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Quantification of Land Fragmentation in Slovakia

**Ľubica HUDECOVÁ, Robert GEISSE – Bratislava¹,
Silvia GAŠINCOVÁ – Košice², Marek BAJTALA – Bratislava¹**

ABSTRACT. During the era of socialist reconstruction the land use was intended to reach large scale agriculture – collectivization. In this period land and land ownership were separated. This situation persisted up to the present day even after the development of socio-economic circumstances. The separation of use and ownership of land, high proportion of land fragmentation and high proportion of state-held agricultural land presents acute issues in regard to land tenure in Slovakia. Current circumstances are forcing the land owner to lend their land. This paper explains that the progress of land tenure situation can be observed via measurement of changes of land fragmentation after processes such as land consolidation. It is imperative to explicitly quantify the scope of land fragmentation. Current methods of land fragmentation calculation in relation to land consolidation are rigid, ad hoc and needlessly complicated. New unified complete yet variable calculation will have wide utilization capabilities in practice. The calculation will enable monitoring of land fragmentation status as well as statistical comparisons correlating with land tenure state in Slovakia.

Keywords: agricultural land, land consolidation, land tenure, ownership, agricultural land market, land fragmentation.

1. Introduction

Agricultural land covers nearly half of area of Slovakia. There are several factors contributing to the designation of its use; 1 of which is land tenure situation. Ownership rights law of parcels is an essential institution which affects the overall operation of society. In the past ownership rights were often inhibited and fragmented to varying degrees. After the World War II – during the era of socialist

¹ Dipl.-Ing. Ľubica Hudecová, PhD., Department of Surveying, Faculty of Civil Engineering, Slovak University of Technology in Bratislava, Radlinského 11, SK-810 05 Bratislava, Slovakia, e-mail: lubica.hudecova@stuba.sk, Dipl.-Ing. Robert Geisse, PhD., Department of Surveying, Faculty of Civil Engineering, Slovak University of Technology in Bratislava, Radlinského 11, SK-810 05 Bratislava, Slovakia, e-mail: robert.geisse@stuba.sk,

Dipl.-Ing. Marek Bajtala, PhD., Department of Surveying, Faculty of Civil Engineering, Slovak University of Technology in Bratislava, Radlinského 11, SK-810 05 Bratislava, Slovakia, e-mail: marek.bajtala@stuba.sk,

² Assoc. Dipl.-Ing. Silvia Gašincová, PhD., Institute of Geodesy, Cartography and GIS, Faculty of Mining, Ecology, Process Control and Geotechnology, Technical University of Košice, Park Komenského 19, SK-040 01 Košice, Slovakia, e-mail: silvia.gasincova@tuke.sk.

reconstruction of society significant changes in regard to land tenure rights were introduced. Land use was intended to reach large scale agriculture – collectivization. Plots were reorganized towards wide scale consolidation (joint agricultural cooperatives). A clear distinction between ownership of land and land use was introduced – persisting to the present day.

The state of land ownership and land use has a correlation with land fragmentation. There are several reasons why land fragmentation occurred within the area of Slovakia. Maria Theresa ordered every municipality a management system for urban land. After the year of 1848 serfs became land owners, however, their lands were scattered across the municipality and had undesirable shapes. Other detrimental factors in regard to land tenure were application of Hungarian hereditary laws and inhibition of land ownership in the socialist era. Fragmentation continued to increase up to 1995 since there were no previous legislation precautions.

After the year 1989 the socioeconomic changes in Slovakia required new revision of legal land ownership and land use. Land ownership law was standardized; owners were given equal legal protection and equal restrictions. “Privatization of land” – transfer of land into private ownership occurred (compulsory collective land use was cancelled) and process of “individualization of farming” – transition to individual cultivation (as opposed to collective) was introduced (Lerman 2001). Development of land-related business was expected, however, over the past years social and economic decline in rural areas intensified instead. The legacy of the communist system gave land owners a set of particular values, personal identity, and emotional bonds (Van Dijk 2007).

Despite the remarkable success of the land-reform process, land fragmentation has emerged as key problem with detrimental implications for land-use planning, land management, for private and public investments, sustainable economic growth and social development. These negative implications can be observed through changes in land fragmentation. The goal of this paper is to propose the methodology for land fragmentation measuring. We presume that exact quantification of land fragmentation will help with monitoring of state of progress of land ownership and land tenure in Slovakia as well as with the search for improvement solutions.

