



An Overview to Land Consolidation Studies of Aydın-Dalama-Turkey Irrigation Area

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Abstract This study, which presents a general evaluation of the land consolidation project carried out in 11 settlements in the Aydın-Dalama Plain of Turkey, was examined. For this purpose, the consolidation rate, road length, change in parcel shapes, irrigation and drainage channel lengths, state of the engineering structures, land leveling, distribution of enterprises according to land size, land assets of enterprises and changes in parcel size and parcel number values of the consolidation project carried out in Dereköy, Yeniköy, Karahayıt, Kozalaklı, Armutlu, Mesutlu, Şahnalı, Gölhisar, Tepeköy, Baltaköy and Çiftlik neighborhoods were investigated. With the land consolidation, the number of parcels decreased from 4187 to 3301. There has been a 21% decrease in the total number of parcels with consolidation. In the project area, the average deduction rate was 3.6%, the consolidation rate was 22%, and the parcel reduction index was 1.29. As an overall evaluation of agricultural enterprises, the average parcel size increased from 0.76 ha to 0.86 ha, while the number of parcels decreased from 1.39 to 1.22. Land consolidation projects have a high potential to increase agricultural productivity and promote sustainable farming practices. Therefore, the results obtained from the study can contribute to the planning and implementation of similar projects.

Keywords Land consolidation, parcel size, Aydın, consolidation rate

1. Introduction

One of the most important reasons for the necessity of land consolidation (LC) in Turkey is the fragmented agricultural land structure. In many countries, fragmentation is a major problem since the 19th century. It is challenging to achieve the targeted productivity increase in this agricultural enterprise type. LC studies should not only be considered as an assembly of parcels. Other agricultural infrastructure services (such as the construction of farm roads, the establishment of irrigation and drainage networks, land development works, land leveling works, conservation and development of soil and water resources) should also be included in the scope of consolidation.

The Food and Agriculture Organization of the United Nations (FAO) stated that Turkey's total surface area is 78,535,000 hectares, and the total size of this area in terms of land assets is 76,963,000 hectares. According to 2014 estimates, 38,561,000 hectares of these lands are arable agricultural lands, and 11,612,600 hectares are forest lands (FAO, 2014; Tunalı & Dağdelen, 2018). According to 2019 estimates, the value of arable agricultural land decreased by 845,000 ha to 37,716,000 ha. There was an approximately 2-fold increase in forest areas, reaching 22,064,360 ha [1].

As in many countries, abandoning agricultural lands, not processing them, and not renting them to other farmers are due to uneconomic agricultural practices in Turkey. This situation is mainly due to small enterprises not generating sufficient income and fragmented land structure [2].



In Turkey, the responsibility and authority for land consolidation and in-field development services have been entrusted to the State Hydraulic Works (DSİ) [3]. The most crucial advantage of DSİ's implementation of the projects is that land consolidation activities can be integrated with irrigation investments. Table 1 shows the land consolidation projects carried out in Turkey over the years.

Table 1: Land Consolidation Studies in Turkey [4]

YEAR	IMPLEMENTING ORGANIZATION	AREA (ha)
1961-2007	General Directorate of Rural Services - Special Provincial Administrations	582,000
2007-2018	General Directorate of Agricultural Reform - Provincial Directorates of Food, Agriculture and Livestock	3,018,021
2018-2023	General Directorate of State Hydraulic Works	3,673,566
TOTAL	-	7,273,587

When Table 1 is examined, land consolidation projects continue to increase yearly. LC works were first started in 1985 in Aydın-Türkiye province, and the project was completed on an area of 67,495 hectares in 2018. After 2018, as a result of the institution change, all LC operations were transferred to the State Hydraulic Works (DSİ) (Table 2).

Table 2: Distribution of LC Studies conducted in Aydın Province by Institutions [4].

