable before consolidation

| Area (m²) = 12,927,188 | Tobacco | Cereals | Sunflower | Sweetcorn |
|---|---|---|---|---|
| Sowing Rate (%) | 30 | 40 | 15 | 15 |
| Planting Area (Decares) | 3878 | 5170 | 1939 | 1939 |
| Fertilizer Cost per Decare (TL) | 500 | 700 | 1000 | 1000 |
| Total Cost (TL) | 1,939,078 | 3,619,612 | 1,939,078 | 1,939,078 |
| Project Area Cost (TL) | | | 9,436,847 | |

**Table 11.** Fertilizer input variable after consolidation

| Area (m²) = 12,552,686 | Tobacco | Cereals | Sunflower | Sweetcorn |
|---|---|---|---|---|
| Sowing Rate (%) | 10 | 10 | 20 | 60 |
| Planting Area (Decares) | 1255 | 1255 | 2510 | 7531 |
| Fertilizer Cost per Decare (TL) | 500 | 700 | 1000 | 1000 |
| Total Cost (TL) | 627,634 | 878,688 | 2,510,537 | 7,531,611 |
| Project Area Cost (TL) | | | 11,548,471 | |

### 3.5. Irrigation input variable

The irrigation of agricultural products is a necessity, as the absence of water cannot be compensated for. Therefore, it is of great importance to farmers. During the consolidation work, a covered irrigation system was constructed in the project area, which has resulted in a reduction in irrigation costs for farmers. Table 12 shows the calculation of the irrigation input variable before consolidation. The quantity of water consumed varies according to the specific product variety. In order to ascertain the total quantity of water consumed, it is necessary to multiply the planted area for each crop by the corresponding water consumption. The total water consumption is then multiplied by the water cost to obtain the total cost. The sum of the irrigation costs for each product yields the project cost. Prior to consolidation, the irrigation cost in the project area was 6,980,682 TL ($ 426,692).

Table 13 shows the calculation of the water input variable after consolidation. The implementation of the covered irrigation system resulted in decreased irrigation costs for farmers. Additionally, changes in water costs occurred due to the shift in product variety. After consolidation, the irrigation cost of the project area was calculated to be 6,721,963 TL ($410,877).

**Table 12.** Irrigation input variable before consolidation

| Area (m²) = 12,927,188 | Tobacco | Cereals | Sunflower | Sweetcorn |
|---|---|---|---|---|
| Sowing Rate (%) | 30 | 40 | 15 | 15 |
| Planting Area (Decares) | 3878 | 5170 | 1939 | 1939 |
| Water Spent per Decare (Ton) | 200 | 150 | 350 | 350 |
| Total Water Consumption (Ton) | 775,631 | 775,631 | 678,677 | 678,677 |
| 1 Ton of Water Price (TL) | | | 2.40 | |
| Total Cost (TL) | 1,861,515 | 1,861,515 | 1,628,825 | 1,628,825 |
| Project Area Cost (TL) | | | 6,980,682 | |

**Table 13.** Irrigation input variable after consolidation

| Area (m²) = 12,552,686 | Tobacco | Cereals | Sunflower | Sweetcorn |
|---|---|---|---|---|
| Sowing Rate (%) | 10 | 10 | 20 | 60 |
| Planting Area (Decares) | 1255 | 1255 | 2510 | 7531 |
| Water Spent per Decare (Ton) | 200 | 150 | 350 | 350 |
| Total Water Consumption (Ton) | 251,053 | 188,290 | 878,688 | 2,636,064 |
| 1 Ton of Water Price (TL) | | | 1.70 | |
| Total Cost (TL) | 426,791 | 320,093 | 1,493,769 | 4,481,308 |
| Project Area Cost (TL) | | | 6,721,963 | |

By subtracting the cost of irrigation before consolidation from the cost of irrigation after consolidation, we obtain a result of 258,719 TL ($15,814 as of 26.05.2022). Although the product variety has shifted towards crops that require more water, the consolidation efforts have led to a decrease in irrigation costs.

