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An Approach to Cadastral Map Quality Evaluation in the Republic of Latvia

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Abstract. An approach to cadastral map quality evaluation is proposed, which is elaborated and implemented by State Land Service of the Republic of Latvia. The approach is based on opinion of Land Service experts about cadastral map quality that depends on its usage points. Quality parameters of cadastral map objects identified by experts and its limit values are used for evaluation. The assessment matrix is used, which allow to define cadastral map quality that depends on its usage purpose. The matrix is used to find out, of what quality a cadastral map should be in order to be used for the chosen purpose. The given approach is flexible, it gives a possibility to change sets of quality parameters and their limit values as well as to use the approach for other type data quality evaluation.

1 Introduction

Scientific literature identifies several aspects of quality: data quality has several components such as accuracy, relevance, timeliness, completeness, reliability, accessibility, precision, consistency, etc. [1], [2]. There are currently two main research streams, which address the problem of ensuring a high level of data and information quality. One is a technical, database-oriented approach, while the second is a management and business-oriented approach. Engineering of information system brings both streams together and addresses issues related to the design and modeling of information systems [3]. Geographical data are data describing an object's spatial location and various properties. High quality geographical data will include space location and object properties at given times (where-what-when) [4].

Data quality is the degree to which data meet the specific needs of a specific customer. Note that one customer may find data to be of high quality (for one use of the data), while another finds the same data to be of low quality (for another use) [5]. What features do experts working with geographical data (data entry, map drawing, supervision of maps, etc.) use to judge the quality of data? The authors are not aware of any published studies in this area to date. This paper presents an approach to the evaluation of the quality of cadastral map that caters for the differing levels of quality required of various parameters in order to meet different goals.

The subjective assessments of experts in geographical data processing are sought to determine the factors which have the most impact upon the quality of geographical

data. When these assessments are evaluated, freed from subjective elements and, classified, it becomes possible to specify parameters for the evaluation of data quality, their values, and the required levels of quality. The result of this is a matrix for quality assessment which can be used to determine the data quality level that is necessary for specific purposes or, alternatively, the specific goals for which data at a specific level of quality may be used.

This paper describes the method that is to be uses in preparing the quality assessment matrix and how this approach is used for cadastral map evaluation in State Land Service of the Republic of Latvia.

2 An Approach to Data Quality Evaluation

The discussion of quality must begin with the identification of the objects of interest. Every object will have a number of quality parameters (QP1, QP2, etc.) (Fig.1). Each quality parameter QPn has values taken from one or more sets of values QPnVSk (Table 1), where QPnVS1 may contain the best values. QPnVS2 contains the second best values for some particular goal, etc. [6]

The quality of the object is based upon several or all quality parameters. For instance, an object can belong to the highest level of quality if all of the estimated values of the relevant quality parameters belong to the best sets of values. It belongs to the second level of quality if the values of the relevant quality parameters belong to the second best sets of values, etc.