Years	Institutions	Status	Project Number (pcs)	Area (ha)	Settlement (pcs)
(1985-2004)- (2004-2008)	Rural Services - Special Administration Period	Completed	26	33,895	69
(2006-2011)- (2011-2018)	General Directorate of Agricultural Reform (TRGM) – Ministry of Food, Agriculture, and Livestock (GTHB)	Completed	6	33,600	60
(2018-2021)	DSİ	Continues	2	21,900	43
Total		-	34	89,395	172

[5] examined and evaluated the changes in Yeniciftlik Village of Canakkale after the LC Project. The total parcel number decreased about 63%. Consolidation and irrigation rates were found 63% and 81.6% respectively. All parcels were provided with a road and an irrigation system. It has been determined that the living conditions of the holdings were improved in social and economic aspects and their income levels were increased considerably. Another study was conducted to evaluate the performance of irrigation in Eskisehir Beyazaltın Village, with LC, number of rectangular parcels increased from 6.82% to 89.5%. A 25.19% decrease was observed in total number of parcels. Local consolidation rate was determined as 25% and irrigation ratio was 100%. All parcels had on access to road network. An improvement in life standards and incomes of 100% households were provided [6]. [7] did a scientific study about general trend of the academic research on LC. Most of the subjects investigated were the effect of LC on land fragmentation, number of parcels and the average parcel size. It is reasonable for the researchers to focus on these issues, because the most important goal of LC is to decrease the number of parcels and increases the size of parcels.

This study's primary purpose is to evaluate the land consolidation works (the general conditions of on-farm development services-TIGH (road length, change in parcel shapes, irrigation and drainage channel lengths, state of the engineering structures, land leveling, distribution of enterprises according to land size, land assets of enterprises) completed in 2011 in 11 settlements (Dereköy, Yeniköy, Karahayıt, Kozalaklı, Armutlu, Mesutlu, Şahnalı, Gölhisar, Tepeköy, Baltaköy and Çiftlik) in the Dalama Plain of Aydın-Türkiye province. Thus, it aims to create a resource for other regional projects.



2. Materials and Methods

Aydın is generally known as a farming and tourist town. Agricultural sector provides livelihood to 55% of the population. Aydın ranks top 10 in 25 of the crops produced in Turkey. In Turkey, Aydın ranks first in figs and chestnut production, second in olives, cotton, artichoke and strawberry production and third in peanut production [8].

Within the scope of the study, Land Consolidation and On-Farm Development Services projects in Dereköy, Yeniköy, Karahayıt, Kozalaklı, Armutlu, Mesutlu, Şahnalı, Gölhisar, Tepeköy, Baltaköy and Çiftlik neighborhoods were completed in 2018 (Fig. 1).

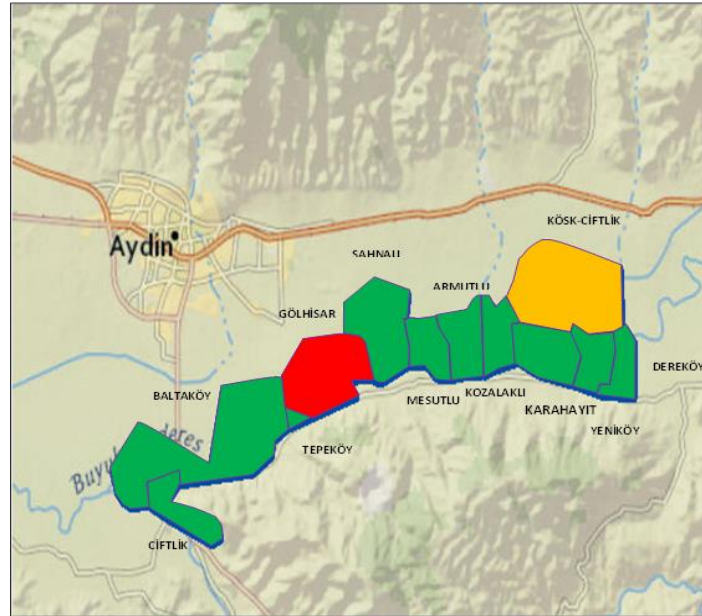


Figure 1: Study area of the consolidation projects.

Within the scope of the project for the purpose of the implementation of LC activities, Geographic Information System (GIS) aided computer programs Netcad and Nettop LC were used. The program was developed with the support of the General Directorate of Agrarian Reform to allow consolidation projects within the framework of the Technical Instructions for LC. Operations performed with Nettop were; digitization of existing cadastral maps, to be introduced to the module the relevant cadastral parcels to whom it belongs, new block plan preparation, calculation of index scores required for the relevant project area. After index calculations were made, farmers' block preferences for their new parcels were taken and these preferences transferred to Netcad environment. According to these choices, distributions of the new plots were made and consolidation reports and document of titles printed [9]. In order to determine the effectiveness of LC; farm holdings size distribution, parcel shape, length of roads and consolidation rates were determined before and after consolidation.