According to Ercan's [34] study on land consolidation practices in Turkey, irrigation savings of 36.7% were achieved. Similarly, Çelebi's [35] study found that land consolidation projects resulted in up to 30% savings in irrigation. Taşdemir [36] found that land consolidation resulted in a net income increase of 652%.

## 4. Discussion

To determine the change in profitability after consolidation, calculate the net profit values before and after consolidation. Subtract the labor input, fertilizer input, and irrigation input variables from the crop production variable in both cases. The change in profitability after consolidation is the difference between the net profit value after consolidation and the net profit value before consolidation. Upon examining Table 14, it was found that the change in profitability after aggregation was 41,469,209 TL, which is equivalent to $2,591,825 based on the May 2022 dollar rate. In his study,

**Table 14.** Profitability after consolidation variable

| | Before Consolidation | After Consolidation |
|---|---|---|
| Crop Production Variable (TL) | 48,994,043 | 91,497,672 |
| Labor Input Variable (TL) | 2,170,582 | 1,352,098 |
| Fertilizer Input Variable (TL) | 9,436,847 | 11,548,471 |
| Irrigation Input Variable (TL) | 6,980,682 | 6,721,963 |
| Net profit (TL) | 30,405,932 | 71,875,140 |
| Profitability Change (TL) | 41,469,208 | |

It can be concluded that the project has been successful in improving profitability and land value. The project area's profitability has significantly increased with consolidation. Farmers have reported a doubling of profitability, which has also led to a 100% increase in the value of their fields. Based on May 2022 data, the value of 1 decare in the project area varies depending on the location of the field, ranging from 50,000 TL ($3056) to 100,000 TL ($6112).

Comparing profitability to the cost of project construction can provide a better understanding of profitability. The cost of constructing the project is approximately 10 million dollars. In other words, the project paid for itself within four years. Based on the data provided, the investment made in land consolidation the project area appears to be highly profitable.

The increase in profitability in the project area is due to the change in product diversity. With the arrival of the irrigation system, most farmers shifted to corn production, which has a high profitability rate.

The land consolidation work significantly contributes to the national economy. Agricultural enterprises have experienced a decrease in diesel costs, which is particularly important for Turkey, a country dependent on foreign energy. The reduction in road costs has become even more crucial due to the recent increase in diesel prices. In addition, increasing agricultural production is crucial in times when food security is of strategic importance and the economy of scarcity is being discussed. Furthermore, the covered irrigation system prevented water evaporation during hot summer months, and modern irrigation systems used by agricultural enterprises have also led to water savings. During the 1st Water Council organized by the Ministry of Agriculture and Forestry, it was reported that agricultural irrigation accounts for over 70% of total water usage in Türkiye. The agricultural sector is particularly vulnerable to drought, which poses a threat to food security. Efforts to increase agricultural production value while reducing diesel and irrigation costs have significant economic benefits.

## 5. Conclusion

In the research, the effect of land consolidation on the economic profitability of agricultural enterprises was examined. With the change in the location of the fields, the road distances of the agricultural holdings and therefore the diesel consumption decreased. Most importantly, with the arrival of irrigation systems, product varieties in the project area have changed and profitability has increased. Based on the results of the analysis, it is seen that land consolidation increases profitability in the neighborhood.

This research showed that land aggregation studies increase the comfort of agricultural enterprises, as well as their profitability. Land consolidation works are important for the development of agriculture and ensuring food security. The impact of aggregation on economic profitability can also be better combined with analyses to be carried out at different sites.

The study is significant because it provides a comprehensive evaluation of the economic profitability of land consolidation in Turkey for the first time.

The study concretely revealed the effects of land consolidation on economic profitability based on farmers' opinions. The study demonstrates the economic profitability of land consolidation and has achieved its goal.

### Author contributions

**Tayfun ÇAY:** Conceptualization, Field study, Writing-Reviewing and Editing **Ramazan Yoldaş SATILMIŞ:** Data Collection and Analysis, Literature Review, Methodology,

### Conflicts of interest

The authors declare no conflicts of interest.