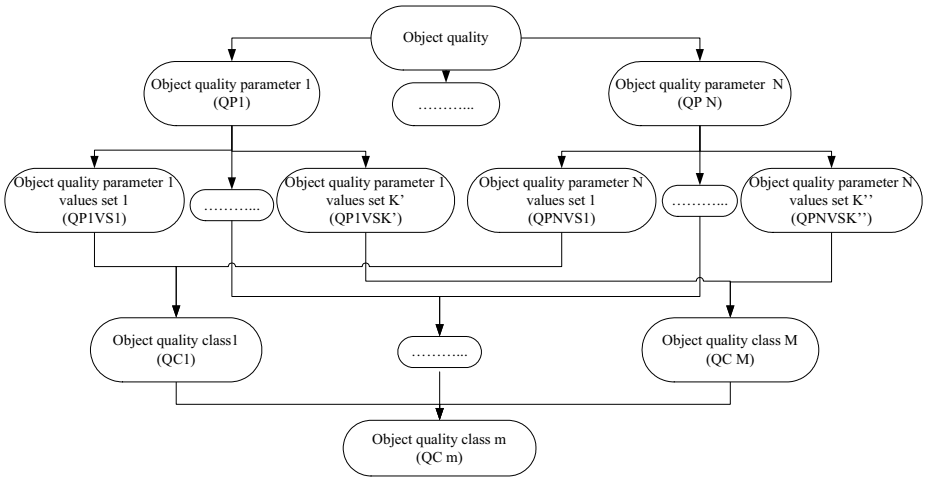

Fig. 1. An Approach to Data Quality Evaluation

Table 1. Quality Parameter Value Set

Quality parameter (QP)	Quality parameter value set (QPVS)			
	QPnVS1 (high)	QPnVS2	...	QPnVSk (low)
QPn	from-until	from-until	...	from-until

As a result the object quality evaluation matrix (Table 2) is obtained, which is used to determine, which quality class the object belongs to, as well as to determine, which should be quality parameter values so that the object would correspond to the chosen aim of use.

Table 2. Quality Assessment Matrix

Object quality class (QC)	Quality parameter/ Quality parameter value set			
	QP1	QP2	...	QPn
QC1 (high)	QP1VS1	QP2VS1	...	QPnVS1
QC2	QP1VS2	QP2VS2	...	QPnVS2
...	...	...	...	...
QCm (low)	QP1VSk'	QP2VSk''	...	QPnVSk'''

Quality parameter quality class (QP_QC) depends on a quality parameter value set, to which belongs the quality parameter value (Formulae 1).

$$QPn\_QC=1, \text{ if } QPn \in QPnVS1;\ 2, \text{ if } QPn \in QPnVS2,\ldots,\ M, \text{ if } QPn \in QPnVSk,\ n=\{1...N\},\ k=\{1...K\} \quad (\mathbf{1})$$

In its turn, object corresponds to the lowest quality parameter quality class ("hard" principle for object evaluation) (Formulae 2).

$$QC=\text{lowest}\ (QP1\_QC, QP1\_QC, \ldots, QP\ N\_QC,) \quad (\mathbf{2})$$

The aim of object quality evaluation is to determine, which quality class the object belongs to and which aims it can be used for. In order to evaluate an object (Fig. 2):

a) check the correspondence of an object to quality criterions (Fig. 2, P1), obtain the list or the number (QPn_list, QPn_count) of items not corresponding to the quality criterions,

b) evaluate each object quality according to quality parameters and obtain a quality class:

- calculate object quality parameter values (Fig. 2, P2), obtain QPn,
- determine, which parameter value set (Table 1) it belongs to (Fig. 2, P3), obtain QPnVSk,
- determine, which quality class the value belongs to (Table 2, Formulae 1) (Fig. 2, P4), obtain quality parameter class QPn_QC,
- determine object quality class (Formulae 2) (Fig. 2, P5), obtain Object QC

