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Efficiency of Agricultural Soil Withdrawals – Case of Slovakia

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Abstract: *Policymakers, scientists or academic experts agree on the necessity of agricultural soil concerning different areas (e.g. rural sustainability, and so on). In response to the above, the EU is therefore taking various measures in the form of concrete strategies for the protection of agricultural soil. The main aim of the paper was to analyse the current state of agricultural soil and its development in the territory of Slovakia, with a special emphasis on the investigation of agricultural soil withdrawals for non-agricultural purposes. The results of regression and correlation analysis showed a statistically significant dependence between the purpose and several quality groups of withdrawn soil in Slovakia. The most common purposes of soil withdrawals were housing and industry which have a demonstrable impact on the constant decrease of agricultural soil. In conclusion, the authors proposed a complex of systematic measures to reduce the volume of agricultural soil withdrawals.*

1. INTRODUCTION

Currently, there is no single definition of soil. Nedd et al. (2021) define soil as a natural resource that humans have utilized for life and various activities. The issue of soil definition is also discussed by many authors from different scientific disciplines (e.g. Fazal, 2013; Schwarcz et al., 2013; Robins, 2016; Palšová et al., 2019; etc.) who consider that important factors for soil characterization are mainly the functions it performs in relation to the environment and society. This includes ecological and non-ecological functions (Tóth et al., 2008; Kefeli & Blum, 2010; Karis & Jettou, 2013; Margottini, 2013; Efe & Ozturk, 2014) which are completed according to Hraško (2017) with the most important values that increase the demand for land as a natural resource: a) soil as an irreplaceable factor of production as a source of livelihood for animals and humans, b) soil as an elementary space for the construction of industrial enterprises, housing, recreation and relaxation, c) soil as a dedicated space for the construction of transport networks, supply facilities and waste disposal, d) soil as a space for quarrying or mining of raw materials.

Soil is the basis of agricultural activities (Ahmad et al., 2020). Agricultural soil is a non-renewable natural resource that requires careful stewardship in order to achieve sustainable development goals (Hou et al., 2020). FAO (2019) specifies that agricultural soil has a special position in terms of the above-mentioned soil functions. Agriculture and agricultural soil in general: a) provide the largest share of food supplies and ensure food security and food self-sufficiency, b) ensure a critical number of ecosystem services, c) contribute to the increase of urban areas livability and access to green spaces, d) reduce the impact of natural hazards, e) contribute to the efficient management of natural resources, f) reduce food waste and waste production, g) reduce the greenhouse gases emission, h) reduce soil degradation, i), etc. (Viana et al., 2022).

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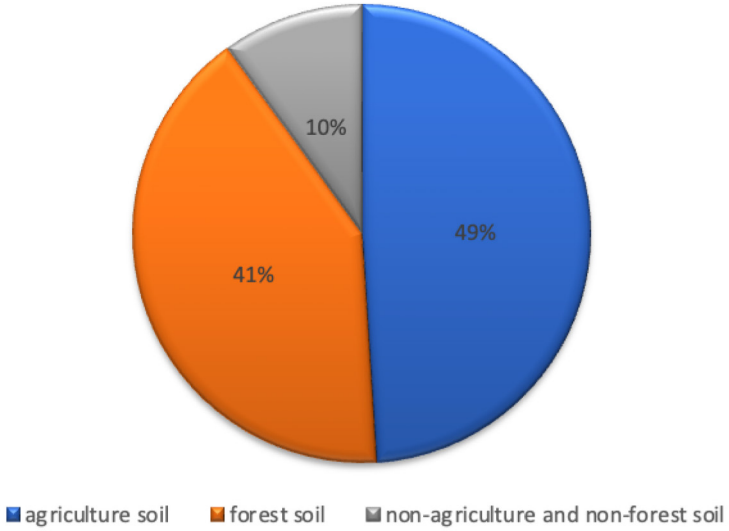


Figure 1. Share of individual types of soil on the total area of the Slovak Republic
Source: Own processing according to the Statistical Yearbook on Soil Fund, 2021

Agricultural soil of varying quality in Slovakia represents 49 % - the majority of the Slovak Republic's total area (Figure 1.) As a result, the Slovak Republic can be considered a primarily rural state.

