The Application of Fuzzy Logic in the Field of Land Consolidation

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***Abstract*— In Hungary land consolidation lacks a plenty of preconditions. The information based decision-making model belongs to these preconditions. This model would be able to optimize the present land structure based on objective aspects. The basis of the consolidation can be the Goldencrown value of the property registry. Since this value is out-of-date, correction factors should be set out. Geoinformatics can contribute to spatial data managing. What is more, fuzzy logic can also provide solution for the description and summation of factors. The present paper gives an example for the description and mapping visualization of modifying factors using sigmoid function on a sample area.**

I. THE NECESSITY OF LAND CONSOLIDATION

The present fragmented land structure originated in the distribution of compensation and joint ownership property happened in the 1990s. The privatization of field land was applied to the ¾ of the arable of the country. 5.6 million hectares were shared among 2.6 million private individuals so that the average land size per capita was about 2 hectares. These land areas were often distributed in parcels and/ or as undivided joint ownership. With this land reform that group in the society received land that did not want to deal with agriculture. Nowadays, in Hungary, 64% of the owners hire out their land property. Therefore the property and the use of land have been significantly diverged. For that reason, in Hungary, land lease – contrary to West-European countries – is not the sign of the spread of competitive farms, but of the unambiguous consequence of privatization [1].

Since the change of the political system some kind of land unification has been observable in Hungary. Land size is a significant part of competitiveness. So the 8.1 hectares average land size [Fig. 1], which has come into existence due to land unification, is still little as compared to other European models [2].

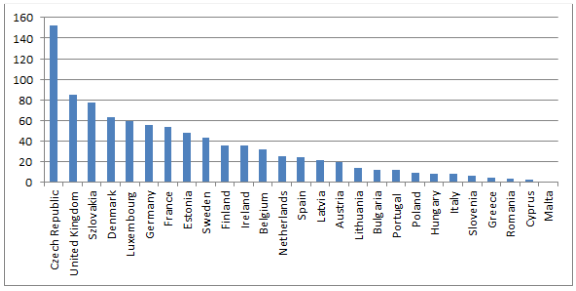

Figure 1. Average land size in the European Union

The Act No. CXXII of 2013 concerning agricultural and forestry land trade has aimed to solve the problem of fragmented land structure. The law supports individual and family farmers as against national and international land speculators. The importance of the regulation is unquestionable, however, the spectacular results can be observed only in the long run. The government has also regulated (374/2014. regulation) the elimination of the undivided joint ownership started up in the course of land privatization. 950.000 hectares land area and 300.000 applicants are involved in the project. Although this act can solve the problem of the undivided joint ownership, it still increases the fragmentation of land structure.

A complex land consolidation would be necessary both for the approximation of land use and land ownership and land unification. According to a comprehensive paper [3] published in 2004, the institutionalized land consolidation could be put into practice. On the one hand, the conditions of such a consolidation are given: there is a land registry system, skilled labour and technical knowledge. On the other hand, there are conditions that can come into existence such as legal regulation, budget, socialization and an appropriate IT solution that can be generally applied in the course of land consolidation. The aim of the present paper is to introduce an IT solution that can be used to determine the exchange value in the course of land consolidation. During land consolidation, it is not necessary to express the exchange value in sale value; the use of modified GoldCrown, that would involve the most essential aspect modifying the value, could be sufficient.

II. FUZZY LOGIC AND LAND CONSOLIDATION

Fuzzy logic is significant because it can describe the imprecise and imperceptible information in a quantitative way. On the one hand, the fuzzy "set" can be seen as a classical mathematical set which means that there exist numbers that are either the elements of the set or not.

$$\mu(x)=1, \text{ if x is the element of X}$$

$$\mu(x)=0, \text{ if x is not the element of X}$$

On the other hand, the fuzzy function assigns a value to each and every element, which can describe the extent to which the element belongs to the set. The value of the fuzzy function can be 0-1.

$$F=\{(x,\mu_F(x)): x\in X\}$$

$$\mu_F(x)\rightarrow[0,1]$$

To lower the capacity of calculation, linear functions have spread. But it is important to know that fuzzy functions can occur in any higher form. Nowadays fuzzy

logic is widely used such as in the field of automotive sector, medical technology, factory farms or entertaining technology [4].

As for land consolidation, fuzzy logic can contribute to estimation of the value in exchange. Due to the lack of land consolidation law, we need to take into account of 54/1997 FM regulation to define the factors affecting valuation of property. According to the regulation, the corrective factors are these: shape, size, location, reach, road conditions, relief and gradient conditions, drainage, landmarks interfering cultivation, esthetical impression, the likelihood of frost, ice and game damage, irrigation, inclination for cultivation, demographical proportions, nutritional farming, agrochemical intervention, environmental pollution and long-term environmental impairment, natural protection, melioration.

The above-mentioned factors always need to be taken into account in the course of valuation of property. However, on the behalf of the social acceptance of land consolidation, it is not practical to take into consideration many factors that could affect the GoldCrown value on a large scale.

