DETERMINATION OF VALUABLE AGRICULTURAL LAND IN THE FRAME OF PREPARATION OF COUNTYWIDE SPATIAL PLANS: ESTONIAN EXPERIENCES AND CHALLENGES

Siim Maasikamäe[1], PhD; **Evelin Jürgenson**, MSc.; **Merit Mandel**, MSc.; **Piret Veeroja**, MSc.
Department of Geomatics, Estonian University of Life Sciences

Abstract. The protection of agricultural land is an important issue because the area of food production per capita will be decreasing by several estimations in the next decades. The planning measures to ensure the preservation of valuable arable land are among the objectives of county plans in Estonia. However, there is no clear methodology for determination of valuable agricultural land as of now. The aim of the study was to develop methodology in order to determine valuable agricultural lands in the frame of preparation of countywide spatial plans in Estonia. The paper presents a description of that methodology and the possibilities to implement it in the course of preparation of county plans. The idea of the methodology is to calculate the complex value index for plots of agricultural land. The complex value index characterises the plots of agricultural land from the agriculture production perspective, and the fiscal value of land is not considered thereof. The soil fertility, spatial properties, and other features of plots have been considered for calculation of the complex value index for Jogeva County in Estonia. All tasks were made in an ArcGIS environment and different digital maps were used as data sources. The calculated indexes made the plots comparable from the agriculture production perspective and conditions for simulation of the different situations of valuable land areas were created. The simulation of different situations of valuable arable land indicated that the proposed methodology gave planners flexible tools for determination of valuable agricultural land.

Key words: valuable agricultural land, complex value index, determination of valuable land area, simulation of different situations.
JEL code: Q38

Introduction

The importance of agricultural land is increasing worldwide because of the need to feed a growing population. It is projected that the world population will increase by 2.3 billion people between 2013 and 2050 (UN, 2013). According to estimates of the FAO (2009), global food production needs to increase by nearly 70% by 2050. On the contrary, the area of arable land per capita in 2010 was 0.23 hectare and the projection for the 2050 is 0.181 hectares (Alexandratos, N. and Bruinsma, J. 2012:108). There are more similar prognoses (Bruinsma, J. 2011; FAO, 2002) that indicate a decrease of arable land per capita in the near future. The global processes clearly indicate that agricultural land should be used more efficiently and not converted to non-agricultural land.

[1] Corresponding author *E-mail: Siim.Maasikamae@emu.ee*

Agriculture has historically been the main user of rural land but today it has to compete for land with other land use types. This competition is a complicated phenomenon because the value of agricultural land has diverse meaning for people with different backgrounds. Real estate developers, for example, are interested in possibilities to convert raw land to build up land and earn a solid profit as a result. The occurrence of rare species of plants or animals on particular areas makes the land valuable from a nature protection point of view. The productivity of soils and land tillage conditions make land valuable for farmers. Therefore, a plot of valuable agricultural land can be and often is the place of contradicting interests.

Rural land use planning has to deal with the negotiation of the wishes and goals of various stakeholders. It is necessary to preserve areas for nature protection and also for food production (Kerselaers, E. et al., 2013). The arable land area per capita in the Baltic States is higher than the world average (Linner, H. and Messing, I., 2012). The area of arable land per capita in Estonia was 0.47 hectares in 2011 by the World Bank data (http://data.worldbank.org/indicator/AG.LND.ARBL.HA.PC). But is it enough to secure its people with food in the longer perspective? Since arable land value in the world increases and climate conditions will foster agricultural production in the Northern Europe, Estonian land resources become more important (Linner, H. and Messing, I., 2012). This, in turn, raises the importance of rural planning.