The agricultural sector has an important role in sustainable rural development. Pašakarnis et al. (2013) attribute the special importance of rural development to the territory of the European Union, considering that more than half of the population in the member states lives in rural areas. Edwards et al. (2012), Karlsson and Rydén (2012), Camp and Heath-Camp (2015), and Janků et al. (2016) agree that sustainable development is very important a soil protection. Therefore, the general scientific community (e.g. van Dijk & Kopeva, 2006; Williams & Schirmer, 2012) advises that rural areas should not be looked at only concerning their production capacity and potential, but also in terms of their other functions. This means that concepts such as rural protection/sustainability (and associated long-term land protection) and economic development should be complementary, not conflicting or competing.

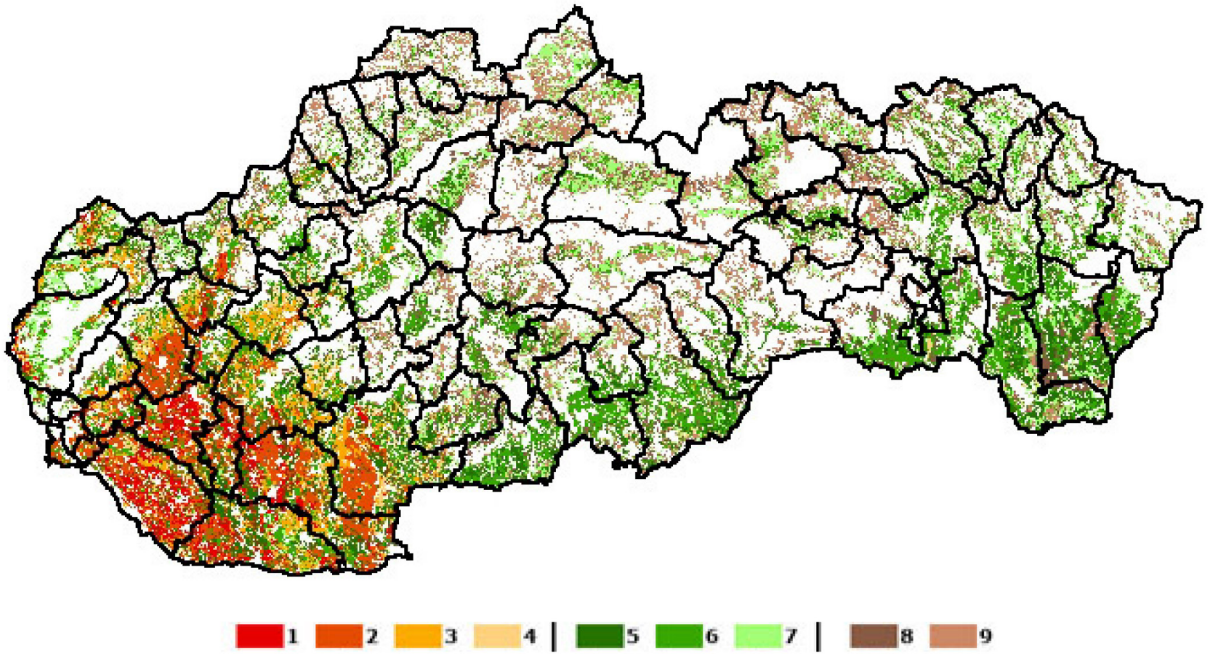
He et al. (2014) and Palchoudhuri et al. (2015) agree that agricultural soil is also a basic prerequisite for the economic growth and development of the territory, as almost all economic activities involve the use of soil in a certain context. According to Szabo and Grznár (2015), agriculture also fulfils the so-called environmental mission, as the management of natural resources, such as soil in particular, shapes and preserves landscape diversity.

