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Preliminary communication

Analysis of The Impact of Land Consolidation Projects on Groundwater Level and Land Quality in The Republic of Serbia

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Abstract: The research carried out in this paper connects land, as a non-renewable and necessary resource, with land consolidation, whose primary task is the arrangement of the land territory, with the aim of determining the extent to which land consolidation projects affect the land itself, as well as to assess the impact of land consolidation to sustainable development. The research is based on the analysis of changes in the quality of the soil, after the realization of land consolidation projects. The studies that were carried out showed that the level of underground water was significantly reduced after the realization of the land consolidation projects. The goal of the research is defined in accordance with the modern definition of land consolidation, according to which compaction tends more and more towards sustainable development and conservation of land. Therefore, in the paper, land consolidation is presented as a measure that resolves the conflict between short-term and long-term goals of spatial planning and land conservation.

Keywords: groundwater level; land consolidation; soil; sustainable development

1 INTRODUCTION

Exploitation of land potential as the basis of economic and social development is an imperative of modern civilization. The estimate of the growth of the human population is described by an exponential function in the following period, which implicitly indicates a similar function of the growth of the needs for food and space. Bearing in mind the limitation of non-renewable land resources, as well as the limitation of spaces suitable and desirable for human life, the only possibility is to find a solution for the sustainable management with mentioned resources.

Land consolidation, which was originally created on the premise of consolidating fragmented properties, has expanded the domain of research as a scientific discipline to the possibilities of solving a number of other related areas, on which it can have a significant impact: from economic development to the implementation of projects of strategic importance for certain areas, countries and regions. Today, land consolidation has retained its primary goal, to group plots and improve agricultural production, but it has also expanded its research domain towards environmental protection and sustainable development, so today land consolidation and sustainable development cannot be viewed separately. Therefore, land consolidation today can be defined as an indispensable instrument that affects sustainable development.

Land consolidation is an important instrument for rural development in Europe, Asia and Africa [1-3]. Land consolidation is widespread in Europe: it is currently implemented in 26 of the 28 countries of the European Union [4]. In most countries where land consolidation projects are implemented, redistribution of land is the most critical aspect, so land consolidation goals are mainly focused on land redistribution [5].

Therefore, many studies were conducted that were focused on the analysis of the effects achieved by the realization of land consolidation projects on the elimination of land fragmentation and the improvement of the efficiency of rural development. For example, in Finland, based on the evaluation of 12 land consolidation projects, it was concluded that the average plot size increases by 106%, the average distance decreases by 6%, and the average number of plots per land consolidation participant decreases by 51% after the realization of land consolidation projects [6]. This result is similar to the results obtained in Turkey, where the average number of plots after land redistribution usually decreases by over 50% [7], and in some projects even by over 80% [8, 9]. In Vietnam, land redistribution has shown to be beneficial not only for increasing agricultural productivity but also for rural development [10]. Research results in the Republic of Serbia show similar results. Thus, based on the analysis of 11 land consolidation projects, it was concluded that the increase in the average area of plots after land consolidation is 164.18%, the decrease in the average number of plots per land consolidation participant is 51.26%, the area under the road network is 1.69%, and the area under the canal network is 82.28% [11]. The above-mentioned studies undoubtedly emphasize the importance of compaction projects for spatial arrangement and elimination of property fragmentation, but in the coming period compaction must be analyzed from the aspect of sustainable development, taking into consideration the modern aspect of compaction and the importance of soil conservation.

Awareness of the importance of land for food production has only been developed in recent times. According to the Food and Agriculture Organization of the United Nations (FAO), land is a "finite" resource because its loss and degradation cannot be compensated for within a human lifetime [12]. As a fundamental component of land resources, agricultural development and ecological sustainability, land is the basis for the production of food, fuel and fiber as well as for the maintenance of many ecosystems. For this reason, soil is a highly valuable natural resource, which is often overlooked [4]. Also, the importance of land for the development of human society is reflected in the fact that 95% of food is directly or indirectly produced on land [13]. On the other hand, land degradation has a trend that the land will be completely unusable for agricultural production in the next 60 years [14]. According to [15], land consolidation projects play an important role in promoting the use of agricultural land,

ensuring food security and raising awareness of the importance of environmental conservation.

The principles of sustainable development become an integral part of all modern human activities because almost all activities of modern society are closely related to the consumption of natural resources, i.e. the reduction of their availability. In this sense, land is not an exception, because modern methods of agricultural production inevitably result in an accelerated decline in the quality of agricultural land.