Table I. contains the most important corrective factors with their intervals and the definition of evaluation.

TABLE I.
CORRECTIVE FACTORS

Corrective factors	Interval		The basic of valuation
	lower	upper	
Shape, area, size	-20	20	Area, perimeter
Location	-20	20	Distance from the clear
Reach and road condition	-20	20	Categories of connected roads
Relief and gradient conditions	-20	0	Categories of slopes
Melioration and drainage	-20	0	Likelihood of flood and polder
Conditions of irrigation	0	20	Distance from the irrigational channel
Environmental protection	-15	0	On the basis of land use limitation

The fuzzy functions can be made on the basis of the intervals of corrective factors. Since, the functions can have only values 0-1, the neutral value should be 0.5 in any cases. The sigmoid function has been selected for fitting to the accurate series. This kind of function is useful because it is possible to give both the neutral value and the value of the slope of the sinus curve.

$$mSig(x,a,c) = 1/(1+\exp(-5/a*(x-c)))$$

, where:

a=the growth of slope

c=neutral value 0,5

The shape factor, that can affect valuation of property, needs some explanation. Since the value of the property is influenced by how it can be cultivated, it is important to determine the extent of correction in an objective way. It is well-known that among plane figures the ratio of the area and the circumference gives the biggest number. This value is influenced by the squared variable derived from two dimensions. Therefore the square can be eliminated and we can get a value that is appropriate for comparison. The value of the property is affected by the growth of a continuous area that is why the above-mentioned value needs to be corrected. The area size needs to be raised to 0.1 power to make the shape and the area size almost equal.

$$\text{Shape factor} = (\sqrt{\text{area}}/\text{perimeter}) * \text{area}^{0,1}$$

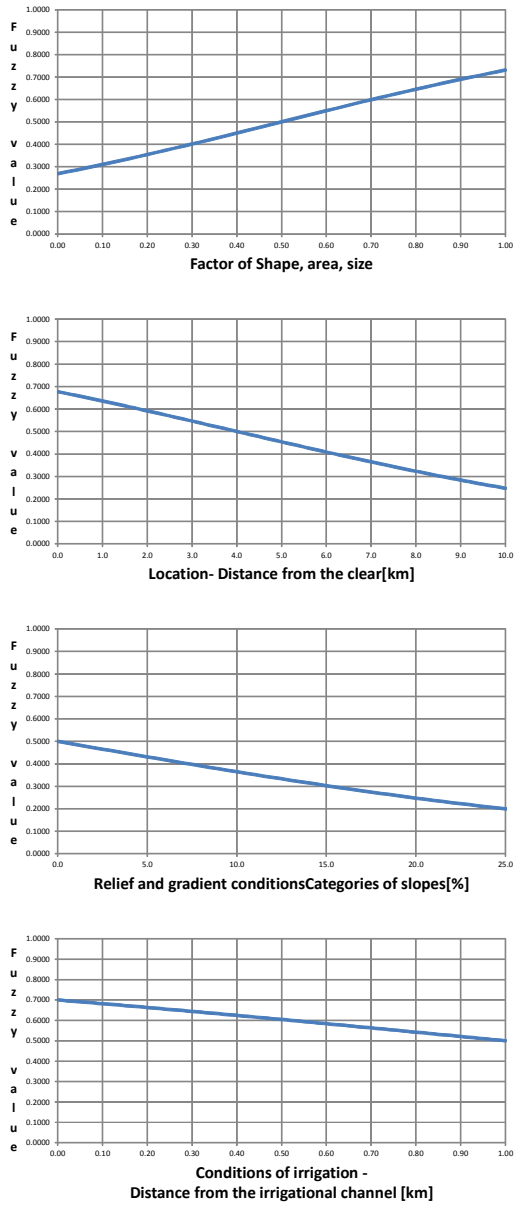

Figure 2. Fuzzy functions

Fig.2 shows the functions of different factors affecting the property. The functions of some factors seem to be linear but to the extreme converging –not seen- sinus curve parts are significant, too, because multiplying by a number greater than 1 or smaller than 0 can be problematical in the course of summation of corrective factors.

III. ANALYSIS OF THE SAMPLE AREA

The formation of the value mapping of the field land expands in Mesterszállás. The village is the sample area of

the Institute of Geodesy, Cartography and Remote Sensing. The Institute has provided the land registry data of the village. The land registry contained 1578 parcels, out of which 566 cultivated parcels have been selected for the analysis. The average size of the parcels is 5.8 hectares, the quality classes are among 2-7. Fig.3 shows the original GoldCrown values.

Figure 3. GoldCrown values on the sample area

Table II. summarizes the results of the analysis containing 6226 records.