There are many ways to measure the quality of agricultural soil. Several authors, such as Džatko (2002, in Vilček, 2011) and Hraško, et al. (2010, in Vilček, 2011) agree that the quality of agricultural land is most closely related to its productive capacity, which is expressed through the rating of agricultural soils. All agricultural soils are classified into 9 soil quality groups (Figure 2.) - the first 4 groups of soils are the highest quality and considered protected, thus they can be withdrawn and used for non-agricultural purposes only if there is no alternative solution (Act No. 220/2004 Coll. Decree of the Ministry of Agriculture of the Slovak Republic No. 508/2004 Coll.).

The quality of agricultural soil is affected by various problems resulting from the historical and economic development of the country: a) unsettled land ownership, b) extreme land fragmentation, c) a large area of agricultural land under state control, d) withdrawals for non-agricultural

purposes (Palšová et al., 2019). Based on initiatives related to raising awareness of the current situation and condition of agricultural land and its indicators, many important documents and programs valid for all EU member states were created, such as the European Green Agreement, Strategy for Soil 2030, etc.

The main aim of the paper was to analyse the current state of agricultural land and its development in the territory of the Slovak Republic, with a special emphasis on the investigation of agricultural land withdrawals for non-agricultural purposes.



1-4 - the highest quality, 5-7 middle quality, 8-9 the lowest quality

Figure 2. Representation of agricultural soil within 9 quality groups in the Slovak Republic

Source: Research Institute of Soil Science and Soil Protection, 2019

2. METHODOLOGY

The primary source was information obtained through the Delphi method, which involved interviews with the Ministry of Agricultural and Rural Development of the Slovak Republic and databases of the Statistical Office of the Slovak Republic and Eurostat.

The objects of the investigation were agricultural soil and agricultural soil withdrawn. The agricultural land withdrawn was subsequently divided into 3 categories: Western, Central and Eastern Slovakia.

The investigation of the relationships between the purposes of the agricultural soil withdrawn and individual levels of its quality was carried out through multiple linear regression in the Excel program, where the dependent variable was the amount of agricultural soil withdrawn in ha for the individual purposes for which soil is most often withdrawn in Slovakia - specifically, housing purposes and industry. The independent, explanatory variables were the amount of agricultural soil withdrawn within the nine quality groups. From the point of view of the coefficient of determination, this method proved to be the most suitable for describing the dependence between monitored variables, for which the general formula applies:

$$y = b_0 + b_1 x_1 + b_2 x_2 + ... + b_n x_n \quad (1)$$

Where:

b_0 – intercept,
b_1 - b_n – regression coefficients,
y – value of the dependent variable,
x_1 - x_n – values of the independent variable.

Regression and correlation analysis consists of 3 parts:

2.1. Correlation Analysis

a) Multiple correlation coefficient (Multiple R)

The degree of dependence between the dependent variable and the independent variables is determined using the multiple correlation coefficient (Multiple R). Dependency can be as follows:

Multiple R < 0.3 – low dependence between variables,
0.3 ≤ Multiple R< 0.5 – moderate dependence between variables,
0.5 ≤ Multiple R < 0.7 – significant dependence between variables,
0.7 ≤ Multiple R < 0.9 – high dependence between variables,
0.9 ≤ Multiple R – very high dependence between variables.

b) Coefficient of determination (R Square)
c) Adjusted coefficient of determination (Adjust R Square)

2.2. ANOVA

Hypotheses:

H0: The multiple linear regression model is not statistically significant.

H1: The multiple linear regression model is statistically significant.

Significance F < α (significance level 0.05) – we reject the null hypothesis.

Significance F > α (significance level 0.05) – we accept the null hypothesis.

2.3. Regression Analysis

Hypotheses:

H0: Intercept and regression coefficients are statistically insignificant.

H1: Intercept and regression coefficients are statistically significant.

P-value < α (significance level 0.05) – rejects the null hypothesis.

P-value > α (significance level 0.05) – we accept the null hypothesis.

3. RESULTS

3.1. Current State of Agricultural Soil in Slovakia

According to the latest available data (year 2022), the share of agricultural soil in the total area of the Slovak Republic was 48.4%. In the monitored period of 2005 - 2021, we note a decrease in the share of agricultural soil in favour of an increase in the area of forest soil (by 1.2%), water areas (2.2%) and built-up areas and courtyards (6.2%). According to the Office of Geodesy, Cartography and Cadastre of the Slovak Republic (2021), the average area of agricultural land per inhabitant was 0.265 ha in 2005 and 0.257 ha in 2021 (a decrease of 3%) (Figure 3.).