The modern concept of agricultural land management implies the use of compaction as an irreplaceable instrument. Therefore, in addition to land consolidation, land consolidation also has the task of enabling better management of natural resources and improving the quality of life in the countryside through land redistribution. Land is under increasing pressure due to general progress and cannot be considered separately in the system of protection from other environmental factors.

The topic of sustainable development and compaction is very current, so many authors connect these two processes and in their research provide guidelines for the application of compaction in accordance with the principles of sustainable development.

In the paper [16], it is stated that land compaction is a process that can resolve the conflict between the economic development of the area and environmental protection. The authors of the paper explain that it is important to examine the significance of the implemented compaction projects on the land itself, especially in areas where soil erosion is present. According to [17], one of the ways to save soil from erosion is to change the purpose of agricultural land to grassland. The paper also emphasizes the importance of the problem itself, as well as that environmental protection should be approached carefully, through the realization of land consolidation projects, especially in those countries where the focus is still on solving property-legal relations and consolidating possessions. The authors state that after soil compaction, the environmental problem cannot be solved completely, if some additional measures are not applied, such as agro-protective forest belts, which would protect the soil from erosion. Therefore, it is concluded that it is necessary to examine the measures that would solve the environmental problem in the long term.

In the paper [17], the importance of considering land consolidation on the protection of natural resources, such as land, was explained. The authors state that the impact of land consolidation on the regulation of ownership and the updating of cadastral records is known, but that the impact on land protection is unknown. Traditional land consolidations are related to the regulation of ownership relations and land consolidation of possessions; however, in today's environment, when environmental protection must be taken care of, these goals are unsustainable.

In the paper [18] the importance of soil quality assessment on the sustainable development of the area is emphasized. The authors emphasize the importance of soil quality on agricultural production and make a recommendation that an in-depth assessment of soil quality could be used as a measure that would define soil by region and therefore, in accordance with the data obtained for each region, make recommendations that lead to the sustainable development of the area.

According to [19], the reclamation project is significant for the quality of arable land, which achieves environmental protection, as well as management and improvement of arable land productivity. According to [20-22], quantifying soil properties is very important and is a key step that can prevent traditional, unsustainable land management. Some authors [22], state that assessing soil quality and defining factors that influence soil quality is a key issue that needs to be resolved in the future.

According to [23, 24], an accurate and reliable assessment of the quality of arable land is crucial for solving environmental protection problems. The authors state that, although land assessment is a difficult and time-consuming undertaking, only in this way can be made recommendations for sustainable land use and management.

According to [25], agricultural land consolidation can effectively improve the quality of agricultural land and the level of agricultural production, and can effectively guarantee the protection of agricultural land and food security. As one of the most effective land management measures to improve agricultural production and ecological environment, agricultural land compaction is widely used in most countries in the world to consolidate fragmented land and improve agricultural production [26-28].

The prevailing attitudes in the field of research undoubtedly indicate that environmental protection must be taken into account in the implementation of cogeneration projects. Particular emphasis is placed on developing countries, where land consolidation is a current topic, and where the focus of application and implementation is still on consolidating possessions and resolving property-legal relations, as is the case in the Republic of Serbia.

Land consolidation in the Republic of Serbia has a long tradition and was mostly carried out on land in Vojvodina (about 60%), followed by central Serbia (about 9%) and the least in Kosovo and Metohija (about 5%). Today, more than 790 land consolidation projects have been implemented in the Republic of Serbia. In the coming period, it is expected that this number will exceed 800 realized projects, considering that several projects have been started, and several projects are in the final phase.

The research carried out in this paper connects land, as a non-renewable and necessary resource, with land compaction, whose primary task is the arrangement of the land territory, with the aim of determining the extent to which compaction projects affect the land itself, as well as to assess the impact of compaction to sustainable development. Given that a large number of land consolidation projects have been implemented in the Republic of Serbia, no research has been done so far on the subject of land consolidation effects from the aspect of sustainable development. In addition, considering that land consolidation is basically dealing with land development, and that it is important to preserve land as a non-renewable resource, it is clear that in the coming period land consolidation and sustainable development cannot be viewed as independent entities. Land compaction is, both in our country and in the world, a very current topic, so it is very important to examine the impact of compaction on sustainable development, and apply the obtained results

and conclusions to the planned projects of initiation and implementation of compaction projects.