Three main land tenure related problems are described in relation to land fragmentation (Bažík and Muchová 2015):

- Separation of ownership and use. Ownership of agricultural land is very fragmented, however; land use structure is not fragmented at all. Large corporations operate on fields which were created after collectivization. Land use is legally administered through thousands of lease agreements with co-owners of small parcels. Entries in lease agreements often contain vague or incomplete data about land owners. The state of land tenure is not a practical problem for agricultural production, but for land owners who want to use it for agricultural purposes. Statistically, 90% of land agriculturally utilized by Slovak farmer is leased. Owner of the land is significantly disadvantaged and prefers leasing of the land. The most common leases are closed for 5 to 10 years.
- Fragmentation of land ownership and land market. In extreme cases of fragmentation of land ownership a situation occurs when real value of ownership is unimaginable and has no use for purposes of land market. The average area

of land in the rural area is 0.45 hectare, with an average of 12–15 joint-owners per 1 parcel (Bandlerová and Marišová 2003). Small co-ownership fractions – lesser than 400 m² and often less than 1 m² are imposing problems regarding lease, trade, use as well as implementation of environmental measures. Every activity requires approval of all co-owners. Minority owner (owner of insignificant area) does not have influence concerning the activity on the parcel. Fees for fraction transfer to another owner are very high. Owners with very small co-owned share are not interested in sales of their fraction (Buday 2007, Schwarcz et al. 2013).

- Agricultural land under state control. Slovak Land Fund (SLF) founded in 1991 (the Act no. 330/1991 Coll.), manages real estates owned by the state (mostly plots that were public property; state roads, waterworks, railways and other constructions fulfilling the criteria of public interest) and real estates of unknown owners (owners without identification such as address, date of birth, and owners whose names are unknown). Unknown owners cannot be contacted and their identity confirmed we cannot conclude if they are alive. The legislature, however; preserves their ownership rights. SLF is subjected to legal limitations when managing land of unknown owners. Their land can only be leased exclusively for agricultural purposes. Sales of this land are completely prohibited. Authority of SLF regarding the management of state owned land is legally limited as well. SLF is the largest lessor of land, however it does not act as a real owner (or co-owner) (URL 3). Annual report of SLF (URL 2) state that they are of agricultural land managed by SLF as of 31st December 2014 was 417 162 hectares. According to Statistical yearbook (URL 1) the net area managed by SLF remains under state control – 17.5%. Overall, SLF as a co-owner affects up to 82% of all agricultural area in Slovakia. In practice this situation translates into restrictions for 82% of agricultural land inhibiting ownership rights of owners.

2. Land Fragmentation

Definition of land fragmentation is determined by historical as well as current state of society. Van Dijk (2004) distinguishes 4 types of land fragmentation: fragmentation of land ownership (it refers to the number of land owners who use a given piece of land), land use fragmentation (it refers to the number of users that are also tenants of the land), internal fragmentation (it emphasizes the number of parcels exploited by each user and considers parcel size, shape and distance as the main issues) and separation of ownership and use (there is a discrepancy between ownership and use).

In case of Slovakia it is more fitting to use 6 indicators (Hudecová 2015):

- 1 owner owns several parcels,
- parcels of 1 owner are scattered across the municipality,
- 1 owner owns a small proportion of a parcel (fragmentation of land ownership),
- parcels are small,
- parcels have undesirable shape,
- parcels are inaccessible.

Land fragmentation is resolved through land consolidation (LC). LC is applied in 2 separate versions with small differences in Slovakia.

2.1. Land Consolidation

Comprehensive LC, which covers agricultural land in municipality (local administration unit – LAU 2) is primarily focused on improvement of agricultural structure and fragmentation. Comprehensive LC is compulsory, representing a tool which the state utilizes to correct the injustice of the past, enabling the owner to use their land for agricultural purposes. Comprehensive LC is part of a wider development of infrastructure and protection of environment. State plot reserves are used to maximal possible extent. LC can be initiated by state or owners. Effects of comprehensive LC include improvement of agricultural business efficiency, improvement of environmental conditions, creation of preconditions for development of infrastructure, introduction of national and regional development plans. Comprehensive LC is co-funded with EU.

