

ENGINEERING AND ECONOMIC CALCULATIONS FOR ASSESSING LAND CONSOLIDATION

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Abstract. Land consolidation is a new concept in Latvia, although in other countries of the world it has been known since the end of the 18th century. Land consolidation is implemented to improve the spatial structure of land holdings and agricultural infrastructure and to rationally use natural resources. It is particularly significant in agriculture when establishing farms of optimal size and territorial location. Land fragmentation hinders not only land management but also increases the transport cost. In the present research, land consolidation is viewed as an excellent instrument to enhance the spatial structure of agricultural holdings, reduce land fragmentation and increase the area size of agricultural holdings by fostering efficient use of land in accordance with the territorial development plan determining land uses in the future. The case of land consolidation and the calculation of the consolidation efficiency are based on Zemgale region Vircava parish of Jelgava municipality, as a benchmark for the region most suited for agricultural production in Latvia. Determining the economic gains from land consolidation may be based on the developed model for calculating the economic indicators of farms.

Keywords: land consolidation, farm, land parcel, land plot.

Introduction

In rural areas the issue of an efficient use of land is becoming more and more popular, since as a result of the last land reform farms and their land properties have been established on several land parcels, located far from the main plot, thus causing land fragmentation. According to the previous studies of the authors which relied on the data of the State Land Service of the Republic of Latvia, yet in 2012, the average total area of farmland plots in property and the land plots in use were only 7.3 ha, moreover almost a third of the total numbers of properties are land properties the area of which is up to 1 ha [1]. These data indicate quite a pronounced fragmentation of the areas of agricultural land properties. Although the initial regulatory enactments of the last land reform envisaged the development of beneficial territorial preconditions for successful agricultural development, recommending to create compact farms avoiding inter-areas, quite often in practice due to different objective and subjective reasons the agricultural land properties were formed on several land parcels, thus causing land fragmentation [2]. Thus, the issue of land consolidation, which has been widely discussed in Western Europe since the end of the 18th century, has become topical in Latvia.

The term land consolidation is traditionally used with regard to taking measures to overcome land fragmentation and establishing optimal farm areas. However, this term is used not only pertaining to the redistribution of land with the purpose to avoid land fragmentation, but it has been used in a much wider sense. *Land consolidation*, according to the UN Food and Agriculture Organisation methodology [3] may be defined as a set of *social, economic, legal and technological activities intended for enhancing the use of land, the tasks of which, given the interests of population, are as follows:*

- improving the spatial structure of land holdings;
- developing rural territories;
- consolidating too fragmented land parcels;
- increasing the size of agricultural enterprises up to optimal sizes;
- introducing the newest technologies and machinery;
- developing sustainable agriculture and socioeconomic infrastructures in rural areas;
- environmental protection and creating sustainable ecosystems.

In most European countries during the recent or more distant past, land consolidation has been carried out and due to that significant issues have been resolved for more rational and economical land management. Land exchange has been determined as a major activity with the aim to unite fragmented land plots, thus eliminating land fragmentation. Land consolidation can increase agricultural production on competitive farms and reduce the production costs [4].

In Latvia it was only in the 90s of the last century when the concept of land consolidation started to be used. With regard to the regulative enactments, it was first included in the Land Survey Law adopted on September 14, 2006, where *the concept of land consolidation is explained as a set of measures which is implemented in the public interest and proposed by natural or legal persons, State, or local government in order to optimize the land use.*

Even though land consolidation is stipulated as one of the land use planning tasks in the current Land Use Planning Law, unfortunately, such projects are not developed in practice. Given the foreign experience [5], land consolidation projects are more complicated, larger-scale activities than land distribution, simple land exchange activities that are presently carried out within land use planning projects in Latvia; therefore, land consolidation requires its own legal framework.

However, despite all that, several improvements are expected with regard to the initiation of development of land consolidation projects, when the Land Management Law enters into force. This Law will determine the project start-up procedure. The draft of the Land Management Law has been developed in compliance with the Cabinet Regulation No 214 of 19 April 2010 “On the Concept of Land Management Law” and the Cabinet Regulation No 613 of 13 October 2008 “On the Land Policy Guidelines 2008-2014”.