The research problem was analyzed through the level of underground water in the areas where compaction projects were implemented. Solving the problem was approached by applying qualitative and quantitative analyzes of the soil, with the aim of defining whether and to what extent the implementation of compaction projects can preserve the quality of the soil and thus achieve sustainable development of the area. The ultimate goal of this work is the analysis of the impact of land consolidation projects on sustainable development, that is, the goal is to present land consolidation as a function of sustainable development, that is, as a measure that resolves the conflict between short-term and long-term goals of spatial planning and land conservation.

2 METHODOLOGY

This paper analyzes the impact of land consolidation projects on the sustainable development of the area. For this purpose, the impact of compaction on the level of groundwater was analyzed, which directly reflects on the quality of the soil itself, and therefore on maintaining the development of the area and soil conservation.

The study is based on the analysis of compaction projects that were realized 30 to 40 years ago, because that period of time is enough for changes in the quality of the soil to be manifested and the degree of changes to be determined. The research was carried out by analyzing the characteristic pedological profiles in the defined research area. Pedological profiles were opened on plots near which canal networks were designed through land consolidation projects and where the influence of groundwater was present. The profiles were analyzed using qualitative and quantitative methods, in accordance with the Rulebook on land cadastral classification and valuation [31]. It is important to note that the Rulebook in the field of applied methods remained the same, so the obtained results were compared with each other.

2.1 Research Aarea

For the area of the experiment, characteristic municipalities were chosen in which land consolidation projects were implemented, and which territorially evenly cover the area of the Autonomous Province of Vojvodina.

Vojvodina, as a research area, was chosen for two reasons:

- the largest number of land consolidation projects were realized in the area of Vojvodina and
- Vojvodina is known for its very fertile land.

Vojvodina has a high potential for arable agricultural production thanks to its richness in quality land, mild climate, abundance of water and long tradition, and soil protection is extremely important in the environmental protection system of Vojvodina

Due to its agricultural land, its quality, spatial concentration and abundance of watercourses, Vojvodina

represents an exceptional economic potential in Europe. Of the total area of Vojvodina (2150600 ha), agricultural land makes up as much as 1747000 ha, or 81.26%, while the share of arable land is 74.6% [29].

In Vojvodina, soils of high fertility, chernozem and rite black, are predominant, covering more than 75% of the total area of the province. But even on the best soils created under natural conditions, some limiting factors can occur, which reduce yields in relation to the genetic potential of a certain plant species, and which can also damage the quality of the soil itself and negatively affect the sustainable development of the area.

Today, due to changes of definition of compaction and increasingly turning to sustainable development, the paper analyzed whether the land underwent certain changes after realized compaction projects, and after a certain time period of 30 or more years.

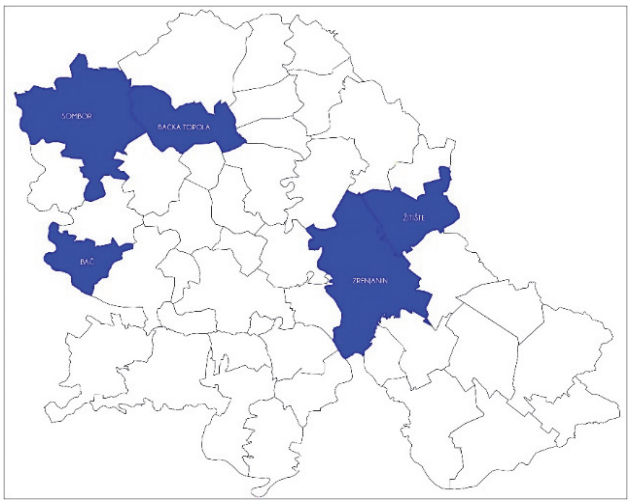

Figure 1 Presentation of the research area

Table 1 Research area number of pedological profiles and samples for analysis

AREA OF RESEARCH			
Municipality	Period when land consolidation projects was done	Number of open pedological profiles	Number of samples for analyses
BačkaTopola (cadastral municipalityBačkaTopola)	1984 - 1986	4	10
Sombor (cadastral municipalities: Gakovo, Rastina and BačkiBreg)	1981 - 1983	5	14
Žitište (cadastral municipalityBanatskiDvor)	1985 - 1987	4	13
Zrenjanin (cadastral municipalityMelenci)	1979 - 1980	4	13
Bač (cadastral municipalityBačko Novo Selo)	1981 - 1983	4	13
Total		21	63

For the purposes of research, for the defined area of interest, relevant data were found on soil analyses performed before the realization of compaction projects. Based on the collected material, localities were selected in the area of the analyzed municipalities, where pedological profiles were reopened and soil analysis was performed. The locations were chosen under the assumption that the greatest changes in the soil structure can be expected at those locations, in addition to the projected irrigation/drainage systems in the compaction process. It is important to note that today the analysis of pedological profiles is done according to the same principles and

methods as before, so that there are no deviations in the applied methods and the obtained data are mutually comparable.