One of the tasks for planning rural areas is to create conditions for the protection of valuable agricultural land from conversion into non-agricultural land. The problem is not topical for Estonia only. For example, Swedish law limits building on agricultural land but it does not work in practice, because municipal governments have strong influence over local land use planning (Linner, H. and Messing, I., 2012). As of now, the protection of agricultural land and, in particular, arable land is not clearly settled in Estonia. Uncontrolled real estate development has often led to the conversion of arable land into built up land (Maasikamäe, S. et al., 2011) and even small real estate development areas on arable land can worsen land use conditions (Veeroja, P. et al., 2013).

The preparation of the next round of county plans was initiated by the Estonian Government (Order No 337, passed 18.07.2013.) (Maakonnaplaneeringute … 2013). The Planning Act (2002) is the legal basis for preparing all spatial plans, including county plans, in Estonia. According to this act the definition of general provisions for the use of land and water areas and the planning measures to ensure the preservation of valuable arable land are among the objectives of a county plan. However, there has not been a clear vision and methodology for determination of valuable agricultural land until now (Lähteseisukohad …, 2013).

The need for the methodology of determination of the areas of valuable agricultural land in the frame of preparation of county plans was the starting point of the study. The value of agricultural land has been estimated only from the farming point of view. Valuable landscapes and areas of high natural value were not subjects of the study. The methodology does not use any economic calculations, because it is very difficult, if not impossible, to predict the production costs and prices of agricultural products for 40−50 years ahead. The question is rather: will we have enough valuable land for agriculture in 50 years in Estonia?

The paper presents the results of the implementation of the methodology for determination of valuable agricultural land. The aim of the study is to evaluate the expediency of the methodology of determination of valuable agricultural lands in the frame of preparation of countywide spatial plans. The hypothesis of the study is that the determination of valuable agricultural land on the basis of soil site class and complex of factors will give different results. Research tasks are: a) to describe the methodology of determination of valuable agricultural land; and b) to show the possibilities to implement that methodology in the frame of preparation of county plans in Estonia.

Materials and methods

The study was carried out in Jogeva County which is located in the middle of the Eastern Estonia. According to Statistics Estonia (http://www.stat.ee/ppe-jogeva-maakond), the area of the county is 2603.83 km² and the population is 30,671, and based on those characteristics it is the ninth biggest county in Estonia (by date 09.12.2013). The main sphere of economic activity in Jogeva County is agriculture.

The determination of valuable agricultural land was limited to arable land only, grassland was not included. The valuation procedures were carried out in the ArcGIS environment and the following digital maps were used for that purpose:

- Estonian National Topographic Database;
- map of land reclamation systems;
- soil map of Estonia.

The procedure of determination of valuable arable land in the frames of preparation of county plans generally consists of two parts. In the first, a complex evaluation of arable land plots has to be made. Complex evaluation means the calculation of a single index for each plot of land. That index (CVI – complex value index in further) includes the impact of different factors that makes land valuable for farming. The second step is the determination of limits of valuable arable land areas by simulating different situations. Different approaches and criteria can be implemented in the simulation process. The valuation procedures consisted of the following steps:

- formation of study units to be evaluated;
- preliminary evaluation of each study unit by different factors (criteria);
- recalculation of results of preliminary evaluation;
- calculation of final grade of comparable value (CVI) for each study unit.

The first task was the formation of study units as undivided and complete pieces of arable land. The study units are the areas of arable land that are delimited by other types of land (e.g. forest), by roads, ditches, or other linear objects. Different overlay procedures in the ArcGIS environment were implemented in order to determine the study units. Depending on local circumstances some study units were less than one hectare, while the largest study unit was 303 hectares. Study units with the areas less than one hectare were excluded from the study. The reason for doing that was the fact that small pieces of arable land are usually a part of small landholdings and such areas do not play important roles in contemporary agriculture. The study units are the main elements of all the following procedures. All data were connected to study units including the CVI.

Once the study units were determined, the next task was to evaluate them from the perspective of agriculture production. The list of factors to be considered for calculating the CVI was created and presented to farmers to evaluate how the factors influence the value of arable land and the CVI. The farmers were asked because they know the local conditions and the impact of different factors on the value of land from an agriculture perspective.