### References

1. UNFPA (2022). World Population Prospects Summary of Results.
2. TUIK (2021). Adrese Dayalı Nüfus Kayıt Sistemi 2021 Sonuçları.
3. Cay, T., & Satilmis, R. Y. (2019). Arazi Toplulaştırma Projelerinin Ekonomik Analizi: Üçhüyük Mahallesi, Çumra-Konya-Türkiye Örneği. Geomatik, 5(2), 112-119.
4. Mevlüt, U. (2019). Comparison of different interpolation techniques in determining of agricultural soil index on land consolidation projects. International Journal of Engineering and Geosciences, 4(1), 28-35.

5. Asgarova, M. (2023). The assessment and management of soil fertility using GIS and remote sensing. Advanced Land Management, 3(2), 97-106.
6. Salvati, L., Kosmas, C., Kairis, O., Karavitis, C., Acikalin, S., Belgacem, A., et al. (2016). Assessing the effectiveness of sustainable land management policies for combating desertification: A data mining approach. Journal of environmental management, 183, 754-762.
7. Eroğlu, H., & Şişman, Y. (2020). Arazi toplulaştırması dağıtım işleminde tek amaçlı genetik algoritmanın kullanılması. Geomatik, 5(2), 91-99.
8. Moravcová, J., Koupilová, M., Pavlíček, T., Zemek, F., Kvítek, T., & Pečenka, J. (2016). Analysis of land consolidation projects and their impact on land use change, landscape structure, and agricultural land resource protection: case studies of Pilsen-South and Pilsen-North (Czech Republic) (Article in Press). Landscape and Ecological Engineering, 1-13. doi:10.1007/s11355-015-0286-y.
9. Jin, X., Xu, X., Xiang, X., Bai, Q., & Zhou, Y. (2016). System-dynamic analysis on socio-economic impacts of land consolidation in China. Habitat International, 56, 166-175.
10. Uyan, M. (2023). Investigation of the effect of urban growth on agricultural areas: A case study in Konya/Türkiye. Advanced Land Management, 3(1), 34-40.
11. Hiironen, J., & Riekkinen, K. (2016). Agricultural impacts and profitability of land consolidations. Land Use Policy, 55, 309-317.
12. Cay, T., Ayten, T., & Iscan, F. (2010). Effects of different land reallocation models on the success of land consolidation projects: Social and economic approaches. Land use policy, 27(2), 262-269.
13. Cay, T., & Cevik, H. (2009). Arazi Düzenleme Sonuçlarinin Anketlerle Analizi. Selçuk Üniversitesi Mühendislik, Bilim ve Teknoloji Dergisi, 24(3), 11-18.
14. Boztoprak, T., Demir, O., Çoruhlu, Y. E., & Nişancı, R. (2015). Arazi Toplulaştırmasının Tarımsal İşletmelere Etkilerinin Araştırılması. Selçuk Üniversitesi Mühendislik, Bilim ve Teknoloji Dergisi, 3(3), 1-11.
15. Ekinci, K., & Sayılı, M. (2010). Tarım arazilerinin parçalanmasını önlemeye yönelik mevzuat üzerine bir inceleme.
16. Sagaydak, A., & Sagaydak, A. (2021). Agricultural land consolidation vs. land fragmentation in Russia. International Journal of Engineering and Geosciences, 7(2), 128-141.
17. Wang, J., Yan, S., Guo, Y., Li, J., & Sun, G. (2015). The effects of land consolidation on the ecological connectivity based on ecosystem service value: A case study of Da'an land consolidation project in Jilin province. Journal of Geographical Sciences, 25(5), 603-616.
18. Van Huylenbroeck, G., Coelho, J. C., & Pinto, P. A. (1996). Evaluation of land consolidation projects (LCPs): a multidisciplinary approach. Journal of Rural Studies, 12(3), 297-310.
19. Van den Noort, P. (1987). Land consolidation in the Netherlands. Land Use Policy, 4(1), 11-13.