Tab. 1 shows the characteristics of the research area, while Fig. 1 shows the position of the analyzed municipalities in the area of AP Vojvodina. The Tab. 1 shows for each analyzed municipality the period when land consolidation was done, the number of open pedological profiles, as well as the number of samples taken for analysis.

Tab. 1 shows that a total of 21 pedological profiles were opened in the defined research area, and a total of 63 samples were taken for analysis.

2.2 Methodology

In order to perform an analysis of pedological profiles and obtain data on soil quality, the initial hypotheses of the research were defined:

- Null hypothesis (Ho): Is there a significant change of groundwater lever before and after the land consolidation.
- Alternative hypothesis (Ha): The groundwater level was not significantly reduced after land consolidation.

In order to test the set hypotheses, the following methods were applied in the work:

1. Field - laboratory soil analysis.

In the first phase of the research, the collection and analysis of descriptive data on the land was carried out. After studying the existing literature, reports, studies and pedological maps (Archive of the Republic Geodetic Authority) terrain reconnaissance was carried out in the selected area and a total of 21 localities where pedological profiles were opened were determined.

Profiles were opened on plots belonging to the first, third, fifth and seventh assessment classes, in order to be able to analyze the impact of land consolidation projects on lands of different quality. On open pedological profiles, up to 2 meters deep, the external and internal morphology of the soil is described.

For the purposes of laboratory research, samples were taken in a disturbed state, from the middle of all established genetic horizons. The samples were dried to an air-dry state, ground and sieved through a 2 mm sieve. During the work, care was taken to avoid any unnecessary trampling of the soil above the front side of the profile, in order to avoid compaction and preserve the natural appearance of the soil surface as best as possible.

2. Statistical analysis of the results.

In order to analyze the obtained results, the paper carried out a statistical analysis of the significance of the reduction in the level of groundwater after the realization of land consolidation projects.

The statistical analysis of the significance of the reduction of groundwater levels before and after compaction includes two potential impacts:

- The influence of the error in determining the depth of groundwater and
- The impact of the error that occurs due to the dynamics of changes in the groundwater level during the year (bearing in mind that the profile is taken at one point in time).

The error of determining the depth of groundwater can be expressed as follows:

$$\sigma_{DPV}^2 = \sigma_M^2 + \sigma_{VDPCV}^2 \tag{1}$$

where:

σ_{DPV} - groundwater depth standard (error of groundwater depth determination);
σ_M - the standard for measuring the depth of groundwater (which is mainly caused by the unevenness of the physical surface of the profile, this size can be determined by multiple measurements, but it should not exceed 1 cm) and
σ_{VDPV} - the standard of groundwater variation that can occur due to taking samples under different atmospheric conditions (one sample can be taken in a dry period, and another during a flood - this quantity is not known, but it can be considered that it changes in a small number of days during the year in relation to the vegetation period of agricultural crops, considering the average rainfall and its distribution in the researched area).

Under the mentioned assumptions and the additional assumption that $\sigma_M \ll \sigma_{VDPCV}$, the following question can be asked: "At what size of the groundwater level determination standard can it be claimed that there are significant differences between the groundwater level before and after compaction?".

$$t = \frac{d}{\sigma_{DPVK}} \sim N(0, 1) \tag{2}$$

$$d = h_{\text{before}} - h_{\text{after}} \tag{3}$$

$$\sigma_{DPVK} = \sqrt{\sigma_{DVPBefore}^2 + \sigma_{DPVAfter}^2} \tag{4}$$

$$\sigma_{DVPBefore} = \sigma_{DPVAfter} = \sigma_0 \tag{5}$$

Then follows:

$$\sigma_{DPVK} = \sigma_0 \sqrt{2} \tag{6}$$

In the previous group of formulas, the labels are as follows:
t - test statistics for checking the equality of groundwater levels before and after land consolidation;
d - the difference in the level of underground water before and after land consolidation;
h_{after} - level (depth) of groundwater after land consolidation;
h_{before} - level (depth) of groundwater before land consolidation;
σ_{DPVK} - standard for determining the level of underground water before and after land consolidation;
$\sigma_{DPVPBefore}$ - standard for determining the level of underground water before land consolidation;
$\sigma_{DPVAfter}$ - standard for determining the level of underground water after land consolidation and
$N(0, 1)$ - normal distribution.