Finally, the seven following factors were used in the study for calculation of the CVI:

- soil fertility is an important factor for every type of agriculture production and it was measured through site classes of soils that are available on digital soil maps. The weighted average of site classes was calculated for each study unit, while soils types and site classes varied within study units. The site class varies between 15 and 64;
- area of a plot (area of study unit in this case) is another factor that affects profit in agriculture production. The importance of this factor is growing due to the developments of cultivation technology; it is difficult to cultivate small plots with big machinery;
- shape (compactness) of a parcel has also an impact on land cultivation conditions. The tillage of a non-compact plot will raise cultivation costs. A square is considered as an ideal shape and every other shape as imperfect in the authors' study. Compactness was measured with a compactness coefficient and for squares it equals one. However, compactness coefficient can be less than one in case the plot is similar to circle. The compactness coefficient increases with the decrease of the compactness of a plot. The calculation of coefficients has been made in GIS environment. The compactness coefficient of study units varied between 0.943 and 6.403;
- accessibility conditions to land affect agricultural production − good accessibility contributes to active land use and poor access conditions can lead to land abandonment (Mandel, M. and Maasikamäe, S., 2013). In this study, accessibility was measured as the distance from the state road network to study units, and it varied between 0 metres and 3890 metres;
- the nearness of plots is understood as the distance from each study unit to the nearest neighbouring study unit. The nearness of plots does not directly affect cultivation costs but are raised by extra expenditures made to access separately located parcels. Therefore, the distance to the nearest neighbour was determined for all study units;
- distance from bigger centres and nearest settlements does not directly affect agriculture production but often centres around aggregate production centres, services and markets. Study units that are located farther from these types of features will have to spend extra costs, also sometimes in the periphery, these kinds of plots can be left out of use. The distance from the nearest bigger settlement (village, small town) to all study units was determined. The limit to being a big settlement was set to at least 100 inhabitants. The total number of settlements in Jogeva County is 239 and 50 of them met the mentioned criterion;
- amelioration is important in those areas where soil fertility is low or humidity is high. This factor was evaluated for all study units as the ratio of the area under amelioration systems and the area of a study unit itself.

The factors listed above are measured in different units and different scales, and thus, they are not comparable. In order to transform the factors into a comparable scale, they should be normalised. Normalisation in this study refers to the procedure where all data of all factors were transformed into a scale from 0 to 1. A particular factor was assigned for the best value; the new value 1 and for worst value was assigned respectively the new value 0, e.g. the study unit with the highest site class of soil was graded with 1 and with the lowest site class of soil was graded with 0, the most compact study unit was graded with 1 and the less compact with 0 etc.

It is still difficult to compare the impacts of different factors after normalisation. The reason is that each factor might have a different impact on the CVI of arable land. Therefore, the factors must have different weights when the CVI is calculated and equation 1 was used for that purpose.

$$CVI_i = \frac{\sum f_i w_i}{\sum w_i}, \quad (1)$$

where

CVI_i - the complex value index for the i-th study unit;

f_i - the rate of the i-th factor;

w_i - s the weight of the i-th factor.

Weights of factors were also determined when the farmers were questioned. The respondents were asked to evaluate impact of each factor on a 5-point scale from the perspective of valuable agriculture land. After data processing the weights for each factor were calculated and the results are presented in Table 1.

Table 1

Weights of factors for calculation the CVI for Jogeva County

Factor	Weight of a factor
Soil fertility	0.1971
Amelioration	0.1606
Area of a parcel	0.1460
Accessibility conditions	0.1460
Shape of a parcel	0.1314
Nearness of parcels	0.1314
Distance from bigger centres and nearest settlements	0.0876
Sum of all weights	1.0000

Source: authors' calculations based on the authors' study

If the parameters are normalised and the sum of weights is transformed to 1 then the CVI can theoretically range from 0 to 1. In practice the range of CVI can be and is less. In our study the calculated CVI for all study units varied between 0.291 and 0.878. The two options to continue are possible. The first is to leave the calculated CVI values as they are. The second option is to normalise the

CVI values by converting them into a range from 0 to 1. The authors used the second option in the present study.