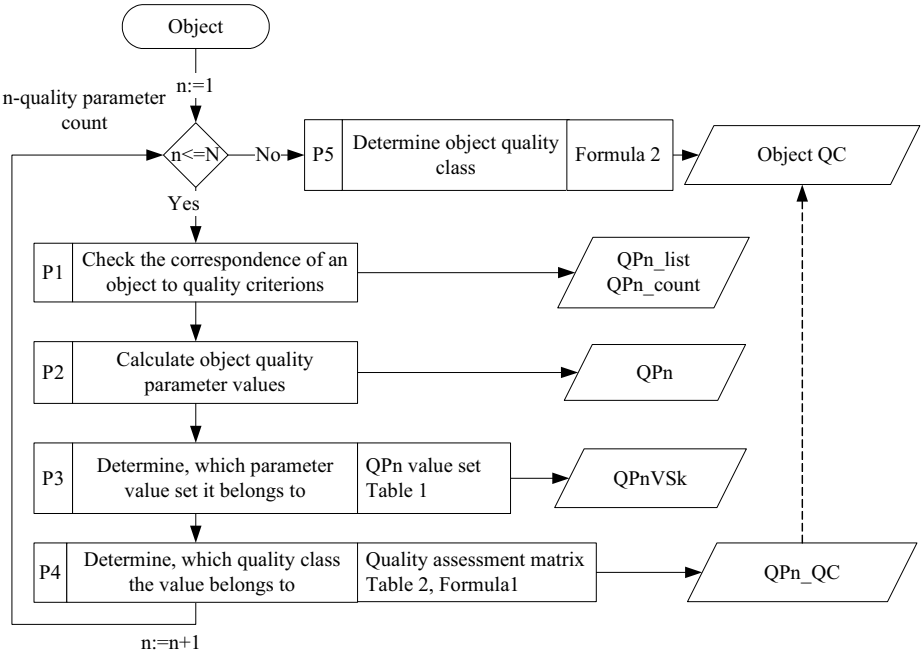

Fig. 2. Object Quality Class

This approach is implemented in State Land Service (SLS) of the Republic of Latvia for cadastral map evaluation and is based on the defined by field experts quality parameters, which describe the usage purpose of a certain cadastral map.

3 Cadastral Map Quality Evaluation in the Republic of Latvia

In the Republic of Latvia, cadastral map (CM) is created in Latvian coordinate system LKS-92 in Transverse Mercator (TM) projection. The following elements are represented in CM: land parcels- boundaries of parcels and their cadastral designations; buildings- outlines of buildings and their cadastral designations; encumbrances- areas occupied by encumbrances of right to use real property and their designations; parts of land parcels- leaseholds and their cadastral designations; boundaries of cadastral territories and cadastral groups. The CM is used to locate cadastral objects with precision so that any changes in boundaries for administrative or other purposes may be accurately described and to describe the relationships between objects for the purposes of environmental and town planning and for various reports. The principles and content of the CM are established by Regulation, which is an ordinance of the SLS of Latvia. The Cadastral IS databases consist of two parts:

the textual part (TP) and the graphical part, which includes the CM in vector graphics form [7].

CM quality depends on the quality of each object, whereof the CM is made. CM can consist of such objects as land parcel, building, encumbrance and part of land parcel. Therefore, in order to evaluate CM quality, firstly, it is necessary to evaluate qualities of land parcel, building, encumbrance and part of land parcel – wherewith the approach described above (Fig. 1) has to be applied for each CM object.

3.1 Cadastral Map Objects Quality Parameters

In this article an approach to CM quality evaluation is proposed, which is based on experts' opinions about CM quality that depends on its usage points. Expert opinions are obtained from more than 50 expert interview surveys. Having summarized the results of surveys, such quality criteria are obtained: the CM meets the legal regulation requirements, CM objects are topologically correct, coordinates of CM land parcels are precise, CM objects (land parcels, building, encumbrance and part of land parcel) are in both Cadastral databases and the data is the same – in the TP and in the CM. Quality criteria are given in Table 3.

Table 3. Cadastral Map Quality Criteria

Code	Title
C1	CM meets the legal regulation requirements
C2	CM objects are topologically correct
C3	Coordinates of CM land parcels are precise
C4	Object data in the TP and the CM are identical:
C4.1	A cadastral object (land parcels, building, encumbrance and part of land parcel) has to be in both Cadastral databases – in the TP and in the CM:
C4.1.1	the object marked in a CM has to be in the TP
C4.1.2	the object in a TP has to be marked in the CM
C4.2	Cadastral object data in both Cadastral databases:
C4.2.1	the surveying type for land parcel has to be the same in both databases
C4.2.2	cadastral surveyed land parcels' and parts of land parcels' legal area (indicated in the documents) and area defined by graphical methods (marked in the cadastral map, further in the text – geographical area) cannot be larger or smaller than the acceptable space difference defined in the Regulations
C4.2.3	a building, in both databases, has to be attached to one and the same land parcel