The null hypothesis is accepted under the assumption that:

$$t = \frac{d}{\sigma_{DPVK}} = \frac{d}{\sigma_0\sqrt{2}} \le 1.96 = z_{0.95} \quad (7)$$

while otherwise, an alternative hypothesis is adopted, whereby $z_{0.95}$ is the value of the quantile of the normal distribution for the significance level $\alpha = 0.05$, i.e. for the probability $p = 95\%$. The case $d < 0$ indicates that there was an increase in the groundwater level after land consolidation, so in that case the alternative hypothesis is adopted.

Since the value of σ_0 is not known, the question about the significance of the change in the level of groundwater can be formulated as follows: "At what value of the standard σ_0 can it be claimed that the level of groundwater has significantly decreased after land consolidation in a certain area?".

The previous formula immediately follows:

$$\frac{d}{\sigma_0\sqrt{2}} \ge 1.96 \rightarrow \sigma_0 \le \frac{d}{1.96\cdot\sqrt{2}} \quad (8)$$

In order to control the data obtained and the conclusions drawn, the data was analyzed as follows:

The a priori value of the standard σ_0 was adopted as the maximum possible value of the error in determining the groundwater level. Considering the simplicity of groundwater level measurement and the similarity of weather conditions in a certain region, the following can be adopted:

$$\sigma_M \le 1 \text{ cm} \quad (9)$$

$$\sigma_{VDPV} \le 2 \text{ cm} \quad (10)$$

which results in the following (using Eq. (1)):

$$\sigma_{DPV} = \sqrt{(1 \text{ cm})^2 + (2 \text{ cm})^2} = \sqrt{5 \text{ cm}} \quad (11)$$

Applying Eq. (5) and Eq. (6), we obtain that the standard for determining the level of underground water before and after land consolidation amounts to:

$$\sigma_{DPVK} = \sigma_0\sqrt{2} = 3.2 \text{ cm} \quad (12)$$

3 RESULTS

By analyzing the open pedological profiles in the field, a decrease in the groundwater level was observed in the analyzed research area.

The change in the groundwater level is shown in Tab. 2.

After the results obtained in the field, using the formulation described in chapter 2.2, a statistical analysis of the significance of the reduction of the groundwater level after the implementation of the land consolidation projects was performed. The results obtained by statistical analysis are shown in Tab. 3.

Table 2 The influence of the designed irrigation and drainage systems in the land consolidation process on the regulation of the groundwater level

The influence of groundwater before and after land consolidation			
Municipality	Evaluation class	Before land consolidation	After land consolidation
BačkaTopola	The sixth	under 68 cm	under 100 cm
	The seventh	under 50 cm	There is no influence of groundwater (profile open up to 80 cm)
Sombor	The first	under 98 cm	There is no influence of groundwater (profile open up to 110 cm)
	The third	under 48 cm	There is no influence of groundwater (profile open up to 100 cm)
	The fifth	under 77 cm	unchanged
	The sixth	under 110 cm	There is no influence of groundwater (profile open up to 120 cm)
Zrenjanin	The third	under 158 cm	There is no influence of groundwater (profile open up to 170 cm)
	The fifth	under 77 cm	There is no influence of groundwater (profile open up to 130 cm)
Bač	The fifth	under 126 cm	There is no influence of groundwater (profile open up to 140 cm)
Žitište	The third	under 64 cm	under 90 cm

Table 3 The influence of the designed irrigation and drainage systems in the land consolidation process on the regulation of groundwater levels - a summary of the results of hypothesis testing