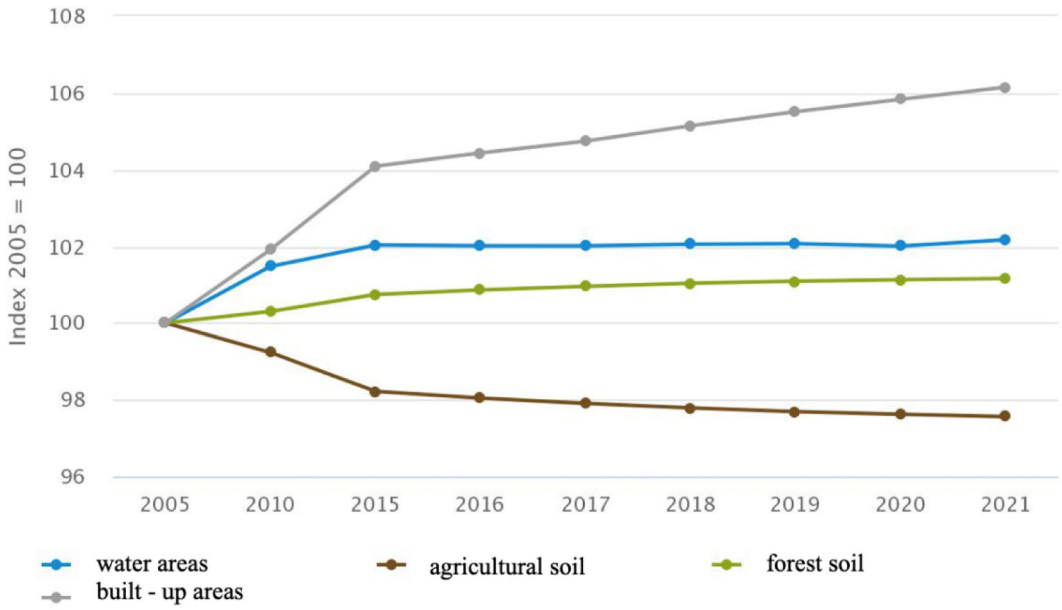


Figure 3. Percentage development of changes in soil use on the territory of Slovakia in the period 2005-2021

Source: Own processing according to the Office of Geodesy, Cartography and Cadastre of the Slovak Republic, 2021

As a result of the mentioned facts, it is possible to identify constant agricultural soil withdrawals on the territory of the Slovak Republic. The phenomenon of agricultural soil withdrawals for non-agricultural purposes continues and during the monitored period of 15 years, a total of 16,717.51 ha of agricultural soil was withdrawn from the land fund, which represents 0.70% of the total area of agricultural soil. The most common purpose for agricultural soil withdrawals during all monitored years was housing (37% of the total volume of withdrawals land) and industry (25% of the total volume of withdrawals land). The highest value of agricultural soil withdrawals for these purposes can be observed in 2008 and 2009, when there were legislative changes regarding the payment of levies for withdrawals (directed interview with experts on agricultural land protection from the Ministry of Agriculture and Rural Development of the Slovak Republic). An exception to the otherwise even trend in the development of soil withdrawn by individual purpose is 2010, when a significantly high amount of soil was withdrawn for purposes designated as other, namely 1324.5400 ha. This is due to the fact that in 2010 the state started to support the construction of photovoltaic power plants that fall into this category through subsidies (Figure 4.) Most of the agricultural soil withdrawn (namely 5,739.607 ha, 32.17% of the total amount of soil withdrawn) belonged to group 6, which represents middle

quality. Most soil was withdrawn in 2008, as this was the last year without levy obligation. The most frequently withdrawn soils were also in quality groups 5 (13.76%), 7 (13.44%), 2 (11.93%) and 4 (6.53%), i.e. middle to high-quality soils. Conversely, the least amount of agricultural soil was withdrawn within quality group 1 (5.14%).