One of the most important indicators of the success of the project carried out in consolidation areas is the size of the consolidation rate. As the consolidation rate increases, enterprise management becomes more appropriate, and land consolidation projects' efficiency increases. In other words, input costs, such as labor, machinery, etc., per enterprise decrease as this ratio increases. In this study, average parcel size, number of parcels, and deduction rate values from parcels in the project area were examined in order to evaluate the project area. In addition, equations (1) and (2) were used to determine the consolidation rate and parcel reduction index [10, 11, 12]:

$$\text{Consolidation Rate} = \frac{\text{Pre consolidation parcel numbers} - \text{Post consolidation parcel numbers}}{\text{Pre consolidation parcel numbers}} \quad (1)$$

$$\text{Parcel Reduction Index} = \frac{\text{Pre consolidation parcel numbers}}{\text{Post consolidation parcel numbers}} \quad (2)$$



By the increase of this rate agricultural holdings becomes more appropriate, the effectiveness of LCPs increases in terms of business administration and duration. Consolidation ratio in land consolidation projects in Turkey is approximately 43%. This ratio is 80% in Spain and 82% in Germany [13]. In Turkey, due to the small amount of land owned by the farmers and too heavy fragmentation of land consolidation ratio is low.

In Turkey, especially in recent years some land development studies such as land levelling, renewal of farm roads and improvement of irrigation and drainage canals are carried out with LCPs. Again, monitoring and evaluation of these studies are very important in determining the consolidation effectiveness. Consideration of the efficiency in construction of irrigation networks is very important. For this purpose, it is necessary to determine the irrigation rate values. The main factor that leads to a low rate of irrigation in irrigation projects in Turkey is small, irregular, scattered parcels of agricultural lands and irregular length of irrigation network. As an alternative solution to these problems, improvement of land consolidation and network density are pointed out as necessary.

Nettop Land Consolidation module is used to determine the criteria except consolidation and irrigation rates. In the Nettop software it is provided in tables of all values by entering some inputs on Reports / Social Studies reports menu. After this process the data is obtained separately for each village and the results transferred to Microsoft Excel [14].

Finally, the situation of agricultural enterprises in the project area was examined. For this purpose, first of all, the average parcel size value per enterprise is obtained by dividing the size of the project area in hectares by the number of parcels. The average number of parcels per enterprise was determined by dividing the number of parcels in the project area by the number of enterprises [7, 15].

3. Results & Discussion

Within the scope of Aydın Dalama Plain 2st Part Land Consolidation and In-Field Development Services projects, the project area, number of enterprises, and the deducted area rates on a neighborhood basis for the 3828 ha part of the project area given in Table 3.

Table 3: General information about the project area

Neighborhood	Total Area (ha)	Number of Enterprises (pcs)	Deduction Rate (%)
Armutlu	305	281	3.8
Baltaköy	715	579	3.9
Dereköy	197	123	3.6
Göhlhisar	652	483	2.2
Karahayıt	399	290	3.9
Kozalaklı	281	289	5.1
Mesutlu	253	253	3.9
Şahnalı	674	333	4.5
Tepeköy	10	15	4.4
Yeniköy	263	126	3.2
Efeler Çiftlik	79	16	1.3
TOTAL	3828	2788	3.6

Among the neighborhoods included in the project, the largest area are Baltaköy and Şahnalı neighborhood. After that, the largest project area is in Göhlhisar, Karahayıt and Armutlu neighborhoods, respectively. The Development Readjustment Share (DOP) deduction rate in the project area was 3.6% throughout the project area. A cut of 1.3-5.1% was made in all neighborhoods. The deduction rate in all neighborhoods in the project area is below 10%. It is preferred that there is no significant difference between the deduction rates made in settlements that are close to each other. This way, farmers will be made to think they are not being mistreated. This will positively affect farmer satisfaction, an essential criterion in evaluating land consolidation projects. In their study examining the Denizli Tavas Plain Consolidation Projects, [16] reported that the deduction rate in 8



villages in the project area varied between 2.20-5.50%, with an average of 4.02%. It is observed that the deduction rate is relatively high in this study compared to the literature. However, the project covers a significant part of the area allocated to the Irrigation Services, and Tourism Road works carried out by DSI and the General Directorate of Highways after the land consolidation and On Farm Development Services Projects in the district. In addition, it is thought that the closeness of the deductions made on a neighborhood basis also positively affects the project's success.