TABLE II.
STATISTICS OF FACTORS AFFECTING VALUATION OF PROPERTY

Corrective factors	Min	Max	Average	Range	Scatter
Shape, area, size	0.32	0.70	0.50	0.38	0.0770
Location	0.32	0.68	0.56	0.36	0.0832
Reach and road condition	0.50	0.60	0.51	0.10	0.0287
Relief and gradient conditions	0.50	0.50	0.50	0.00	0.0000
Melioration and drainage	0.30	0.40	0.30	0.10	0.0094
Conditions of irrigation	0.56	0.70	0.68	0.14	0.0309
Environmental protection	0.45	0.50	0.50	0.05	0.0051
Sum	0.45	1.62	0.94	1.17	0.2070

The above mentioned data show how the different kinds of factors have influenced the valuation of the analysed parcels. There are significant differences among the corrective factors; however, they are not surprising in view of the sample area. The smallest extent corrective factor can be found in case of relief. The reason for this is that the difference between the highest and the shortest point of the village does not reach 10 metres; therefore there are no measurable differences in slope. The largest correction can be observed in case of "Shape, area and size". This conclusion is in accord with the result coming from a representative survey among land owners.

According to this survey, the above mentioned factor influences the unit value eminently after the GoldCrown value. After the summation of the corrections, the discrepancy between the smallest and the biggest correction is 117%. The smallest correction (0.45) was given to a parcel (its topographical number 0188/7) which has worse shape and size factors than the average: it is the farthest from the inland, it can be approached on dirt road, the likelihood of flood damage is high, it has average irrigational conditions and it does not stand under environmental protection. The highest corrective factor (1.62) was given to a parcel (its topographical number 0312/4) which has better shape and size factors than the average: it is near the inland; it can be approached on pitched road, the likelihood of flood damage is high, it has average irrigational conditions and it does not stand under environmental protection. Fig.5 shows the value of totalized corrections – the values are shaped after normal distribution.

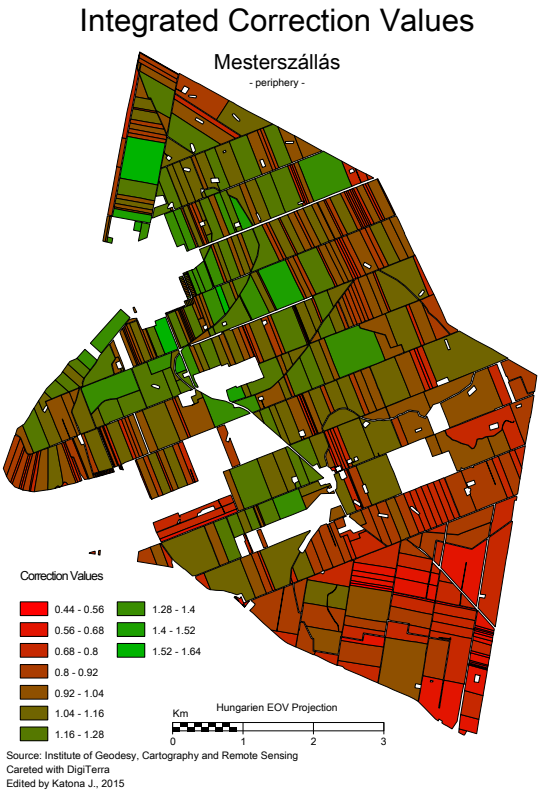

Figure 4. Integrated Correction values on the sample area

The analysis principally leans on cadastre mapping substance. Two corrective factors (shape, area, size, location, geographical position) have been elicited from this data resource. What is more, this substance has

provided the mapping basis of other corrections. Free available digital resources (such as Interior Ministry General Directorate of Water Management - Floodmap, Rural Development Ministry – Nature Conservation Information System) have also contributed to the determination of other factors.

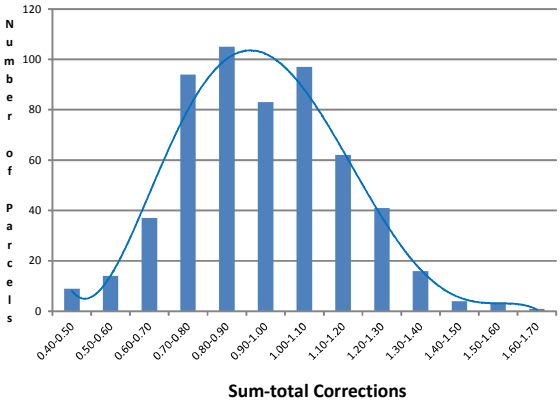

Figure 5. Statistics of Sum-total Correction

IV. SUMMARY

To carry out successful land consolidation, social support is necessary. The development of the IT solution mentioned in the present paper serves this aim. The statistical weighting of certain factors can be easily modified by the change of the slope values of Fuzzy functions. Therefore it can be geared to the demand of the community that is affected by the consolidation. Naturally, an institutionalized land consolidation has got several conditions and it also needs trial projects that analyse the technical realization. The following part of the research dealing with land consolidation aims to use the results of the evaluation method that applies fuzzy logic.

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