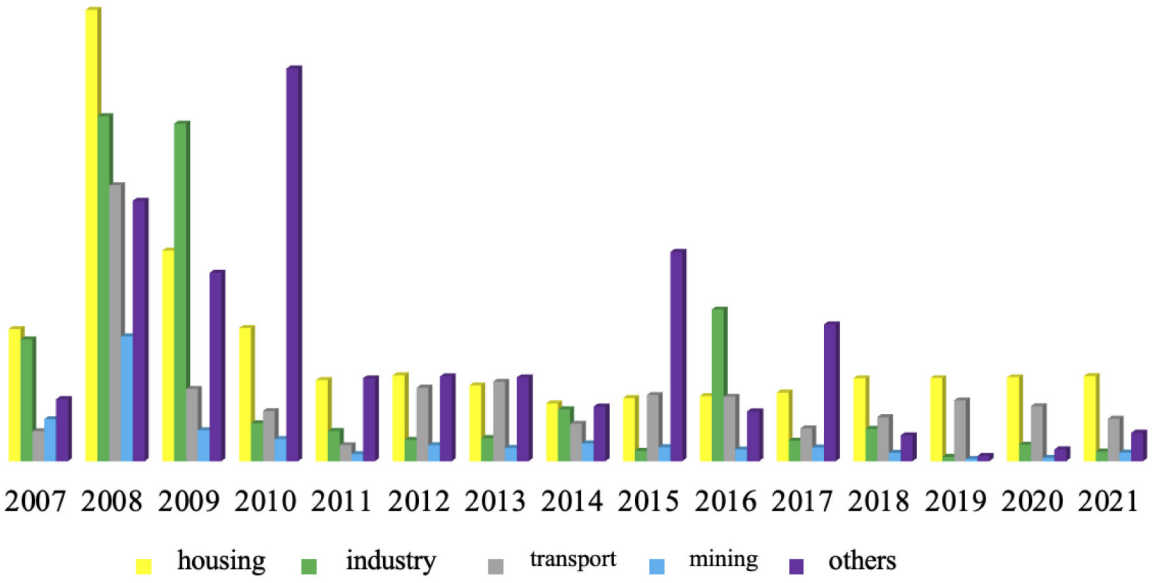


Figure 4. Development of agricultural soil withdrawals for specific non-agricultural purposes in ha on the territory of Slovakia in the period 2007-2021

Source: Own processing
according to the Ministry of Agriculture and Rural Development of the Slovak Republic

3.2. Regression and Correlation Analysis

Table 1 shows the results of regression and correlation analysis evaluating the impact of agricultural soil withdrawn within all nine groups of its quality for housing purposes in Western, Central and Eastern Slovakia.

Table 1. Impact of the amount of agricultural soil withdrawn in quality groups for housing purposes in 2021

Western Slovakia		**Central Slovakia**		**Eastern Slovakia**	
SUMMARY OUTPUT		**SUMMARY OUTPUT**		**SUMMARY OUTPUT**	
Regression Statistics		*Regression Statistics*		*Regression Statistics*	
Multiple R	0,999079996	Multiple R	0,99650383	Multiple R	0,989751728
R Square	0,998160838	R Square	0,993019884	R Square	0,979608482
Adjusted R Square	0,994850345	Adjusted R Square	0,96160936	Adjusted R Square	0,933727568
Standard Error	0,863172904	Standard Error	0,998382264	Standard Error	1,002424749
Observations	15	Observations	12	Observations	14

Source: Own processing

The output of the regression and correlation analysis consists of three parts. The first part is correlation analysis, which was used to test the strength of the dependence between observed variables. The multiple correlation coefficient (Multiple R) takes on a value of 0.9991 for Western Slovakia, 0.9965 for Central Slovakia and 0.9898 for Eastern Slovakia - this indicates a very high dependence between the amount of agricultural soil withdrawn in quality groups 1-9

(independent variables) and the amount of agricultural soil withdrawn for housing purpose (dependent variable). The coefficient of determination (R Square) informs that the chosen model explains the variability of the amount of agricultural soil withdrawn for housing purposes to approximately 99.82% for Western Slovakia, 99.30% for Central Slovakia and 97.96% for Eastern Slovakia - the remaining part is unexplained variability of the influence of random and other factors. The adjusted coefficient of determination (Adjusted R Square) explains that approximately 99.49% within Western Slovakia, 96.16% within Central Slovakia, and 93.37% within Eastern Slovakia of the variation in the amount of agricultural soil for monitored purposes is collectively explained by all independent variables, namely the amount of agricultural soil withdrawn in quality groups 1-9.