The influence of groundwater before and after soil compassion			Hypothesis testing			
1. Municipality of Bačka Topola			1. method		2. method	
Evaluation class	Before land consolidation / cm	After land consolidation / cm	σ_0	Hypothesis	σ_0	Hypothesis
The sixth	68	100	11.54	H_0	10.00	H_0
The seventh	50	80	10.82	H_0	7.10	H_0
2. Municipality of Sombor			1. method		2. method	
Evaluation class	Before land consolidation / cm	After land consolidation / cm	σ_0	Hypothesis	σ_0	Hypothesis
The first	98	110	4.33	H_0	2.84	H_0
The third	48	100	18.76	H_0	12.31	H_0
The fifth	77	77	0.00	H_a	0.00	H_a
The sixth	110	120	3,61	H_0	2,37	H_0
3. Municipality of Zrenjanin			1. method		2. method	
Evaluation class	Before land consolidation / cm	After land consolidation / cm	σ_0	Hypothesis	σ_0	Hypothesis
The third	158	170	4.33	H_0	2,84	H_0
The fifth	77	130	19.12	H_0	12.54	H_0
4. Municipality of Bač			1. method		2. method	
Evaluation class	Before land consolidation / cm	After land consolidation / cm	σ_0	Hypothesis	σ_0	Hypothesis
The fifth	126	140	5.05	H_0	3.31	H_0
5. Municipality of Žitište			1. method		2. method	
Evaluation class	Before land consolidation / cm	After land consolidation / cm	σ_0	Hypothesis	σ_0	Hypothesis
The third	64	90	9.38	H_0	6.15	H_0

The results of the research show that the groundwater level has been significantly reduced after the implementation of the land consolidation projects. Tab. 4 shows the average reduction of groundwater level after the realized land consolidation projects, by assessment classes.

Fig. 2 shows the change in groundwater levels, for the period before and after the implementation of the land consolidation projects.

Table 4 Presentation of the decrease in the level of groundwater after the realized land consolidation projects

The level of underground water after the realized land consolidation projects	
Evaluation classes	Reduction / %
The first	100
The third	40
The fifth	83
The sixth	23
The seventh	100

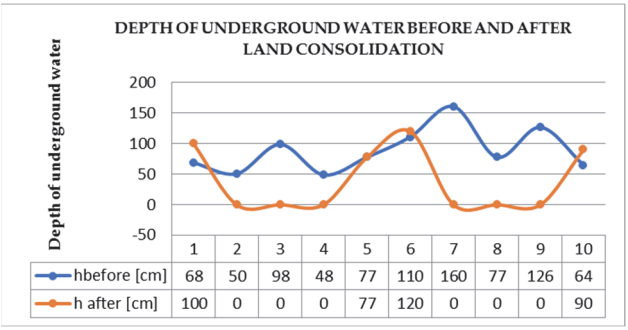

Figure 2 Change in the level of underground water before and after the realization of land consolidation projects

4 DISCUSSION

The obtained results indicate that in most of the analyzed cases the null hypothesis is adopted, that is, that the level of underground water has been significantly reduced after the implementation of the land consolidation projects.

Deviation from the stated conclusion occurred only in the Municipality of Sombor, on land belonging to the fifth assessment class. The reason for this should be found in the type of soil itself. The type of soil in question is salt flats, for which only the canal network is not enough, but some other measure, such as underground drainage, must be provided to improve the quality. These soils are formed under the influence of saline groundwater, and are very difficult to cultivate, therefore they require a specific example of hydromelioration, so for their improvement, only the design of the canal network is not enough. Therefore, it is concluded that the appropriate hydromelioration measure was not applied for halogenated soils, and that the type of soil itself influenced the state of soil quality to remain unchanged, and the above example cannot be generally adopted for all soils belonging to the fifth evaluation class.

Tab. 3 shows that by applying the two mentioned formulations of the statistical analysis of the significance of the reduction of the groundwater level after the implementation of the land consolidation projects, the same conclusions are drawn, that is, the null hypothesis is adopted, so it can be concluded that the groundwater level has significantly decreased after the realization of the land consolidation projects.

Based on the experiment and hypothesis testing, the following conclusion can be drawn:

- Lands of the best quality have retained their properties and characteristics. An important conclusion is that there was no soil degradation, and that the short-term effects of compaction did not overcome the long-term effects, but the soil was preserved and agricultural production improved.
- Medium-quality lands have undergone the greatest changes, most often through the elimination/reduction of groundwater, so it can be concluded that agricultural lands of medium productivity should be the key target areas for the implementation of land consolidation projects. This information indicates that when selecting cadastral municipalities for the initiation and implementation of land consolidation projects, an important criterion when defining the optimization model should be precisely the share of arable land of medium quality, because in this way the quality of the land could be improved, in accordance with the principles of sustainable development.

The performed analysis shows that through artificial conditions, through the design of the canal network, excess water is drained from the soil, the soil thus receives air and the quality of that soil increases. Therefore, the research confirmed the set hypotheses, i.e., the conclusion is drawn that soil compaction significantly affects the improvement of soil quality, and therefore the sustainable development of the area.