The project area consolidation rate and parcel reduction index values, which are among the most important criteria in evaluating the success of consolidation works, are given in Table 4.

Table 4: Consolidation rate and parcel reduction index values according to the number of parcels in the project area

Neighborhood	Pre-Consolidation Parcel Number (pcs)	Post-Consolidation Parcel Number (pcs)	Consolidation Rate (%)	Parcel Reduction Index
Armutlu	366	295	19.40	1.24
Baltaköy	753	576	23.51	1.30
Dereköy	260	173	33.46	1.50
Göhlhisar	824	683	17.11	1.20
Karahayıt	443	350	20.99	1.26
Kozalaklı	412	313	24.03	1.31
Mesutlu	329	314	4.56	1.04
Şahnalı	564	397	29.61	1.42
Tepeköy	10	16	-	-
Yeniköy	216	159	26.39	1.35
Efeler	10	25	-	-
Çiftlik	10	25	-	-
TOTAL	4187	3301	22.0	1.29

When the consolidation rate and parcel reduction index values in Table 4 are examined, it is seen that all neighborhoods, respectively, are below the Turkey average [10, 17]. Considering other regional consolidation works, the project area's consolidation rate is somewhat low [14, 18]. The project area's average parcel reduction index value was 1.29. When the parcel reduction index values reflect the technical quality/efficiency of the consolidation project, they show an increase in parallel with the consolidation rate. The lowest parcel reduction index values are 1.04 and 1.20 in Mesutlu and Göhlhisar neighborhoods, respectively. The highest parcel reduction index values were in the Dereköy, Şahnalı and Yeniköy neighborhoods, with 1.50, 1.42, and 1.35, respectively. In other studies conducted on this subject, parcel reduction index values were determined as 6.1 in Galicia (Spain) according to [11], 4.28 in Serem, and 1.51 in Beyköy according to [12]. According to [15], it was found to be 0.99 in 16 villages in Bingöl Center.

In Table 5, the change in the average parcel areas of the project is given together with the increased rates.

Table 5: Change in average parcel sizes

Neighborhood	Pre-Consolidation Parcel Area (ha)	Post-Consolidation Parcel Area (ha)
Armutlu	0.81	0.97
Baltaköy	0.50	0.93
Dereköy	0.54	0.74
Göhlhisar	0.50	0.77
Karahayıt	0.80	0.86
Kozalaklı	0.66	0.83
Mesutlu	0.74	0.74



Şahnalı	0.89	1.21
Tepeköy	0.92	0.55
Yeniköy	1.18	1.55
Efeler Çiftlik	0.77	0.31
TOTAL	0.76	0.86

The average parcel size value of the post consolidation project area is 0.86 ha. According to Law No. 5403 dated 3/7/2005 on Soil Conservation and Land Use and Law No. 6537 on Amending the Law on Soil Conservation and Land Use (Official Gazette No. 29001 dated 5/5/2014), the minimum income irrigated agricultural land size for Dalama district is accepted as 5.0 ha [19]. Although the average parcel size of the project area is lower than the limit values specified in the Law (Table 6). The changes in the parcels belonging to the agricultural enterprises in the project area are examined in Table 6.