The main role of the second part of the output was to test the suitability of the selected model. The null hypothesis was tested (H_0), according to which the chosen multiple linear regression model is not suitable - statistically significant (alternative hypothesis H_1 is opposite). The F test is used to evaluate the statement, i.e. the comparison of the Significance F value with the alpha significance level: a) Western Slovakia: 2.68946E-06 (Significance F) < 0.05 (alpha), b) Central Slovakia: 0.031029064 (Significance F) < 0.05 (alpha), c) Eastern Slovakia: 0.0049 (Significance F) < 0.05 (alpha), as a result, the null hypothesis was rejected and accept the alternative hypothesis - multiple linear regression model was chosen correctly.

The last part of the output consists of a regression analysis, examining the relationship between the observed variables. Based on this were formulated regression functions in the following form:

Western Slovakia:
$y = 0.13 - 0.76\ x_1 + 1.50\ x_2 + 0.50\ x_3 + 0.15\ x_4 + 0.47\ x_5 + 1.05\ x_6 + 0.01\ x_7 + 0.61\ x_8 + 1.04\ x_9$

Central Slovakia:
$y = -0.40 - 0.55\ x_4 - 0.13\ x_5 + 0.64\ x_6 + 0.52\ x_7 + 0.54\ x_8 + 1.80\ x_9$

Eastern Slovakia
$y = 0.63 - 21.84\ x_4 - 0.03\ x_5 + 0.49\ x_6 + 0.20\ x_7 + 2.04\ x_8 + 0.29\ x_9$

The value of the intercept expresses that with zero values of the amount of agricultural soil withdrawn in quality groups 1-9, the value of the amount of agricultural soil withdrawn for housing purposes would be 0.13 ha for Western Slovakia, -0.40 ha for Central Slovakia and 0.63 ha for Eastern Slovakia. The most significant values for Western Slovakia indicate that if the amount of agricultural soil withdrawn in group 2 increases by 1 ha (assuming that other variables remain unchanged), then the amount of agricultural soil withdrawn for housing purposes increases by 1.50 ha, in group 6 by 1.04 ha and in group 8 0.61 ha. For Central Slovakia, if the amount of agricultural soil withdrawn in Group 9 increases by 1 ha, then the amount of agricultural soil withdrawn for housing purposes increases by 1.80 ha and in Eastern Slovakia in Group 6 by 0.49 ha.

Also, in this part, the null hypotheses regarding the intercept and regression coefficients were tested. The null hypothesis states that the coefficient is statistically insignificant, and the alternative hypothesis states the opposite. P-value was compared with the alpha significance level (significance level 0.05). With the intercept, it can be seen that its P-value is higher than alpha, which means that the intercept is statistically insignificant in all three parts of Slovakia. The

P-value for the regression coefficients of the amount of agricultural soil withdrawn in quality groups is lower than alpha in Western Slovakia for 2.,6.,8. quality groups, in Central Slovakia for 9. quality group and in Eastern Slovakia for 6. quality group thereby confirming the statistical significance of these coefficients by rejecting the null hypothesis.

Table 2 shows the results of regression and correlation analysis evaluating the impact of agricultural soil withdrawn within all nine groups of its quality for industry purposes in Western, Central and Eastern Slovakia.