Simple LC is focused on only a part of municipality. Simple LC is used when an urgent investment opportunity arises and land tenure changes are necessary. This version of LC is voluntary, initiated and financed by relevant owners. Since only a fraction of municipality is covered the criteria for environmental protection are less strict. Simple LC can also be used in cases of wider infrastructural development or projects focused on environmental protection.

2.2. Land Fragmentation Quantification in Land Consolidation Process

Land fragmentation is quantified in relation to process of LC. Methodology for land fragmentation quantification is yet to be standardized, currently; there are 2 different approaches to the quantification in Slovakia.

One approach is performed by competent authority when compulsory comprehensive LC initiation is in proceeding. Competent authority determines justification in favor or against LC (the Act no. 330/1991 Coll.). Grounds for LC are reviewed including their urgency and agricultural impact. The goal for a particular location is to rank severity of land fragmentation of municipalities “from the worst to the best” to determine the order in which municipalities will be prioritized after the LC initiation. In evaluation of ranks 14 indicators are considered (Table 1).

The second calculation is performed by processor of LC in order to justify LC after the completion of a project. The state of 8 indicators is considered to express situation before and after LC (Figure 1). These relative values express improvement of the situation of land fragmentation but do not allow comparisons with other projects.

Both approaches for determination of the extent of land fragmentation serve their goal; however, they are ad hoc, heterogeneous and incomparable. They neither provide simple solution for calculations, nor the possibility of statistical evaluations and international comparisons. They also do not consider spatial parameters such as parcel shape as well as non-spatial parameters such as type of ownership and existence of access road for each individual parcel.

Point based evaluation is used to describe the state of parameters. In order to preserve equal treatment among districts (local administration unit – LAU 1) absolute values are expressed in percentage (50% representing the average value within the district). Resulting values are compared within the district. Calculation is lengthy and depends upon local conditions.

Table 1. Indicators for justification of land consolidation (in Slovakia).

Indicator	Rating
The average number of parcels per 1 owner	5–30
The average number of owners per 1 parcel	5–30
The average number of parcels per 1 hectare	5–30
The average number of owners per 1 hectare	5–30
The average number of ownership relations per 1 hectare	5–30
The incidence of hop fields, vineyards and orchards	5–30
The incidence of forest land	5–30
Inaccessibility of parcels	10–30
Ecological stability of that territory	0–30
Claiming of land for social and municipality interests	5–30
Vulnerability zones	5–30
Roma settlements	0–20
Economic conditions	0–30
Other reasons	0–20

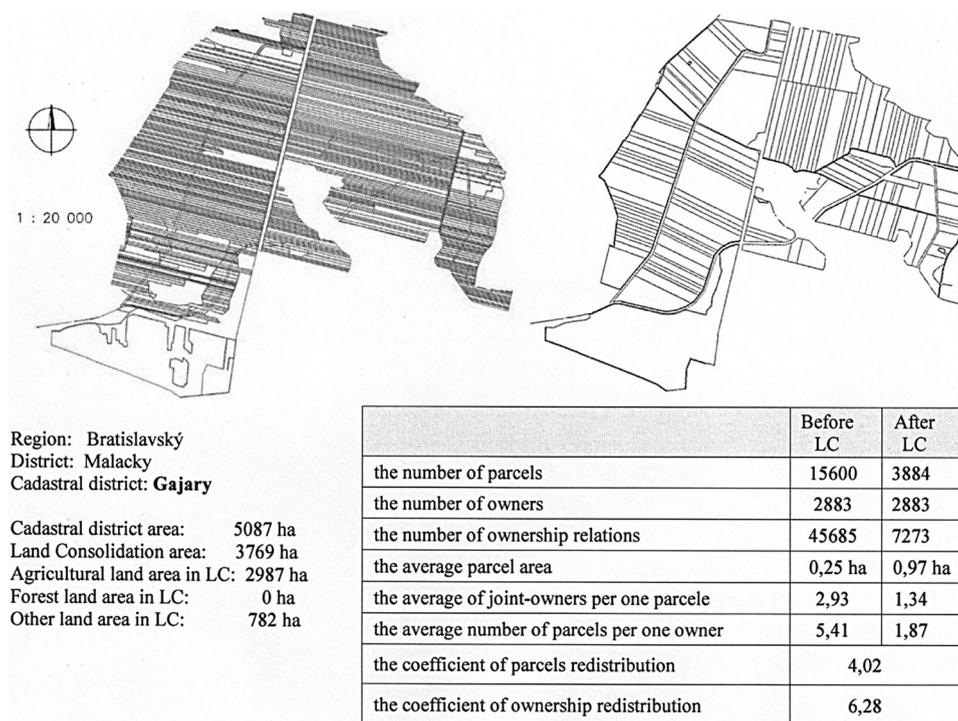


Figure 1. LC Gajary before LC (left) and after LC (right).