Research results and discussion

As a result of the present study, the authors got the digital map of arable land plots (study units) for Jogeva County in ArcGIS shape format. All study units have the descriptions of different components of the complex value and the CVI. The calculated CVI is meant to help the planners in the decision-making process when the areas of valuable land are needed to be determined. There are two basic approaches to use the CVI for that purposes. The first option is to set a certain threshold for CVI and all land that has higher complex ratings will be considered as valuable land. The second option is to arrange all study units by the CVI and then find the certain area (or percentage) of the most valuable arable land.

The use of the first option for the determination of valuable land is described first. It is necessary to mention that some particular components (e.g. soil site class) of the complex ratings can also be used besides the CVI. The area of valuable land will be changed depending on the setting of the threshold. Table 2 illustrates these changes.

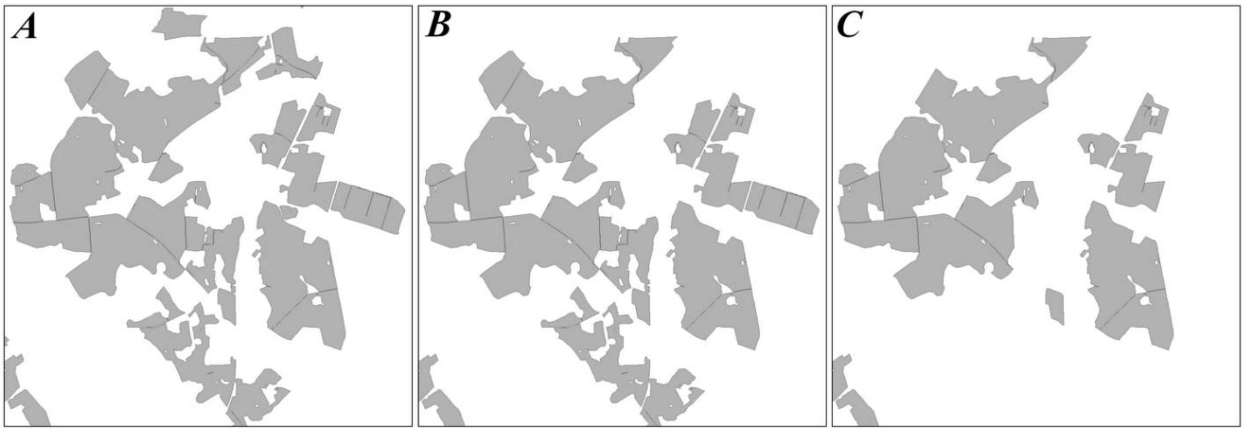
Table 2

Areas and percentages of valuable arable land for different thresholds calculated by normalised complex value indexes (CVI) and normalised site classes of soil for Jogeva County

Value of thresholds	Normalised CVI		Normalised site class of soil	
	Area of arable land considered as valuable (ha)	Percentage of valuable arable land from total area of arable land	Area of arable land considered as valuable (ha)	Percentage of valuable arable land from total area of arable land
0.3	77745	99.1	76402	97.4
0.4	76460	97.5	74084	94.4
0.5	72394	92.3	69741	88.9
0.6	62003	79.0	57603	73.4
0.7	45539	58.0	37116	47.3
0.8	22770	29.0	13473	17.2

Source: authors' calculations based on the authors' study

Data in Table 2 clearly indicate that most land will be determined as valuable if the threshold is set to 0.3. It is not reasonable to set threshold less than 0.3 because in those cases almost all agricultural land will be determined as valuable. The total area of arable land included in the study was 78,395 hectares. The area of valuable land will decrease if the threshold is set higher. However, the areas of valuable land will be different if some component of value is used instead of the CVI (soil site class in this particular case). That difference became bigger if the threshold was set higher. The data of Table 2 show that soil site class cannot be used instead of the CVI when the areas of valuable agricultural land are determined. Depending on the threshold the corresponding map can be produced immediately as all calculations are made in a GIS environment.