Table 6: Data on agricultural enterprises located in the project area

Neighborhood	Average Parcel Size per Enterprise (ha)		Average Number of Parcels per Enterprise (pcs)	
	Pre Consolidation	Post Consolidation	Pre Consolidation	Post Consolidation
	Armutlu	0.81	0.97	1.30
Baltaköy	0.50	0.93	1.30	0.99
Dereköy	0.54	0.74	2.11	1.41
Göhlhisar	0.50	0.77	1.71	1.41
Karahayıt	0.80	0.86	1.53	1.21
Kozalaklı	0.66	0.83	1.43	1.08
Mesutlu	0.74	0.74	1.30	1.24
Şahnalı	0.89	1.21	1.69	1.19
Tepeköy	0.92	0.55	0.67	1.07
Yeniköy	1.18	1.55	1.71	1.26
Efeler Çiftlik	0.77	0.31	0.63	1.56
TOTAL	0.76	0.86	1.39	1.22

From the results in Table 6, the average parcel size per enterprise in the project area increased from 0.76 ha to 0.86 ha. After completing the project, the highest and lowest average parcel size values per enterprise were seen in Yeniköy and Çiftlik neighborhoods, respectively. However, when the proportional changes of these values are examined, the highest parcel size increase occurred in Şahnalı and Yeniköy neighborhoods with 36% and 31% respectively; and the lowest parcel size increase occurred in Mesutlu neighborhood. Again, when the number of parcels in the project area is evaluated, the average number of parcels per enterprise between 0.99 and 1.56. However, some change was observed before and after the project.

Cadastral maps were used in order to identify parcel shapes before and after LCP. All parcels were examined individually. Parcels divided into five groups according to their shapes as rectangle, square, triangle, trapezium and shapeless. Parcel shapes before and after LCP were given in Table 7.

Table 7: Parcel shapes before and after the consolidation project

Project Area		Rectangle		Square		Triangle		Trapezium		Shapeless	
		Nmbr	%	Nmbr	%	Nmbr	%	Nmbr	%	Nmbr	%
Armutlu	Pre Consolidation	137	37.74	10	2.75	16	4.41	110	30.30	90	24.79
	Post Consolidation	129	43.73	13	4.41	9	3.05	101	34.24	43	14.58
	Pre	34	19.54	8	4.60	8	4.60	46	26.44	78	44.83



Efeler	Consolidation										
Çiftlik	Post Consolidation	5	20	-	-	-	-	16	64	4	16
Karahayıt	Pre Consolidation	140	29.91	6	1.28	39	8.33	145	30.98	138	29.49
	Post Consolidation	116	33.14	7	2.00	17	4.86	124	35.43	86	24.57
Mesutlu	Pre Consolidation	104	25.24	6	1.46	5	1.21	131	31.80	166	40.29
	Post Consolidation	149	47.45	7	2.23	8	2.55	109	34.71	41	13.06
Tepeköy	Pre Consolidation	1	8.33	-	-	-	-	6	50.00	5	41.67
	Post Consolidation	2	12.50	-	-	1	6.25	7	43.75	6	37.50
Dereköy	Pre Consolidation	69	25.56	1	0.37	23	8.52	101	37.41	76	28.15
	Post Consolidation	49	28.32	7	4.05	9	5.20	62	35.84	46	26.59
Baltaköy	Pre Consolidation	194	9.64	38	1.89	117	5.82	562	27.93	1101	54.72
	Post Consolidation	153	26.56	13	2.26	28	4.86	226	39.24	156	27.08
Göhlisar	Pre Consolidation	204	23,08	21	2,38	52	5,88	339	38,35	268	30,32
	Post Consolidation	230	33.67	23	3.37	26	3.81	288	42.17	116	16.98
Kozalıklı	Pre Consolidation	148	31.49	9	1.91	29	6.17	141	30.00	143	30.43
	Post Consolidation	131	41.85	10	3.19	11	3.51	107	34.19	54	17.25
Şahnalı	Pre Consolidation	78	20.37	8	2.09	24	6.27	128	33.42	145	37.86
	Post Consolidation	147	37.03	10	2.52	18	4.53	107	26.95	115	28.97
Yeniköy	Pre Consolidation	39	20.31	1	0.52	17	8.85	55	28.65	80	41.67
	Post Consolidation	34	21.38	1	0.63	5	3.14	68	42.77	51	32.08