Every country utilizes their own methods and procedures for quantification of land fragmentation in relation initiation and evaluation of LC (Sklenička 2006, Demetriou et al. 2013, Leï et al. 2016, Janus et al. 2016, Muchová et al. 2016).

Methodology for quantification of land fragmentation proposed by Demetriou et al. (2013) is among the few that are flexible and applicable to every country. Land fragmentation is expressed through 6 factors (Table 2). Each factor is individually measurable. In order to reach homogeneity of these factors they are standardized in intervals between 0 and 1. The state of land fragmentation is quantified by Global Land Fragmentation Index GLFI, which is also expressed in value between 0 and 1.

Global land fragmentation index *GLFI* is calculated as an average (Demetriou et al. 2013):

$$GLFI = \sum_i^n \frac{LFI}{n}, \quad (1)$$

where:

n – the number of owners

LFI – land fragmentation index for one owner.

Land fragmentation index for one owner (LFI) is calculated based on weighted factors of land fragmentation *F1* to *F6* (Demetriou et al. 2013):

$$LFI = \sum_{i=1}^6 F_i \times w_i, \quad (2)$$

where:

F – standardized value of a factor

w – factor weight.

Table 2. Adjustment of land fragmentation factors proposed for Slovak conditions.

Factor	GLFI (Demetriou et al. 2013)	GLFI _{SR} ** (Slovak conditions)
F1	dispersion of parcel	no change
F2	size of parcels	new calculation
F3	shape of parcels	no change
F4	accessibility of parcels	no change
F5	dual ownership	number of parcels for 1 owner + calculation
F6	shared ownership	new calculation

* GLFI – Global Land Fragmentation Index

** GLFI_{SR} – Global Land Fragmentation Index for Slovak conditions

Calculation of GLFI was selected as a method for Slovakia because it allows consideration of land tenure specifics in every country and user can select which factors need to be taken into account.

3. Global Land Fragmentation Index for Slovak Conditions

New methodology for calculation of the state of land fragmentation in Slovakia (GLFI_{SR}), which can replace current procedures and expand the usability of calculation, was proposed. Used data were obtained from LC project in municipality Primoravské Lúky. This LC project covered area of 154 hectares and was finalized in year 2015. Data from register of initial status (RIS) (before LC), register of new status (RNS) (after LC) and corresponding map outputs were utilized. Calculation of GLFI_{SR} was conducted in Visual Basic for Applications.

Legislation (the Act no. 330/1991 Coll.) and regulations (Methodical guide 2008) respective to LC were analyzed and results were incorporated:

- Calculation of factors F2, F5 and F6 were proposed for Slovak conditions (Hudecová et al. 2016).
- Calculation of factors F1, F3 and F4 was proposed by Demetriou et al. (2013).
- Calculation of GLFI_{SR} based on analysis of sensitivity of factors F1–F6.

3.1. Calculation Factor F2, F5 and F6

New function for standardized calculation of parcel size factor (F2) is defined with minimal parcel size of 400 m² (the Act no. 330/1991 Coll.) and maximal recommended size of 1.3 hectare.

New standardized function of parcel size factor F2 is (Hudecová et al. 2016):

$$V(x_i) = (1 \div 12600) \times x_i - (2 \div 63), \quad (3)$$

where:

x – parcel size in m².

Number of parcels owned by a single owner (new factor F5) is in large proportion historically conditioned.

New standardized function of number of parcel factor F5 is (Hudecová et al. 2016):

$$V(y_i) = 1 \div y_i, \quad (4)$$

where:

y – number of parcels for 1 owner.

High fragmentations of ownership of agricultural land means that parcel have several owners instead of 1. We proposed new calculation of shared ownership factor F6 so that value of 1 represents exclusive ownership.

New standardized function of shared ownership factor F6 is (Hudecová et al. 2016):

$$V(z_i) = 1 \div z_i, \quad (5)$$

where:

z – number of joint-owners.

