

USE OF ANALYTIC HIERARCHY PROCESS IN EVALUATION OF LAND SURVEY PROJECTS: CASE OF LATVIA

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Abstract

Legislative acts of Republic of Latvia define the requirements for development of land survey projects but there are no unified methodology and criteria for applying of these requirements. It is also not determined how to evaluate the priorities of land survey projects in cases when the project is developed in several versions. In legislative acts there are eight criteria nominated for designing of land parcels in land survey projects that is an object of instant research. The task of research is to develop the methodology for comparison of versions of land survey project. As the most appropriate method for this purpose was chosen the Analytic Hierarchy Process because for comparison of versions of land survey project it is necessary to obtain numerically comparable values. Using the Analytic Hierarchy Process the global priorities (numerically comparable values) were calculated, and higher global priority allows make a choice of prior version of land survey project.

Key words: Land survey project, the Analytic Hierarchy Process, importance of criterion, pairwise comparison matrice, global priority

Introduction

The purpose of land survey projects is to improve land use conditions for sustainable use of the land resources and better organization of agriculture production. Because agriculture production is changed to new technologies, importance of rational organization of household territory and proper configuration of land parcel boundaries has increased (Locmers, Jankava, 2002). Rational approach to location of land parcel boundaries in development of land survey projects has vital importance because every concept can be implemented in many ways, and it is required to be able to evaluate them for choosing the prior version.

In frame of land reform the acreage of land parcels, pattern of their mutual placement and location of external boundaries (geometry) was regulated by laws of land reform and special regulations (Law On Land Use and Land Survey, 1991). As a result of the land privatization state owned land gradually has been granted into private ownership. New real properties were established on the base of decisions made by Land Commissions, which approved acreage and external boundary of land parcel, designed in the graphical material –land survey project of local municipality or town. The task of land survey project was:

- to create a preconditions for a sustainable use of the land and other natural resources, to preserve priority agriculture and forestry to suitable land for their requirements;
- to establish a favourable managerial and territorial preconditions for successful agriculture production;
- to allocate boundaries of land parcels as much as possible synchronized to features of constant natural elements of locality (rivers, brooks, ditches, edges of roads, etc.).

The latest legislative acts regulating design of land parcels in Latvia are Land Survey Law, adopted in 2006 and Cabinet Regulations No 867 “Regulations for the development of a land survey project” adopted December 11, 2007. In the land survey projects have to be considered main requirements as follows:

- land parcels have to be designed with a compact configuration (with the shortest perimeter);
- inter-areas have to be eliminated, if possible;
- by subdivision of the common property in real parts is not allowed to create new inter-areas.

The boundaries of land parcels have to be designed as broken lines with turning angle near to 90° but individual boundary sections are straight virtual lines without breaches and agree with features of constant natural elements of locality.

Legislative acts of Latvia define the requirements for development of land survey projects but there is no unified methodology for determination of the best version of land survey project fulfils the appropriate requirements. Therefore the criteria for designing of the land survey projects were chosen as **research object**. The **goal of research** is to chose the criteria that can serve as basis for development of methodology for comparison of land survey projects versions. The **task of research** is

to select the criteria for designing of land parcels boundaries and evaluate these criteria using the Analytic Hierarchy Process.

In the research have been used laws and other legislative acts. For comparing of land survey project versions has been used the Analytic Hierarchy Process, created by American mathematician T.L.Saaty. The Analytic Hierarchy Process (AHP) is a theory of measurement through comparisons and relies on the judgements of experts to derive priority scales. The comparisons are made using a scale of absolute judgements that represents, how much more one element dominates another with respect to given attribute (Saaty, 2008).

Discussion and results

For comparing of land survey project versions have been chosen eight criteria defined for designing of land parcels:

- existing inter-areas are eliminated;
- by subdivision of the common property in real parts new inter-areas haven't been created;
- boundaries have been designed taking into account existing buildings;
- in case of subdivision of the building distributive line of land parcel coincides with the distributive line of the building;
- land parcels have been designed with a compact configuration (with the shortest perimeter);
- boundaries of land parcel have been synchronized to features of constant natural linear elements of locality;
- individual boundary sections have been designed as straight virtual lines without breaches;
- turning angles of broken lines are near to 90°.