The Land Management Law will include an important regulatory tool for land consolidation, creating a legal prerequisite for consolidating agricultural lands into a more advantageous land plot, resulting in larger farms. The objective of the new law would be not only to regulate the unsolved issues of the land reform, but also regulate the land consolidation issues in Latvia, since land consolidation is one of the means to enhance more efficient land use, achieving higher productivity and meeting the needs of society. Good evidence of the necessity of this law is the long and complicated “way” the Law draft has covered until reaching its adoption stage, with several ministries and interested institutions being involved in the discussions.

Aim of the research: land consolidation as an integrated instrument for the sustainable development of agricultural holdings. *Main task:* to calculate technical and economic indicators in order to analyse the current situation of the farms included in the project before and after the implementation of this land consolidation project. The case of land consolidation and its engineering and economic calculations are based on Vircava parish as a benchmark for the region most suited for agricultural production in Latvia.

Materials and methods

The State Land Service State Real Estate Cadastre Information System data on Vircava parish of Jelgava municipality were summarised in the present research (as of 1 September 2010).

A model for calculating the economic indicators of farms was developed using the computer program *Poversim Studio*.

In the model, the distance is calculated in kilometres – from the farm centre to a land parcel. In case the land owner does not live in the project territory, the distance to the largest parcel is calculated. The decision to calculate the distance to the largest parcel is appropriate in the present situation, as the land consolidation project purpose is to liquidate intermediate land parcels and increase the size of main land parcels. The distance has to be calculated based on the road network depending on the type of the road surface: asphalt (1.00), gravel (1.25) or rural roads (1.60), applying the road quality coefficient to select the best transport route.

Some land parcels of the farm are of various sizes, therefore, the amount of loads to be transported from various parcels may differ. For this reason, it is advised to use the *weighted average real distance* in which the size of the land parcel serves as a weight:

$$R = \frac{\sqrt{rp}}{\sum p} \quad (1)$$

where R – weighted average real distance, km;

p – land of agriculture use (UAA) of the land parcel, ha;

r – distance from the farm centre to land parcels, km.

To calculate the amount of loads to be transported on the farm and the load transport cost, excluding the cost of loading and unloading, before and after the project, Formulas 2 and 3 were employed in the present research.

An amount of loads transported on the farm (P_k) is calculated according to Formula 2:

$$P_k = R \cdot P_s \cdot k \quad (2)$$

where R – average weighted real distance between the farm centre and the main fields of agricultural land, km;

P_s – size of agricultural land of the farm, ha;

k – amount of loads to be transported per hectare of agricultural land – 10 t·ha⁻¹; depending on the specialisation of farms, this indicator value may be changed in the present research; it is assumed based on gross margin calculations performed by experts of the Latvian Rural Advisory and Training Centre [6].

Load transport cost (P_i), excluding the cost of loading and unloading, is calculated, according to Formula 3:

$$P_i = P_k \cdot a \cdot K_n \quad (3)$$

where a – load transport cost per kilometre – EUR 0.90, which is derived, according to the Latvian Rural Advisory and Training Centre experts' gross margin calculations, taking into consideration the labour cost, fuel consumption and depreciation [6].

K_n – coefficient of unaccounted transports and trips (≈ 1.3).

Results and discussion

A land consolidation project requires a lot of financial, labour and time resources, therefore, the necessity for the project and the gains have to be economically justified. An analysis of the project cost and gains may be a credible means when making a decision on the project implementation and the acquisition of financial resources. Accordingly, it is required to elaborate a quite precise methodology for analysing the costs/gains and to develop instruments for implementing the project.

The land consolidation project involves a lot of various advantages, yet, in the present situation the author focuses on gains from the exchange of land parcels. Problems may be faced when making precise calculations, as various factors can make their effects in the project territory: land parcel size, configuration, distance etc. In the result of the project, some farmers would gain more, some less.

In the present research, it is very difficult to determine an increase in productivity after the land consolidation project implementation, as agricultural production prices may differ across various regions. Accordingly, the factors affecting the crop yield increases will not be calculated. The case of land consolidation does not envisage investment in raising land productivity (for instance, projects of construction/reconstruction/renovation of amelioration systems etc.). It means that the gains arise from the change in the land cultivation cost before and after the consolidation project. The main kinds of costs that will change:

- land cultivation costs, as the configuration of the land parcel will improve;
- land cultivation costs, as the size of the land parcel will increase;
- agricultural machinery costs, as the average distance from the farm centre to its parcels will decrease.