3.2. Analysis of Sensitivity and Calculation of $GLFI_{SR}$

Before the weights to each factor F1 to F6 were assigned their sensitivity was tested. Calculation of $GLFI_{SR}$ for Register Initial Status (RIS) and for Register New Status (RNS) was performed 6 times. In each calculation only 1 factor was assigned the highest value of 0.95, remaining factor were assigned the value of 0.01 (Table 3). The resulting value of $GLFI_{SR}$ (auxiliary calculation) in different weight distributions was observed (Table 3 – last 2 rows). The difference in values of $GLFI_{SR}$ (RIS) and $GLFI_{SR}$ (RNS) displayed the measure of sensitivity of given factor F .

$GLFI_{SR}$ calculation involves assignment of weight to individual factor of land fragmentation F1 to F6 in accordance with their measure of sensitivity. Assignment of weights for conditions on Slovakia is displayed in Table 4.

Values $GLFI_{SR}$ (RIS) and $GLFI_{SR}$ (RNS) for LC Primiravské lúky were calculated with formula 1 (Table 4 last 2 rows). According to Demetriou et al. (2013) correct assignment of weight is confirmed or rejected through $GLFI$ calculation for before LC values $GLFI < 0.4$ and after LC values $GLFI > 0.7$. This condition was met.

Table 3. Analysis of sensitivity of factors F1–F6 and auxiliary calculation of $GLFI_{SR}$

Factor	Weight					
	F1 – dispersion of parcels	0.95	0.01	0.01	0.01	0.01
F2 – size of parcels	0.01	0.95	0.01	0.01	0.01	0.01
F3 – shape of parcels	0.01	0.01	0.95	0.01	0.01	0.01
F4 – accessibility of parcels	0.01	0.01	0.01	0.95	0.01	0.01
F5 – number of parcels	0.01	0.01	0.01	0.01	0.95	0.01
F6 – shared ownership	0.01	0.01	0.01	0.01	0.01	0.95
$GLFI_{SR}$ (RIS) =	0.70	0.25	0.09	0.96	0.62	0.26
$GLFI_{SR}$ (RNS) =	0.71	0.09	0.17	0.97	0.74	0.77

Table 4. Assignment of weights for calculation of $GLFI_{SR}$

Factor	Weight
F1 – dispersion of parcels	0.01
F2 – size of parcels	0.01
F3 – shape of parcels	0.12
F4 – accessibility of parcels	0.01
F5 – number of parcels	0.15
F6 – shared ownership	0.70
$GLFI_{SR}$ (RIS) =	0.31
$GLFI_{SR}$ (RNS) =	0.70

4. Analyses of Results

Calculation of GLFI in conditions of Slovakia required:

- recognize specifics of land tenure,
- select defining factors of land fragmentation,
- standardize functions for every factor,
- define sensitivity of factor and
- propose definite weight distribution for every factor.

F1 and F2:

Dispersion of parcels (F1) and also size of parcels (F2) are heavily influenced by specific rules adopted by respective parcel owners. This relationship can be observed through size of parcels where situation worsened – as shown in the last 2 rows of Table 4 – $GLFI_{SR}(RIS) > GLFI_{SR}(RNS)$. After LC size of parcels was decreased. (Experiences from other municipalities also confirm that size of parcels after LC decreases.) In response weights for factors F1 and F2 were minimalized.

F3:

Shape of parcels was significantly affected by historical events. Current rules for design of parcel shape are dependent on numerous parameters, compromise solutions are considered in practice. Nevertheless, after LC an improvement in shape of parcels is always achieved. We have assigned moderate weight to factor – Shape of parcels (F3).

F4:

Accessibility of parcels (F4) is in Slovak circumstances difficult to assess for 2 reasons. The specificity of municipality transport infrastructure and the lack of interest of the side of numerous owners to farm their land (but lease it) fundamentally affects accessibility of these parcels. In presented case (Table 3 last 2 rows) almost every parcel was accessible before and after LC. These circumstances are extraordinary, resulting from narrow shape of municipality area and preserved historical infrastructure. Because of these reasons weight for factor F4 was minimalized.

F5 and F6:

Analysis of sensitivity of factors F1–F6 confirmed our expectations, factor with the most significant impact were shared ownership (F6) and number of parcels (F5). Their weights were prioritized.