The Analytic Hierarchy Process provides that mutual importance of criteria have to be estimated by experts according nine-point scale. In the research were chosen 5 experts – professionals in land survey. Using T.L.Saaty scale of absolute judgements experts compared the criteria in pairs, that allows the textual information convert to figures (Saaty, 1980). This scale indicates how many times one criterion is more important or dominant over another criteria.

After fulfilment of the matrices of hierarchical comparison was obtained an assessment given by each expert and was calculated the importance of criterion. The importance of specific criterion was calculated as average of assessments given by all experts. Assessments given by experts are summarized in Table 1 where criteria are adjusted in rows according their importance. Experts are indicated with letters A, B, C, D, and E.

Table 1

Results of calculation of importance of criteria

Criteria	Expert					Importance of criterion
	A	B	C	D	E	
	Components of priority vector					
Distributive line of land parcel coincides with the distributive line of the building	0.298	0.308	0.362	0.385	0.329	0.336
Boundaries have been designed taking into account existing buildings	0.308	0.076	0.298	0.261	0.236	0.236
In subdivision of the common property new inter-areas haven't been created	0.160	0.073	0.119	0.079	0.109	0.108
Boundaries of land parcel have been synchronized to features of constant natural linear elements of locality	0.090	0.100	0.067	0.039	0.197	0.098
Existing inter-areas have been eliminated	0.032	0.103	0.102	0.135	0.043	0.083
Land parcels have been designed with a compact configuration	0.036	0.192	0.025	0.077	0.058	0.078
Turning angles are near to 90°	0.035	0.109	0.012	0.011	0.012	0.036
Individual boundary sections have been designed as straight virtual lines without breaches	0.042	0.040	0.016	0.014	0.015	0.025
Total						1.000

As the most important criterion experts have evaluated "distributive line of land parcel coincides with the distributive line of the building" (importance of criteria is 0.336) and "boundaries have been designed taking into account existing buildings" (importance of criterion is 0.236). Quite similar importance is given to the criterion "in subdivision of the common property new inter-areas haven't been created" (0.108) and "boundaries of land parcel have been synchronized to features of constant natural linear elements of locality" (0.098). Almost all experts for criteria "distributive line of land parcel coincides with the distributive line of the building" have given the highest priority. Criterion "turning angles of broken lines are near to 90°" and "individual boundary sections have been designed as straight virtual lines without breaches" with importance of criterion 0.036 and 0.025 is of secondary importance.

Calculated importance of criterion (Table 1) for comparison of versions of land survey projects is used as weight, and these values are constant. Using The Analytic Hierarchy Process it is possible to compare the versions of land survey projects according criteria and the best version of the project can be determined.

The Analytic Hierarchy Process includes hierarchy pyramid divided into three levels. The hierarchy is created from the top: 1th level is general target, 2nd level is intermediate level - criteria, and 3rd - lowest level includes alternatives. General target is determination of the best version of land survey project. The 2nd level includes eight criteria that specify the general target. The 3rd level includes possible versions of land survey projects that have to be evaluated taken into account the criteria of 2nd level (Figure 1).

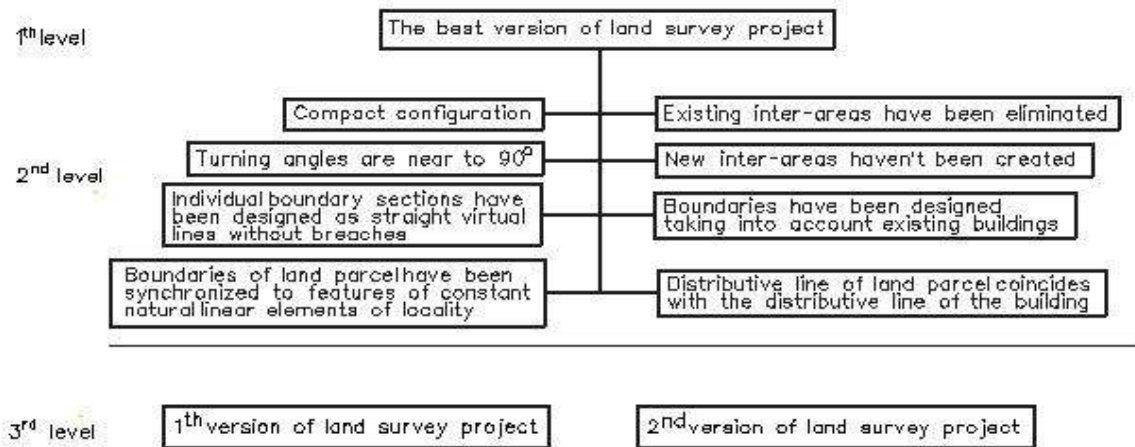


Fig. 1. Hierarchy pyramid for evaluation of versions of project

Making of decision according The Analytic Hierarchy Process involves many criteria used to rank the alternatives of a decision. In evaluation of versions of land survey project is necessary to determine how many times one of the versions of project is pre-eminent in comparison with another version (Saaty, 2008). The versions of project are compared eight times according to each criterion using the scale of relative importance (Table 2).