When the distribution of parcel shapes examined in the project area, average shapeless parcels were found to be with 22.7%. After the project is completed average rate was rectangular parcels (28.6%). Biggest change from shapeless to rectangle were seen in Mesutlu, Armutlu and Kozalıklı village. One of the LCPs goals is to create rectangular parcel which is best for agriculture. In this study area, the average rectangular shaped parcels was approximately 28.6%. However, it was not possible to plan all of the parcels as rectangular shaped because of the boundary of the irrigation area and also blocks. After the LCP in Konya-Çumra-Küçükköy, shapeless and polygon parcel rates were decreased from 83% to 16% [20]. Smooth rectangular and trapezoidal parcel ratio before LC were determined 82.9% in Yuvatepe, 62.2% in Bolukyazi, 79.3% in Hamidiye and 79.5% in Kilbasan. This ratio was respectively 78.5%, 81.4%, 91.9% and is 87.7% after LCP. Smooth rectangular and trapezoidal parcel ratio has increased in all except Yuvatepe project [21].



One of the main objectives of the LCPs is to ensure that all parcels benefit from the transport network in the area. Using completed transport lines through consolidation, farmers should be able to go to their fields four seasons and implement all agricultural mechanization activities. Before LC the presence of many small parcels in the area interrupts the transportation, available transport network is provided with access often obtained through legal fight for access rights or agreements between farmers as well [22]. The lengths of the transportation system information relating to settlements were given in Table 8.

Table 8: The length of transportation system before and after land consolidation (LC)

Project area	Parcels number benefiting from road service before LC (number)	Parcels number benefiting from road service after LC (number)	Transportation system length before LC (m)	Transportation system length after LC (m)	Road per parcel before LC (m/ha)	Road per parcel after LC (m/ha)
Armutlu	132	295	4530	20998	1.22	5.65
Baltaköy	368	576	9305	61973	2.50	16.67
Efeler Çiftlik	10	25	1956	2183	0.53	0.59
Göhlhisar	328	683	9876	42756	2.66	11.50
Karahayıt	186	350	8084	34915	2.17	9.39
Kozalaklı	214	313	4444	29196	1.20	7.85
Mesutlu	78	314	4470	18565	1.20	4.99
Şahnalı	234	397	13192	37733	3.55	10.15
Tepeköy	9	16	0	0	0	0
Yeniköy	67	159	2434	16159	0.65	4.35
Dereköy	117	173	1868	12671	0.50	3.41
TOTAL	1743	3301	60159	277149	16.18	74.55

The numbers of parcels benefiting from road service were 1743 in the project area before LC; after LCP, this value increased to 3301, an increase of 89.3%. On the other hand, transportation length of 60159 m road before LC increased to 277149 m after LC. The increase in road length was determined as 360%. Largest increases occurred in the village of Baltaköy, Göhlhisar and Yeniköy. Each parcel path planning is done on the basis of the provision of transport services was increased the number of field plots on the road after LCP. In this regard, while the amount of roads per unit area was 16.18 m/ha before LC; after LC, the amount of roads per unit area increased to 74.55 m/ha. It can be seen that, in the planning, all of the parcels were provided with road access. Similarly; in Cemalettin village (Boyabat – Duragan Participatory Land Consolidation Project) with LC a total of 17 870 meters field roads were made to provide access to 545 parcels. While road length was 4 900 m before LCP in the research area, road length reached 22 770 m after consolidation with a 17 800 m of increase. Again in Cemalettin village; amount of roads per unit area was 12.93 m/ha before LC, it is increased to 69.34 m/ha after LC. Maximum amount of roads built with LCPs were in Cemalettin Village [23].

4. Conclusion

In this study, the land consolidation project completed in 2018 in the area covering 11 settlements in the Dalama plain was evaluated in general terms. The average consolidation rate in the project area was 22%, and the parcel reduction index was 1.29. This value was slightly below the Turkish average. However, when examined on a village basis, since the number of parcels per enterprise was not a very high value before the project, it becomes clear that the shareholding status of the lands should also be taken into consideration when examining the problem here. The projects should aim to reduce the amount of shared land. One of the primary goals of the consolidation projects is to provide irrigation networks and transportation to all parcels. This study provided all



parcels that benefitted from road networks, one of the success indicators of the On-Farm Development Services project. Parcel sizes, especially in the Aegean Region, are lower than in some other regions in Turkey. Here, the lands' productivity and economic values are very effective. For this reason, it is concluded that parcel sizes do not increase much.

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