Experts' opinions about CM quality are subjective and therefore have to be structured and, according to normative acts and existing IT solutions in State Land Service, we obtain cadastral object quality parameters (QPn) (Fig. 1) – for land parcel (LP) 5 quality parameters are defined (LP_QPn, n=1…5) (Table 4), for building (BD) – 4 quality parameters (BD_QPn, n=1…4) (Table 7), for encumbrance (EB) – 2 quality parameters (EB_QPn, n=1…2) (Table 8), for part of land parcel (PLP)– 3 quality parameters (PLP_QPn, n=1…3) (Table 9).

3.1.1 Land Parcel Quality Parameters

Land parcel quality is described by 5 quality parameters (Table 4).

Table 4. Land Parcel Quality Parameters

Code	Description	Value High - low	Quality criteria
LP_QP1	Describes how much (%) of CM land parcels are missing in the TP	0%-100%	C4.1.1
LP_QP2	Describes how much (%) of TP land parcels are not marked in the CM	0%-100%	C4.1.2
LP_QP3	Describes how much (%) of CM land parcels surveying type differs from TP surveying type	0%-100%	C4.2.1
LP_QP4	Describes how much (%) of CM cadastral surveyed land parcels' geographical area is larger or smaller than the acceptable space difference of TP legal area	0%-100%	C4.2.2
LP_QP5	Describes how much (%) of CM land parcels are cadastral surveyed	100%-0%	C3

LP_QP1 and LP_QP2 characterize land parcels completeness in Cadastral IS TP and CM databases.

LP_QP1 describes how much (%) of CM land parcels are missing in the TP. Quality parameter values can vary from 0% (all the cadastral map land parcels are also in the textual part) to 100% (none of cadastral map land parcels are in the textual part). Quality parameter value is obtained by applying Formulae 3, where LP_QP1_count – number of cadastral map land parcels, which are not in the textual part, CM_LP_count – number of cadastral map land parcels.

$$LP\_QP1 = LP\_QP1\_count/CM\_LP\_count*100 \quad (3)$$

LP_QP2 describes how much (%) of TP land parcels are not marked in the CM. Quality parameter values can vary from 0% to 100%. Quality parameter value is obtained by applying Formulae 4, where LP_QP2_count – number of land parcels in the textual part, which are not in the cadastral map, TD_LP_ number – count of land parcels in the textual part.

$$LP\_QP2 = LP\_QP2\_count/TD\_LP\_count*100 \quad (4)$$

LP_QP3 characterizes land parcels survey type (Table 5) consistency between in TP and CM and describes how much (%) of CM land parcels surveying type differs from TP surveying type. Quality parameter values can vary from 0% to 100%. Quality parameter value is obtained by applying Formulae 5, where LP_QP3_count – number of cadastral map land parcels, which surveying type does not match the surveying type in the textual part, CM_LP_count – number of cadastral map land parcels.

$$LP\_QP3 = LP\_QP3\_count/CM\_LP\_count *100 \quad (5)$$

Table 5. Land Parcel Survey Types

Survey type in CM	Survey type in TP
surveyed land parcels	– instrumental survey – global positioning, – photogram survey
allocated land parcels	– allocation – allocation in orthophoto maps – allocation in photoplan
designed land parcels	designed land parcel do not have survey type

LP_QP4 characterize trusted land parcels area. In accordance with the Regulations for CM, the graphical area of a surveyed land parcel listed in the CM (which is calculated on the basis of coordinates) can possibly differ from the legal area of the land parcel shown in the TP (which is declared in legal documents) but within prescribed limits. The admissible level of variation is determined by Regulation (Table 6). LP_QP4 describes, how much (%) of CM cadastral surveyed land parcels' geographical area is larger or smaller than the acceptable space difference of TP legal area. Quality parameter values can vary from 0% to 100%. Quality parameter value is obtained by applying Formulae 6, where LP_QP4_count – number of cadastral map land parcels, which area is smaller or larger than the allowed difference of the legal area, CM_LP_count– number of cadastral map land parcels

$$LP\_QP4 = LP\_QP4\_count/CM\_LP\_count*100 \quad (6)$$

Table 6. The Allowed Area Difference of the Surveyed Land Parcel Graphical Area

1)in towns:

Area (ha)	Up to 0.50	0.51-1.00	1.01-5.00	5.01-10.00	10.01-50.00	50.01-100.00	More than 100.00
The allowed difference (%)	± 3.00	2.30	1.80	1.50	1.25	1.05	1.00

2)settlement, summer cottage and gardening areas, country region:

a) the difference, which is determined using formula ± 0,1 $\sqrt{P}$ (P – land parcel or part of land parcel area (ha)), if the area is not larger than 1.0 ha;

b) the difference, which is determined using formula ± 0,25 $\sqrt{P}$ (P – land parcel or part of land parcel area (ha)), if the area is larger than 1.0 ha;

c) the difference, which is determined using formula ± 0,3 $\sqrt{P}$ (P – land parcel or part of land parcel area (ha)), if the area is not larger than 200 ha.

Comment: This parameter relates only to cadastral surveyed land parcels, cadastral unsurveyed land parcels, t.i. cadastral allocated and cadastral designed land parcels, graphical area is not analysed because historically no conditions are proposed to it.

LP_QP5 characterize accuracy of land parcels co-ordinate. The database which includes the graphic component of the cadastral register includes graphic data to various levels of accuracy. The database of land parcels includes data at three different levels of data accuracy – surveyed land parcels, allocated land parcels, and designed land parcels. The coordinates of the surveyed land parcels are obtained by

surveying the relevant parcel with the appropriate instruments. Coordinates of allocated land parcels may have been obtained with older measuring instruments that are no longer in use (field compasses, tape measures), or through conversion from other co-ordinate systems which differ from the specified LKS-92 TM coordinate system. The coordinates of designed land parcels are approximate, because they are usually obtained from orthophoto maps, photo plans or other materials. These coordinates are not based on direct land measurement. LP_QP5 describes, how much (%) of CM land parcels are cadastral surveyed. Quality parameter values can vary from 100.00% (all cadastral map land parcels are cadastrally surveyed) to 0% (none of cadastral map land parcels are cadastrally surveyed). Quality parameter value is obtained by applying Formulae 7, where LP_QP5_count – number of cadastrally surveyed land parcels in a cadastral map, CM_LP_count – number of cadastral map land parcels.

$$LP\_QP5 = LP\_QP5\_count/CM\_LP\_count *100 \quad (7)$$

Comment: This quality parameter gives statistical information – how many land parcels are cadastrally surveyed. The most precise coordinates in the cadastral map and the most arranged textual data are cadastral for the surveyed land parcels, therefore – the more cadastral map land parcels are cadastrally surveyed, the higher the quality of cadastral map data is. However, SLS cannot affect cadastral map quality by this parameter, because it depends only on its owners and dealings with land parcels.

3.1.2 Building Quality Parameters

Quality of a building is described by 4 quality parameters (Table 7).

Table 7. Building Quality Parameters

Code	Description	Value High - low	Quality criteria
BD_QP1	Describes how much (%) of CM buildings are missing in the TP	0%-100%	C4.1.1
BD_QP2	Describes how much (%) of TP buildings are not marked in the CM	0%-100%	C4.1.2
BD_QP3	Describes how much (%) of CM buildings have different land parcel cadastral designation in TP, to which the building is attached	0%-100%	C4.2.3
BD_QP4	Describes how much (%) of CM buildings are cadastrally surveyed	100%-0%	C3

BD_QP1 and BD_QP2 characterize building completeness in Cadastral IS TP and CM databases. Both quality parameters values can vary from 0% to 100%.