In legislative acts two of eight criteria are determined as **compulsory requirements**. They are:

- in subdivision of the common property new inter-areas haven't been created;
- in case of subdivision of the building distributive line of land parcel coincides with the distributive line of the building.

If the author of land survey project has observed these compulsory requirements, intensity of importance of versions of land survey project is 1 (equal importance). If in one of the versions of land survey project these compulsory requirements aren't observed, intensity of importance of versions of land survey project is 9 - extreme. These two requirements are included in criteria so that compulsory requirements of law would be observed.

Six of eight criteria for designing of land parcels in legislative acts are observed as **advisable requirements**.

T.L.Saaty scale of absolute judgements

Intensity of importance	Definition	Explanation
1	Equal importance of criteria	Two activities contribute equally to the objective
3	Moderate one criteria importance over other	Experience and judgement slightly favour one activity over another
5	Strong one criteria importance over other	Experience and judgement strongly favour one activity over another
7	Very strong one criteria importance over other	An activity is favoured very strongly over another; its dominance demonstrated in practice
9	Extreme one criteria importance over other	The evidence favouring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values of intensity of importance	Used in cases of compromise

Source:

<http://inderscience.metapress.com/media/p3pnvmytjxc7cvkybrl/contributions/0/2/t/6/02t637305v6g65n8.pdf>

Land parcels have to be designed with a compact configuration, i.e. with the shortest perimeter. That means that the purpose is to obtain designed land parcels with minimal amount of the length of external boundaries. Wherewith the land parcel which length of external boundaries is the shortest is designed with the most compact configuration. The compactness of land parcels have been investigated by M.Locmers and other researchers, using coefficient of external compactness, extendness, inter-areativity and location of external boundaries. These coefficients were used for the characterization of external compactness of household (Zemes ierīcības projektēšana, 1978). Using this criterion the versions of land survey projects are compared concerning perimeter of external boundaries. Best is version of project with shorter perimeter.

Concerning criterion “individual boundary sections have been designed as straight virtual lines without breaches” the versions of land survey project are compared concerning length of artificial boundaries. Best is version of project with shorter length of artificial boundaries.

Inter-areativity in Latvia is one of the most common disadvantages of territorial location. It is possible to eliminate or reduce these disadvantages by developing the land survey projects for land consolidation, the reorganization of land parcel boundaries or the exchange of land parcels. These problems have been investigated by researchers M.Locmers, A.Jankava, D.Platonova etc. Legislative acts define that in designing of land survey projects, if possible, existing inter-areas shall be eliminated. Evaluating the versions of project by elimination of inter-areas or reduction of the number of inter-areas the best is that version of project where more inter-areas are eliminated.

For evaluation whether boundaries of land parcels are designed taking into account existing buildings, it is necessary to analyze requirements defined in legislative acts:

- buildings belonged to landowner fully shall be located within each new developed boundaries of land parcel;
- the minimal area of developed land parcel in particular building site shall be observed considering spatial utilisation and building conditions;
- boundaries shall be designed considering:
 - minimal distance to the building, owned by neighbour, according physical plans or binding regulations;
 - minimal distance of fire security from the building to adjacent boundaries of land parcel;
 - minimal distance from outhouse or barn to lateral or back boundary of land parcel;
- area of open area, indices of building intensity and building density of designed land parcels shall not exceed minimal indices defined in physical plans or binding regulations.

Evaluating the versions of land survey project by criteria mentioned above best is version of project with a larger amount of positive responses.