The case of land consolidation and the calculation of the consolidation efficiency are based on Zemgale region Vircava parish of Jelgava municipality, as a benchmark for the region most suited for agricultural production in Latvia. The present research includes eight economically most prospective farms in Vircava parish. Overall, the areas of land possessed by all the farms are relatively large (within a range of 215-1135 ha), yet, their individual land parcels are spread across the entire territory of the parish [2].

In the present research, land consolidation is used as an instrument to reduce land fragmentation, enhance the spatial structure of farms and increase the area size of farms by fostering efficient use of land in accordance with the territorial development plan determining land uses in the future.

The project seeks alternative solutions to make the farms compact by exchanging their land parcels in order to reduce the distances covered and form larger land parcels. Small territorial improvements can serve as the first step towards extending the current land parcels and planning prospective consolidated parcels, thus gradually liquidating the fragmentation of land.

The elaboration of the land consolidation project in Vircava parish is based on a cadastral map, and the Field Register geographic information map of agricultural parcels is used for a detailed analysis of the territories, which enables us to identify particular land parcels, infrastructure objects and natural obstacles (rivers, ditches) that have to be taken into account when working on the project.

The project was elaborated for the territories for which the permitted and planned use is agriculture, in accordance with the municipality territorial planning documents. While working on the land consolidation project, the territories in which prospective consolidated land parcels will be formed were encircled in the map.

In the present research, a territory of monolithic land plot, according to V.Paršova and E.Kāpostiņš, is the land owned by an individual and a set of land parcels, belonging to other individuals, with a common external boundary. So, a territory of monolithic land plot may consist of several land parcels (or part of the land parcel) of different ownership. A territory of monolithic land plot may consist of the land parcels rented by the consolidated parcel holder [7].

It is advised to establish prospective consolidated land parcels in the vicinity of the main parcel where the agricultural production centre is located. For instance, the territory of monolithic land plot for Farm No 2 is formed around the residential building and production premises, planning all the possessed parcels as close as possible (Fig. 1).

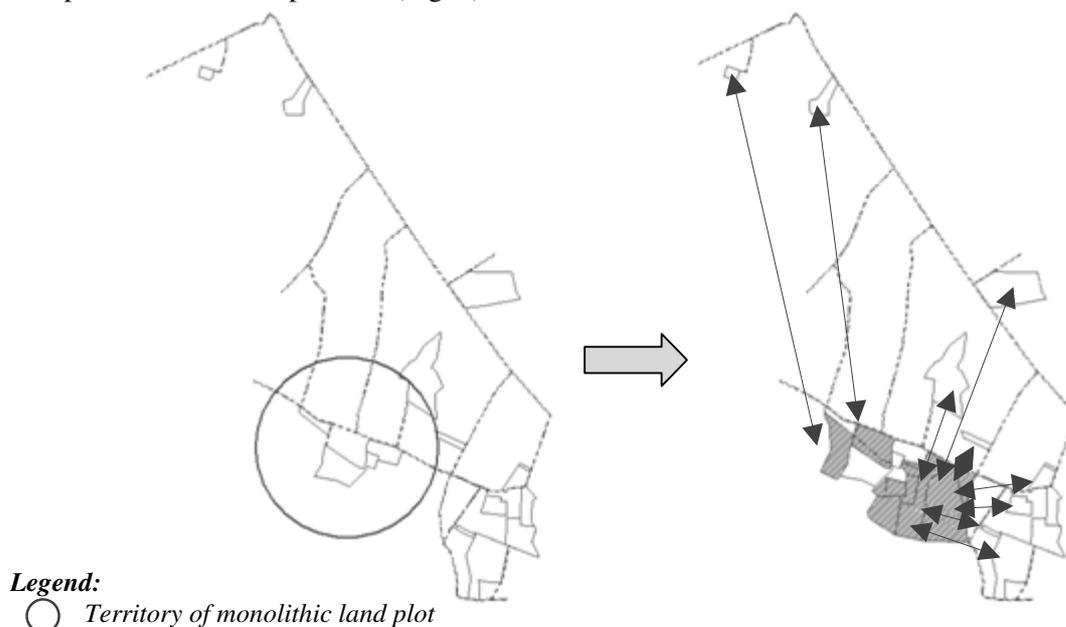


Fig. 1. Formation territory of monolithic land plot for agricultural holding No 2 in Vircava parish

Within the project, voluntary decisions on exchanging land parcels have to be made and the minimum offer of land of equal value has to be accepted or compensation in money has to be paid for a higher value of land.