Table 2. Impact of the amount of agricultural soil withdrawn in quality groups for industry purposes in 2021

Western Slovakia		**Central Slovakia**		**Eastern Slovakia**	
SUMMARY OUTPUT		**SUMMARY OUTPUT**		**SUMMARY OUTPUT**	
Regression Statistics		*Regression Statistics*		*Regression Statistics*	
Multiple R	0,949169285	Multiple R	0,998466004	Multiple R	0,951383947
R Square	0,900922331	R Square	0,996934362	R Square	0,905131414
Adjusted R Square	0,722582526	Adjusted R Square	0,983138991	Adjusted R Square	0,691677096
Standard Error	0,612201929	Standard Error	0,128200568	Standard Error	0,955552304
Observations	15	Observations	12	Observations	14

Source: Own processing

In the ANOVA output section, we tested the null hypothesis that the chosen is not appropriate (statistically significant) by comparing the Significance F value with the alpha significance level: a) Western Slovakia: 0,044613868 (Significance F) < 0,05 (alfa), b) Central Slovakia: 0,013721549 (Significance F) < 0,05 (alfa), c) Eastern Slovakia: 0,088831834 (Significance F) > 0,05 (alfa), as a result, we can reject the null hypothesis and accept the alternative hypothesis, which means that the multiple linear regression model was chosen correctly for Western Slovakia and Central Slovakia. The multiple correlation coefficient (Multiple R) for both parts of Slovakia acquire values greater than 0.9, which indicates a very high dependence between the amount of agricultural soil withdrawn in quality groups 1-9 (independent variables) and the amount of agricultural land withdrawn for industrial purposes (dependent variable).

The adjusted coefficient of determination (Adjusted R Square) explains that approximately 72.26 % within Western Slovakia and 98.31 % within Central Slovakia of the variation in the amount of agricultural soil for monitored purposes is collectively explained by all independent variables, namely the amount of agricultural soil withdrawn in quality groups 1-9. The intercept value expresses that with zero values of the amount of agricultural land withdrawn in quality groups 1-9, the value of the amount of agricultural land withdrawn for industrial purposes would be - 0.29 ha for Western Slovakia and 0.01 ha for Central Slovakia. The most significant values for Western Slovakia indicate that if the amount of soil withdrawn in group 5 increases by 1 ha, assuming that other variables remain unchanged, then the amount of soil withdrawn for industry will decrease by 0.60 ha and in group 7 by 0.40 ha. For Central Slovakia, if the amount of soil withdrawn in group 5 increases by 1 ha, assuming that other variables remain unchanged, then the amount of land withdrawn for industry will increase by 0.06 ha. The P-value for the regression coefficients of the amount of agricultural land withdrawn in the quality groups is lower than alpha (significance level 0.05) in Western Slovakia for the 5th and 7th quality groups and in Central Slovakia for the coefficients of the 5th quality group, which confirms the statistical significance of these coefficients by rejecting the null hypothesis.

4. CONCLUSION

The results show that agricultural soil in the Slovak Republic has continuously decreased over the years in favour of built-up areas, forest soil and water areas. It is most often withdrawn for housing and industry purposes in connection with the necessary economic development of the country, especially in the western part of Slovakia, where the best quality land is also located. This was also confirmed by the results of the multiple linear regression, which showed a statistically significant influence between the purpose (housing and industry) and several groups of the quality of the withdrawn soil. These results show a significant impact of the agricultural soil withdrawn for housing purposes in the area of Western Slovakia, where the highest quality soil is found to the greatest extent and there is the most concentrated construction activity. When designing and implementing a national strategy for the protection of agricultural land, it is extremely necessary to distinguish, among other things, the assumptions and predispositions of individual locations and territories. In conclusion, the authors therefore point to the proposal of systematic measures for the protection of agricultural soil in Slovakia:

- enforce the use of alternative land in the event of the threat of soil withdrawn of the highest quality,
- cancellation/revaluation of exemptions from the payment of levies for the withdrawal of agricultural soil,
- increase in the number of levies for agricultural land withdrawn,
- establishment of the fund for the protection of agricultural soil,
- implement appropriate legislative and economic motivational tools in connection with the emphasis on reclamation projects in the area of agricultural soil protection,
- personnel strengthening of the relevant control bodies in the field of agricultural land protection,
- raising awareness/education about individual problems in the area of agricultural soil protection and their solution options.

The authors propose to strengthen the importance of research and educational projects or international cooperation in the field of agricultural soil protection and through appropriate communication or motivational channels to raise the awareness of the scientific community and other experts in this area about the need for research in this area.

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