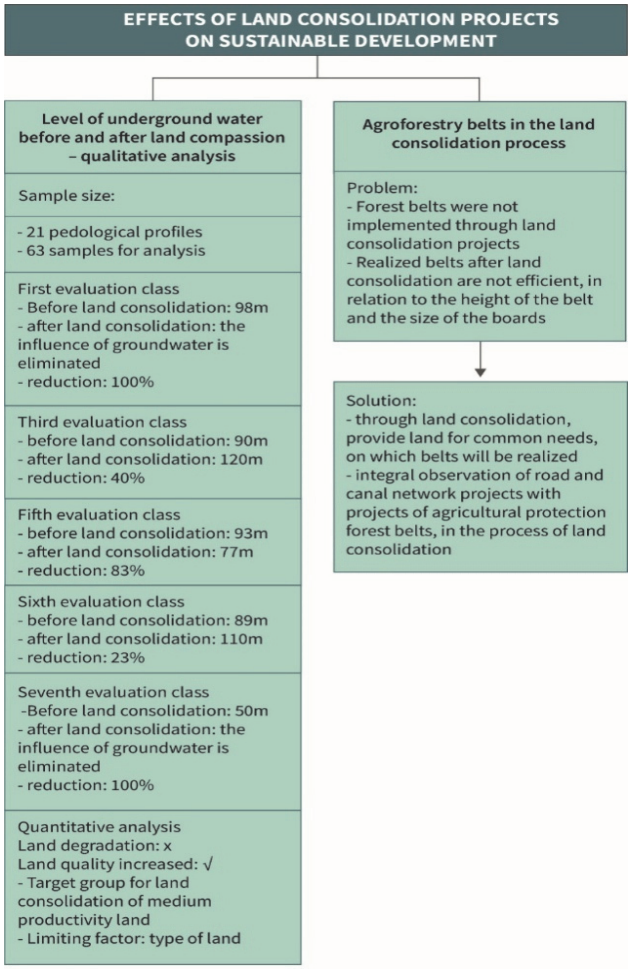

Figure 3 The impact of land consolidation projects on the sustainable development of the area

Also, as land development by land consolidation leads to optimization of the road network, i.e., shorter transportation time of machinery, savings in fuel consumption can be expected, which reduces the negative impact of agricultural works on the environment. From this point of view, composting can reduce the negative impact of agricultural production on the environment, as well as the costs of land cultivation, which contributes to lower costs and better economic effects.

In addition to the positive effect of land consolidation projects on sustainable development, the paper [30] analyzed the level of raising agroforestry belts through land consolidation projects in the Republic of Serbia. The aforementioned studies indicate that forest belts are not realized through land consolidation projects (although some projects are foreseen), which from the point of view of sustainable development can be evaluated as a negative effect because the long-term exclusion of forest belts from land consolidation projects can damage the quality of the land.

Therefore, the impact of land consolidation on sustainable development in the Republic of Serbia can be shown as follows (Fig. 3).

According to the above, it can be concluded that the contribution of land consolidation to sustainable development is reflected in land conservation, social and economic effects, because a regulated property with an increase in land value leads to an improvement in the quality of life in rural areas. The contribution of land consolidation to sustainable development is shown in Fig. 4.