Source: authors' construction based on the calculations in GIS environment

Fig. 1. **The examples of valuable arable land determined by different thresholds, fragments of valuable arable land map. The threshold for CVI is set to 0.5 in section A of the figure and to 0.6 and 0.7 in sections B and C, respectively**

Figure 1 presents the fragment of three different maps of the same area. The difference among sections of the figure is that the different thresholds have been set for the CVI as criteria of valuable arable land.

The setting of the correct threshold for determination of valuable arable land is not the issue of valuation of the study units. It is rather the land policy issue. The criterion should be set by policymakers and planners. On the contrary, the use of different thresholds for the CVI gives the flexible possibility to simulate different situations of valuable arable land. It is possible to find answers to questions like: What … if …? The starting point of the second approach is setting the area (or percentage) of arable land that should be considered as valuable. It can be settled that the particular area in hectares or percentage of agricultural land should be considered as valuable. Table 3 gives an overview on the CVI and soil site class values if a particular percentage of land is decided to be considered as valuable.

Table 3

The complex value indexes (CVI) and soil site classes for different ratios of arable land as valuable land for Jogeva County

Percentage of valuable land as threshold	Threshold	
	Complex value index	Soil site class
10	0.864	57.8
20	0.828	55.6
30	0.797	54.0
40	0.765	53.1
50	0.734	51.8
60	0.692	50.5
70	0.646	49.0
80	0.593	47.2
90	0.523	43.6

Source: authors' calculations based on the authors' study

The figures of Table 3 are needed for generation of different maps of valuable arable land if the percentage of valuable land as a threshold has been settled. If it is decided, for example, that 50% of the best arable land should be valuable then the CVI should be set to 0.734 if a map of valuable arable land for Jõgeva County has to be generated. The data of Table 3 allow easy generation of different maps of valuable arable land. The planner can quickly simulate different situations of valuable arable land if information like in Table 3 is provided.

The hypothesis of the study was that the determination of valuable agricultural land on the basis of soil site class and complex of factors will give different results. Data from Tables 2 and 3 are proving this hypothesis. The soil site class does not consider influence of factors that are important from the land use perspective. The implementation of CVI will eliminate this disadvantage. The methodology for determination of valuable agricultural land must be simple and general enough. It is not oriented to plan the agricultural activities in the short run, e.g. from five to ten years. The advantage of the presented methodology is also the fact that different factors with different scales and different units were combined into a single index. A problematic issue can be the determination of weights for different factors. The opinions of farmers are a good source of information but it is obviously based on local knowledge and experience. The local conditions of different counties are different. The flat areas of the Northern Estonia are not comparable with the hilly areas of the Southern Estonia. It means, for example, that the relief as one of the factors should be considered if the CVI is calculated in some regions and not considered in others. The weights for different factors, when calculating the CVI, can vary depending on the region.

The results of the present study will be used in compilation of the Jogeva County plan that was initiated among other county plans by the Estonian government. The results show that some elaboration of methodology for determination of valuable agricultural land can be needed but the basic principles are settled and can be implemented.

Conclusions

The proposed method for determination of valuable agricultural land is simple, robust, and easy to use. The necessary initial data are mostly available. The only drawback is the incomplete data about soil productivity for some areas of agricultural land. However, the problem can be solved as the database of soil maps contains the necessary initial data for the determination of soil productivity.

1. The proposed methodology gives planners flexible tools for simulation of different situations of valuable agricultural land.
2. There were (and still are) some problems with the input data. Soil productivity data are missing for some agricultural land parcels.
3. The weights of different factors need more careful investigations. However, the results show that the most important factors to be considered when determining valuable agricultural land are the productivity of soils, the presence of amelioration systems, areas of parcels, and accessibility conditions.