The elaboration of proposals for exchanging land parcels takes place until the prospective consolidated parcel becomes compact - within limits, all the intermediary parcels are liquidated, the distance between particular parcels is reduced, the average area of agricultural land per parcel is increased and the configuration of the land parcel is enhanced.

According to the land consolidation project, enhancing the spatial structure of farms causes considerable changes in the management of territories and production of farms; therefore, within the project, the efficiency of expected changes has to be calculated. To determine the project efficiency, technical indicators, which may be used in analyses of the current situation before and after the

project, are required, but the problem is that the indicators do not yield the final result on the project efficiency in terms of money. By employing the technical indicators, the economic indicators of the farms may be calculated for the situation after the project implementation and compared with the corresponding farm indicators before the project implementation.

Calculating the engineering and economic indicators of the farms, the author developed a land consolidation model. In the model offered by the author, the indicators are based on the current situation on the farms so that, within the project, it is possible to analyse gains for the farms that are ready to engage in land consolidation projects to enhance their spatial structure if the current and future situations are compared (Fig. 2).

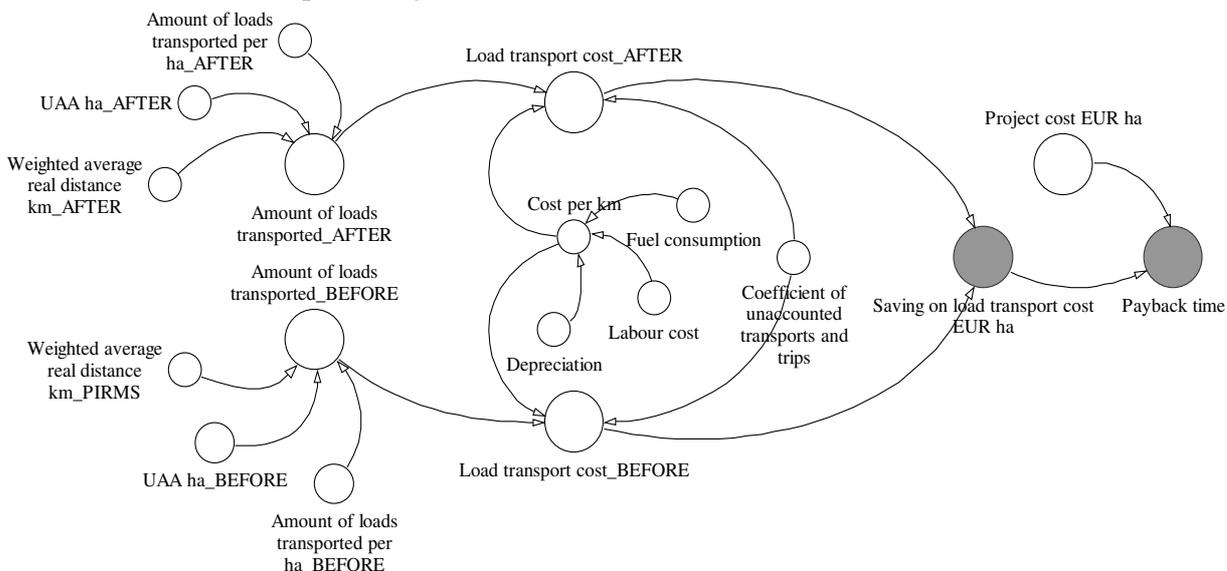


Fig. 2. Model for calculating economic indicators

Individual land parcels of a farm are of different sizes, therefore, the amount of loads to be transported from various parcels may differ. For this reason, it is advised to use the weighted average real distance in which the size of the land parcel serves as a weight.

The indicators calculated by the model show that if farms engage in the land consolidation project, the amount of loads to be transported and the load transport cost decrease (Table 1).