20. Wojewodzic, T., Janus, J., Dacko, M., Pijanowski, J., & Taszakowski, J. (2021). Measuring the effectiveness of land consolidation: An economic approach based on selected case studies from Poland. Land Use Policy, 100, 104888.
21. Pašakarnis, G., Maliene, V., Dixon-Gough, R., & Malys, N. (2021). Decision support framework to rank and prioritise the potential land areas for comprehensive land consolidation. Land Use Policy, 100, 104908.
22. Liao, N., Gu, X., Wang, Y., Xu, H., & Fan, Z. (2021). Analysis of ecological and economic benefits of rural land integration in the manas river basin oasis. Land, 10(5), 451.
23. Bahar, S. K., & Kirmikil, M. (2021). The evaluation of agricultural landowner inputs before and after land consolidation: The Kesik Village example. Land Use Policy, 109, 105605.
24. Tunca, H., & Deliktas, E. (2015). OECD Ülkelerinde Tarimsal Etkinlik Ölçümü: Dinamik Veri Zarflama Analizi/Measurement of Agriculture Efficiency in OECD Countries: Dynamic Data Envelopment Analysis. Ege Akademik Bakis, 15(2), 217.
25. Özlem, E., & Kenan, U. (2012). Arazi Toplulaştırılması Etkinliğinin Belirlenmesi. KSÜ Doğa Bilimleri Dergisi, 15(2), 38-45.
26. Heinrichs, J., Kuhn, T., Pahmeyer, C., & Britz, W. (2021). Economic effects of plot sizes and farm-plot distances in organic and conventional farming systems: A farm-level analysis for Germany. Agricultural Systems, 187, 102992.
27. Janus, J. (2020). A new approach to calculating distances to parcels: A way to increase the accuracy of farm efficiency analyses and the assessment of land consolidation projects. Computers and electronics in agriculture, 175, 105512.
28. Nimetoğlu, S. T. (2013). Karabucak Köyü'nde arazi toplulaştırmasının değerlendirilmesi. Gaziosmanpaşa Bilimsel Araştırma Dergisi, (6), 55-62.
29. Albalasmeh, A. A., Mohawesh, O., Gharaibeh, M. A., Alghamdi, A. G., Alajlouni, M. A., & Alqudah, A. M. (2022). Effect of hydrogel on corn growth, water use efficiency, and soil properties in a semi-arid region. Journal of the Saudi Society of Agricultural Sciences, 21(8), 518-524.
30. Cevik, B. (1974). Konya ili Çumra-Karkın köyünün kültürteknik sorunları ve bu sorunların çözümünde arazi toplulaştırmasının yeri ve önemi üzerinde bir araştırma. Ankara Üniv. Basımevi.
31. Kumbasaroğlu, H., & Dağdemir, V. (2007). Erzurum Merkez ilçede tarım arazilerinde parçalılık durumuna göre tarım işletmelerinin ekonomik analizi. Atatürk Üniversitesi Ziraat Fakültesi Dergisi, 38(1), 49-58.
32. Hamza, K., Arslan, F., & Değirmenci, H. (2018). Arazi toplulaştırma projelerinde yol uzunluklarının analizi: Şanlıurfa Türkeli Köyü örneği. Ziraat Fakültesi Dergisi, 19-25.
33. Bayramoğlu, Z., & Cennet, O. (2004). Arazi Toplulaştırması Yapılmış Tarım Alanlarında Girdi Tasarrufu Üzerine Bir Araştırma, Çumra Küçükköy Örneği. Selcuk Journal of Agriculture and Food Sciences, 18(34), 46-50.

34. Ercan, F. (1973). Türkiye'de arazi toplulaştırma çalışmaları. Köyişleri Bakanlığı, Topraksu Genel Müdürlüğü, Ankara.
35. Celebi, M., & Kara, M. (1989). Karaman Ovasında Toplulaştırma Alanlarındaki Parselasyonun Parsel Boyutları ve Kültürteknik Hizmetlere Etkisi Üzerinde Bir Araştırma. SÜ Fen Bilimleri Enstitüsü, Basılmamış Doktora Tezi, Konya.
36. Taşdemir, N. (2001). Konya-İçeri Çumra'da Tarla İçi Geliştirme Hizmetleri İle Birlikte Uygulanan Arazi Toplulaştırmasının Ekonomik Analizi. Köy Hizmetleri Konya Araştırma Enstitüsü Müdürlüğü, Trakya Toprak ve Su Kaynakları Sempozyumu, 24-27.