For evaluation whether boundaries of land parcels are determined by the situation on the natural linear elements, versions of project was compared by amount of positive responses to these questions:

- boundaries of land parcel are synchronized to middle line of rivers, brooks, ditches;

- boundaries of land parcel are determined by the margin or middle line of the road.
- For comparing of versions of land survey project by the criterion “turning angles of broken lines are near to 90°” shall be determined in which version of project turning angles are more close to 90°. After filling in of eight pairwise comparison matrices as geometrical mean are calculated specific vector components. Thereafter is calculated component "x" dividing every number (special vector component) by the sum of all numbers priority vector. As an example in Table 3 is shown the calculation of priority of vector component "x6" of criteria "land parcels have been designed with a compact configuration". Intensity of importance of the second version of land survey project is evaluated as 5 (strong importance of second version of the project over the first version).

Table 3

Pairwise comparison matrix for calculation of priority of vector component “x6”

Land parcels have been designed with a compact configuration	1st version	2nd version	Special vector components	Priority vector component x6
1st version	1	1/5	0.45	0.17
2nd version	5	1	2.24	0.83
Total	6.00	1.50	2.69	1.00

The data in the Table 3 show that evaluating criterion “land parcels have been designed with a compact configuration” the second version of project has higher priority vector component (0.83>0.17). This means that concerning this criterion the second version of project is better.

Filling in of eight pairwise comparison matrices, in each matrix are calculated two priority vector components "x". It describes mutual importance of versions of project by the respective criteria.

As a final step for comparison of versions of land survey project is calculation of global priorities that includes intensities of importance of criteria, determined by experts and comparison of versions of land survey project by these criteria (priority vector components x1-x8). For this purpose it is necessary to obtain numerically comparable values.

Global priorities of versions of project can be calculated using formula 1.

$$G = (0.336 \cdot x_1) + (0.236 \cdot x_2) + \dots + (0.025 \cdot x_8) \tag{1}$$

where x1 - x8 - priority vector components.

An example for determination of the best version of land survey project by importance of criteria is shown in Table 4.

Table 4

Example of evaluation of versions of land survey project

Criteria	Importance of criterion	1st version	2nd version
Distributive line of land parcel coincides with the distributive line of the building	0.336	x1	x1
Boundaries have been designed taking into account existing buildings	0.236	x2	x2
In subdivision of the common property new inter-areas haven't been created	0.108	x3	x3
Boundaries of land parcel have been synchronized to features of constant natural linear elements of locality	0.098	x4	x4
Existing inter-areas have been eliminated	0.083	x5	x5
Land parcels have been designed with a compact configuration	0.078	x6	x6
Turning angles are near to 90°	0.036	x7	x7
Individual boundary sections have been designed as straight virtual lines without breaches	0.025	x8	x8
	Global priorities	G₁	G₂

After calculation of global priorities (G_1 and G_2) two numerically comparable values using formula (1) are obtained and higher global priority allows to judge about the best version of land survey project.

Conclusions and proposals

1. Requirements of development of land survey projects defined in legislative acts aren't enough detailed; they cannot be used for determination of the best version of land survey project.
2. Analytic hierarchy process provides a proven, effective means to deal with complex decision making involving multiple criteria and can assist with identifying and weighting selection criteria.
3. The results of research prove that the Analytic hierarchy process is appropriate for evaluation of land survey projects and comparison of versions of land survey project.

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Резюме

АЛИСЕ ГИЛУЧА, ВЕЛТА ПАРШОВА, МАРТИНЫШ ЗГИРСКИС. ПРИМЕНЕНИЕ МЕТОДА АНАЛИТИЧЕСКОЙ ИЕРАРХИИ ПРИ ОЦЕНКЕ ПРОЕКТОВ ЗЕМЛЕУСТРОЙСТВА В ЛАТВИИ

Законодательные акты Латвии определяют требования к разработке проектов землеустройства, но нет установленной единой методики и критериев применения этих требований для оценки вариантов проектов землеустройства, если проект разработан в нескольких вариантах. В исследовании разработана методика для сравнения проектов землеустройства. На основе оценки пяти экспертов – специалистов землеустройства была проведена оценка восьми критериев, и, применяя метод аналитической иерархии, была установлена их взаимная значимость. Примененный метод позволяет рассчитать сравняемые в численном измерении величины, необходимые для сравнения вариантов проекта землеустройства. На основе метода аналитической иерархии были рассчитаны глобальные приоритеты - сравняемые в численном измерении величины, где полученный более высокий приоритет позволяет принять решение о более оптимальном варианте проекта.

Ключевые слова метод аналитической иерархии, глобальный приоритет, критерий оценки

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