It is appropriate to ask whether our proposal for calculation of $GLFI_{SR}$ is correct and definite, since only data from single project were utilized in proposal for $GLFI_{SR}$ calculation. Analysis of sensitivity was performed in 3 other projects and results were considered in $GLFI_{SR}$ calculation (Table 4 last 2 rows). Calculations of $GLFI_{SR}$ need to be performed on larger number of projects in order to solidify and increase accuracy of the process. It is essential to particularly monitor

proposed procedure for calculation number of parcels factor (F5) and joint-ownership factor (F6) and prioritization of their weights in $GLFI_{SR}$ calculation.

5. Possibilities for Utilization of $GLFI_{SR}$

$GLFI_{SR}$ is indubitably utilizable since definite quantification method for land fragmentation is continually inexistent in practice. $GLFI_{SR}$ can be utilized in consideration process for initiation of LC as well as assessment of LC effectiveness.

In our opinion the utility of GLFI can be even broader in practice. For instance; through land fragmentation the progress of land tenure problems can be measured and monitored. The importance of GLFI will be manifested in long term monitoring of relationship between land fragmentation and land tenure problems.

Improvement of land fragmentation will affect other areas:

- Improvement of land ownership and land use structure (quantity of leased land, the number of lease agreements, duration of the lease, area managed by SLF under state control, etc.),
- Changes in size structure of parcels and in ownership structure in land registration system (average area of land in the rural area, average number of joint-owners per 1 parcel, total number of parcels),
- Improvement of land market (number of sales, area of sold land, etc.).

6. Conclusion

Since development of agriculture in Slovakia is still affected by transformation of forms of land ownership it is important to monitor and analyze progress of land tenure status. The main land tenure problems in Slovakia and their connection to land fragmentation were explained and emphasized.

Severity of land fragmentation was previously impossible to quantify explicitly. Procedures for purposes of land consolidation are intricate and ad hoc. It is reasonable to assume that exact quantification of land fragmentation can help with monitoring of state of progress of land ownership and land tenure in Slovakia as well as with the search for improvement solutions.

Verified procedures of GLFI calculation were utilized and adjusted to fit conditions in Slovakia. Standardization of used factors guarantees that resulting GLFI always belongs on the interval of 0 to 1. Our proposed explicit quantification for the extent of land fragmentation offers several advantages.

Definite calculation of $GLFI_{SR}$ enables utilization in planning of initiation of LC projects, analysis of LC effectiveness as well as monitoring of overall state of land tenure in a country and management of agricultural politics. It will be possible to monitor, statistically evaluate and compare the development of land fragmentation and also review correlation between progress of land fragmentation and land tenure problems. Another advantage is an option to monitor individual development of factors of land fragmentation. Various state institutions can utilize results in accordance with their individual needs.

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Kvantifikacija fragmentacije zemljišta u Slovačkoj

SAŽETAK. Tijekom razdoblja socijalističke obnove, korištenje zemljišta bilo je usmjereno na postizanje poljoprivrede velikih razmjera – kolektivizacije. U tom je razdoblju bilo odvojeno zemljište od vlasništva nad zemljištem. Takvo je stanje potrajalo sve do danas, čak i nakon nastanka socioekonomskih čimbenika. Odvajanje korištenja zemljišta od vlasništva zemljišta te visoki udio fragmentacije zemljišta i visoki udio državnoga poljoprivrednog zemljišta predstavljaju ozbiljne probleme vezane uz vlasništvo nad zemljištem u Slovačkoj. Trenutne okolnosti prisiljavaju vlasnika zemljišta unajmiti zemljište. Ovaj rad objašnjava kako se napredak stanja s vlasništvom nad zemljištem može promatrati putem praćenja promjena fragmentacije zemljišta nakon postupaka kao što je komasacija zemljišta. Neophodno je eksplicitno kvantificirati opseg fragmentacije zemljišta. Suvremene metode izračunavanja fragmentacije zemljišta vezane uz komasaciju su nefleksibilne i suviše komplicirane. Novi jedinstveni i cjeloviti izračun s varijablama imat će široku mogućnost primjene u praksi. Izračun će omogućiti praćenje stanja fragmentacije zemljišta, kao i statističke usporedbe, koje su u skladu sa stanjem posjedovanja zemljišta u Slovačkoj.

Ključne riječi: poljoprivredno zemljište, komasacija zemljišta, posjedovanje zemljišta, vlasništvo, tržište poljoprivrednog zemljišta, fragmentacija zemljišta.

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