Table 1
Amount of loads transported and the load transport cost before and after the project for the farms involved in the project in the case of Vircava parish

Farm No	Amount of loads transported, thsd. t·km		Load transport cost, EUR		Saving on load transport cost if implementing the project, thsd EUR a year
	Before the project	After the project	Before the project	After the project	
1.	2.7	1.7	3.2	2.0	1.2
2.	7.6	4.2	8.9	5.0	4.0
3.	0.8	3.7	9.3	4.3	5.0
4.	15.0	7.1	17.5	8.3	9.3
5.	20.6	10.4	24.1	12.2	11.9
6.	18.8	11.0	22.0	12.9	9.1
7.	20.0	13.4	23.4	15.7	7.7
8.	53.3	40.7	62.4	47.6	14.7

The greatest saving on the load transport cost may be made by Farms No 5 and 8, as these farms have the longest distances between their parcels, which is one of the factors affecting the quality and timing of the planned field operations. Timing of field operations is critical to agriculture, according to the observations of practitioners [8], as timing determines the best conditions for performing a certain field operation, thereby the quality of an operation performed in a certain period will be the highest,

leading to higher yields per hectare. For example, a delay of sowing by one day may reduce the crop yields by 1-3 %, as technological requirements are not met in time.

The technical and economic indicators of the farms included in the project of Vircava parish are calculated as average indicators both, for the current situation and for the expected situation and are summarised in Table 2.

An overall analysis of the average farm indicators summarised in Table 2 leads to a conclusion that the land consolidation project results in enhancing all the technical and economic indicators, which allows the farms to exploit agricultural land more efficiently, reduce unproductive machinery trips and save on the cost of field operations, i.e., to raise the labour productivity as well as to enhance the conditions for the management of the farm and its internal territory.

Table 2

Average characteristics before and after the land consolidation project for the agricultural holdings involved in the project in the case of Vircava parish

Indicators	On average per farm		
	before the project	after the project	change
Number of land parcels	23.00	4.00	-19.00
Weighted average real distance, km (R)	4.39	2.51	-1.88
External boundary placement coefficient (K_2)	4.71	2.56	-2.15
Farm compactness coefficient (K)	5.43	1.98	-3.45
Farm external compactness coefficient (K_1)	4.42	1.95	-2.47
Main parcel compactness coefficient (K_0)	4.04	2.25	-1.79
Land fragmentation coefficient (K_j)	0.23	0.38	+0.15
Amount of loads transported, thsd. t·km (P_k)	18.20	11.50	-6.70
Load transport cost, ths EUR (P_i)	21.30	13.50	-7.80

The main indicators of land consolidation and their effect on the gains:

- by reducing the distance between parcels and by enhancing the road infrastructure, the cost of agricultural machinery decreases;
- by enhancing the configuration of parcels and by increasing the size of parcels, the proportion of the area needed for unproductive trips and turns decreases;
- management of compact land parcels results in better management of crops. Compact land parcels are maintained more carefully (better fertilising, spraying chemicals, etc.), which increases the crop yields.

Analysing the gains, changes in crop yields are not taken into consideration, as it is difficult to calculate the other consolidation factors that make effects. The greatest gains may be expected when the main indicators of land consolidation change after the land consolidation project implementation. Accordingly, within the project, the indicators are calculated, both for the present situation and for the expected situation, determining the saving on the load transport cost (EUR) and the payback period.

Based on the in-depth interviews with the experts – leading specialists – the author, in her research, calculated the provisional cost for implementing the land consolidation project based on the project of Vircava parish, which totalled EUR 614 thsd or 188 EUR·ha⁻¹, taking into account the number of parcels possessed by the farms and the total land area.

The overall payback period of the land consolidation project of Vircava parish is 10 years, yet, it has to be considered that the given land consolidation project, which is based on Vircava parish as a benchmark for the region most suited for agricultural production in Latvia, is recommendable; if implementing this project, in addition, the wishes of land owners, endogenous and exogenous factors and other circumstances have to be taken into consideration, which points to the fact that the cost of implementing land consolidation in a particular rural area and at the current stage of economic development in the country will change.

Conclusions

1. Determining the economic gains from land consolidation may be based on the developed model for calculating the economic indicators of farms.
2. If land consolidation does not yield saving on costs in physical terms, the solution of this essential consolidation problem, from the perspective of long-term development, will lead to higher labour productivity, higher competitiveness of agricultural products and more rational long-term management.
3. To implement a particular land consolidation project in Latvia, a legal framework is necessary. The complicated and long decision-making process of the draft law on land management, which one of the most important provisions refers to land consolidation, indicates the importance of and necessity for this activity.

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