Bibliography

1. Alexandratos, N., Bruinsma, J. (2012). *World Agriculture towards 2030/2050: The 2012 Revision*. ESA Working Paper No. 12-03. Rome, FAO.
2. Bruinsma, J. (2011). The Resources Outlook: by How Much Do Land, Water and Crop Yields Need to Increase by 2050? *In: Looking Ahead in World Food and Agriculture: Perspectives to 2050, Edited by Piero Conforti, Food and Agriculture Organization of the United Nations*, pp. 233-278.

3. FAO. (2002). *World Agriculture: Towards 2015/2030. Summary Report*. Food and Agriculture Organization of the United Nations, Rome, p. 97.

4. FAO. (2009). *Global Agriculture Towards 2050. High-level Expert Forum*, Rome 12-13 October 2009. Retrieved: http://www.fao.org/fileadmin/templates/wsfs/docs/Issues_ papers/HLEF2050_Global_Agriculture.pdf. Access: 16.12.2013.

5. Kerselaers, E., Rogge, E., Vanempten, E., Lauwers, L., Van Huylenbroeck, G. (2013). Changing Land Use in the Countryside: Stakeholders' Perception of the Ongoing Rural Planning Processes in Flanders. *Land Use Policy* Volume 32, pp. 197-206.

6. Linner, H., Messing, I. (2012). Agricultural Land Needs Protection, *Acta Agriculturae Scandinavica, Section B - Soil & Plant Science*, Volume 62, Issue 8, pp. 706-710.

7. Lähteseisukohad Maakonnaplaneeringute Koostamiseks (2013). (Basic Standpoints for the Preparation County Plans. Annex to Estonian Government Order NO 337) Retrieved: https://www.siseministeerium.ee/public/LSK_MKP_koostamiseks_2013.pdf. Access: 26.11.2013.

8. Maakonnaplaneeringute Algatamine (2013). (Origination the Preparation County Plans. Estonian Government Order NO 337, passed 18.07.2013) Retrieved: https://www.riigiteataja.ee/ akt/323072013006.pdf. Access: 16.12.2013.

9. Maasikamäe, S., Hass, H., Jürgenson, E. (2011). The Impact of Uncontrolled Development on the Use of Arable Land. *Proceedings: The Fifth International Scientific Conference Rural Development 2011, 24-25 November, 2011, Akademija,* Volume 5, Book 2, pp. 446-451.

10. Mandel, M., Maasikamäe, S. (2013). Correlation between Conversion of Arable Land into Brushwood and Distance of Plots from Roads. *Proceedings: The Sixth International Scientific Conference Rural Development 2013, 28–29 November, 2013, Akademija*, Volume 6, Book 3, pp. 343-348.

11. Planning Act (2002). Retrieved: http://www.legaltext.ee/et/andmebaas/tekst.asp?loc=text&dok=X70006K3&keel=en&pg=1&ptyyp=RT&tyyp=X&query=Planeerimis. Access: 17.12.2013.

12. Statistics Estonia. (2013). Jogeva Maakond. Retrieved: http://www.stat.ee/ppe-jogeva-maakond. Access: 16.12.2013.

13. Veeroja, P., Heil, E., Maltis, M., Maasikamäe, S. (2013). Impact of Discrete New Real Estate Developments on the Spatial Properties of Arable Land. *Proceedings: The Sixth International Scientific Conference Rural Development 2013, 28–29 November, 2013, Akademija,* Volume 6, Book 3, pp. 501-506.

14. United Nations (UN) (2013). World Population Prospects. The 2012 Revision: Key Findings and Advance Tables. Retrieved: http://esa.un.org/wpp/Documentation/pdf/ WPP2012_%20 KEY%20FINDINGS.pdf. Access: 17.12.2013.

15. World Bank (2013). Arable Land (hectares per person). Retrieved: http://data.worldbank.org/indicator/AG.LND.ARBL.HA.PC. Access: 16.12.2013.