BD_QP1 value is obtained by applying Formulae 8, where BD_QP1_count– number of cadastral map buildings, which are not in the textual part, CM_BD_count - number of cadastral map buildings.

$$BD\_QP1 = BD\_QP1\_count/CM\_BD\_count*100 \quad (8)$$

BD_QP2 value is obtained by applying Formulae 9, where BD_QP2_count- number of textual part buildings, which are not in the cadastral map, TD_BD_count– number of textual part.

$$BD\_QP2 = BD\_QP2\_count/TD\_BD\_count*100 \quad (9)$$

BD_QP3 characterizes building land parcel attachment consistency between TP and CM (in both databases the building has to be attached to one and the same parcel). BD_QP3 describes how much (%) of CM buildings has different land parcel cadastral designation in TP, to which the building is attached. Quality parameter value can vary from 0% to 100%. Quality parameter value is obtained by applying Formulae 10, where BD_QP3_count – number of buildings in the cadastral map, which designation of land parcel does not match with the designation of land parcel in the textual part, which it is attached to, CM_BD_count – number of buildings in the cadastral map.

$$BD\_QP3 = BD\_QP3\_count/CM\_BD\_count*100 \quad (10)$$

BD_QP4 characterize accuracy of building co-ordinate. The database which includes the graphic component of the cadastral register includes graphic data to various levels of accuracy. The database of building includes data at three different levels of data accuracy – surveyed building, stereo vectorized building, and vektorized building. The coordinates of the surveyed building are obtained by surveying with the appropriate instruments. A stereo vectorized building contour is marked by a stereo tool, but a vectorized building – by scanned material, the building is not surveyed. BD_QP4 describes, how much (%) of CM buildings are cadastral surveyed. Quality parameter values can vary from 100.00% to 0%. Quality parameter value is obtained by applying formulae 11, where BD_QP4_count – number of cadastrally surveyed buildings in the cadastral map, CM_BD_count – number of buildings in the cadastral map.

$$BD\_QP4 = BD\_QP4\_count/CM\_BD\_count*100 \quad (11)$$

Comment. This quality parameter gives statistical information – how many buildings are cadastrally surveyed. The most precise coordinates in the cadastral map and the most arranged textual data have cadastrally surveyed buildings; therefore the more buildings in the cadastral map are cadastrally surveyed, the higher the quality of cadastral map data is. However, SLS cannot affect cadastral map quality by this parameter, because it depends only on its owners and dealings with land parcels.

3.1.3 Encumbrance Quality Parameters

Encumbrance quality is described by 2 quality parameters (Table 8).

Table 8. Encumbrance Quality Parameters

Code	Description	Value high - low	Quality criteria
EB_QP1	Describes how much (%) of CM encumbrances are missing in the TP	0%-100%	C4.1.1
EB_QP2	Describes how much (%) of TP encumbrances are not marked in the CM	0%-100%	C4.1.2

EB_QP1 and EB_QP2 characterize encumbrance completeness in Cadastral IS TP and CM databases. A CM for encumbrances has been drawn from the 1st of July 2002 and only road servitudes. Both quality parameters values can vary from 0% to 100%.

EB_QP1 value is obtained by using Formulae 12, where EB_QP1_count – number of cadastral map encumbrances, which are not in the textual part, CM_EB_count – number of cadastral map encumbrances.

$$EB\_QP1 = EB\_QP1\_count/CM\_EB\_count*100 \quad (12)$$

EB_QP2 value is obtained by applying formulae 13, where EB_QP2_count – number of encumbrances in the textual part, which are not marked in the cadastral map, TD_EB_count – number of encumbrances in the textual part.

$$EB\_QP2 = EB\_QP2\_count/TD\_EB\_count*100 \quad (13)$$

3.1.4 Part of Land Parcel Quality Parameters

Quality of part of land parcel is described by 3 quality parameters (Table 9)