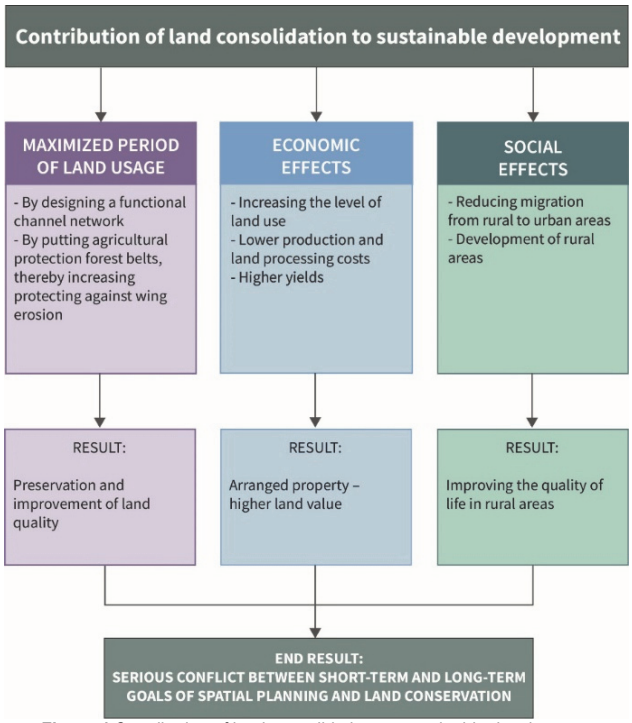

Figure 4 Contribution of land consolidation to sustainable development

5 CONCLUSIONS

The impact of land consolidation projects on sustainable development is explained by the reduction of groundwater levels after realized land consolidation projects, whereby the average reduction of groundwater levels by assessment classes amounts to:

- First evaluation class: 100%;
- Third evaluation class: 40%;
- Fifth evaluation class: 83%;
- Sixth evaluation class: 23%;
- Seventh evaluation class: 100%.

As a direct result of the research, a set of measures is adopted that has a positive impact on sustainable development:

- Lowered level of underground water;
- Differentiation of horizons under the influence of groundwater drainage;
- Increased quality and soil free of clay.

Based on the above, the following conclusions can be drawn:

- The change in soil quality significantly depends on the type of soil itself, but with proper planning in the soil compaction process, higher soil productivity can be achieved, then soil conservation through increasing its quality, which is a necessary condition for sustainable soil management;
- Land belonging to the first assessment class, that is, land of the best quality, in the analyzed cases, retained its properties and characteristics. Therefore, it can be concluded that the land has been preserved by proper arrangement of the space through compaction projects;
- Medium-quality lands have undergone the greatest positive changes (the dominant example is the Municipality of BačkaTopola), so it can be concluded that agricultural lands of medium productivity should be the key target areas for the implementation of land compaction projects, and this should be taken into account when choosing cadastral municipalities for initiation and implementation of land consolidation projects;
- This conclusion points to a more correct approach when defining criteria for ranking cadastral municipalities, using optimization methods. Namely: if the goal of compaction is to increase the quality of soil in a certain area, then medium quality soils should be given more weight. This is certainly a goal to strive for in the future.

In previous research and practical application, during the selection of cadastral municipalities in which land consolidation projects will be implemented, criteria related to land quality were not taken into account, but they cannot be omitted if environmental protection and sustainable development are ensured through land consolidation. Research shows that compaction projects should be implemented in areas where it is necessary from the aspect of sustainable development, that is, that the development direction of land compaction in the coming period should be in the direction of soil protection and preservation, that is, in the direction of sustainable development.

As a result of the research, it is concluded that the contribution of compaction to sustainable development is reflected in the maximization of the period of land utilization according to the appropriate purpose, then that through the design of the canal network in the process of compaction, the quality of the land is certainly improved, to the extent that uncultivable lands, through gradual planning in the process of compaction, can get the function of arable land. Therefore, land consolidation resolves the

conflict between the short-term and long-term goals of spatial planning and soil conservation.

Based on the research carried out, analyzing the land consolidation projects and postulates of sustainable development, it can be concluded that the implementation of land consolidation projects in accordance with the principles of sustainable development could achieve the following effects:

- Preservation and improvement of soil quality through the design of a canal network, irrigation / soil drainage systems and the construction of agro-protective forest belts, which would achieve the preservation of soil quality over a longer period of time;
- The economic effects would be reflected in an increase in the degree of land utilization, lower costs of production and land processing, thus a well-organized property with built infrastructure would lead to a higher value of the land;
- The social effects would be reflected in the reduction of migration from rural to urban areas and, accordingly, an increase in their development and overall contribution to economic growth.

Land consolidation of agricultural land, along with the modern approach of setting goals during its implementation, that is, by including the principles of sustainable development in the process of land consolidation, can slow down the process of soil degradation, that is, contribute to the long-term achievement of sustainable development goals. Land compaction projects, through activities that would lead to the creation of larger and better shaped plots, construction of irrigation and drainage systems, design of the road network to improve access to the plots and the construction of agro-protective forest belts, which would effectively prevent soil erosion, would lead to improvements of the quality of the arable land, which means that the quality of the plots could reach the highest value after effective compaction of the land.

Also, having in mind that land is a dynamic category, i.e. that it changes over time and depending on the goals of society, with simultaneous fragmentation of possessions, it can be concluded that compaction is a process that should be periodically analyzed and applied in areas where compaction has already taken place, whenever there is justification for it from the aspect of sustainable development.

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