Table 9. Part of Land Parcel Quality Parameters

Code	Description	Value high - low	Quality criteria
PLP_QP1	Describes how much (%) of CM parts of land parcels are missing in the TP	0%-100%	C4.1.1
PLP_QP2	Describes how much (%) of TP parts of land parcels are not marked in the CM	0%-100%	C4.1.2
PLP_QP3	Describes, how much (%) of CM cadastral surveyed parts of land parcels' geographical area is larger or smaller than the acceptable space difference of textual part legal area	0%-100%	C4.2.2

PLP_QP1 and PLP_QP2 characterize part of land parcels completeness in Cadastral IS TP and CM databases. Both quality parameters values can vary from 0% to 100%.

PLP_QP1 value is obtained by Formulae 14, where PLP_QP1_count – number of parts of land parcels in the cadastral map, which are not in the textual part, CM_PLP_count – number of parts of land parcels in the cadastral map.

$$PLP\_QP1 = PLP\_QP1\_count/CM\_PLP\_count*100 \quad (\mathbf{14})$$

PLP_QP2 value is obtained by applying Formulae 15, where PLP_QP2_count – number of parts of land parcels in the textual part, which are not in the cadastral map, TP_PLP_count – number of parts of land parcels in the textual part.

$$PLP\_QP2 = PLP\_QP2\_count/TP\_PLP\_count*100 \quad (\mathbf{15})$$

PLP_QP3 characterizes trusted part of land parcels area. The purpose of this parameter is the same as that of quality parameter LP_QP5.

$$PLP\_QP3 = PLP\_QP3\_count/CM\_PLP\_count*100 \quad (\mathbf{16})$$

3.2 Cadastral Map Quality Class

In collaboration with experts and in the result of experiments, sets of quality parameter values are defined. There are three sets of values for all the parameters: excellent, good, and bad values (Fig. 1, QPnVSk, k=1...3).

Parameter values of excellent quality are such as ones, which describe that an object meets quality criteria; values of good quality are such as ones, which do not overrun the defined acceptable error rate, but values of bad quality are such as ones, which overrun the defined rate (Table 10). Parameter value of excellent quality to any quality parameter (except for land parcels and buildings) is 0%, but to the surveyed land parcels and buildings – 100%. Value of good quality to any quality parameter (except for land parcels and buildings) is from 0.01% to 5%, but to the surveyed land parcels and buildings – from 99.99% to 10%. Value of bad quality to any quality parameter (except for land parcels and buildings) is from 5.01% to 100%, but to the surveyed land parcels and buildings – from 9.99% to 0%.

Table 10. Quality Parameters Values Sets

Quality parameters	Quality parameter values sets		
	QPiVS1 excellent	QPiVS2 good	QPiVS3 bad
- LP_QP1, LP_QP2, LP_QP3, LP_QP4, - BD_QP1,BD_QP2,BD_QP3, - EB_QP1, EB_QP2, - PLP_QP1,PLP_QP2, PLP_QP3	0%	0.01-5.00%	5.01-100%
- LP_QP5, - BD_QP4	100%	99.99%-10%	9.99%-0%

Theoretically, object quality parameters and sets of values can be chosen in thousands of variants, but practically, suitable is only such a variant, where

parameters are defined by field experts that depends on what object (in this case – a CM) will be used for.

Taking into account the purpose of a CM and collaborating with experts, three quality classes of objects are defined (Table 11): high, medium and low (Fig. 1) QCm, m=1…3.

Table 11. Quality Classes

Quality class		Description
High	1st quality class (QC1)	A CM can be used for making decisions and other activities, where information from the CM is needed
Medium	2nd quality class (QC2)	A CM can be used for making decisions, but it is necessary to be sure about quality of a certain object, which is used for making the decision
Low	3rd quality class (QC3)	A CM cannot be used for making decisions, it can be used to get primary information

Having summarized quality parameter sets of values and quality classes, an object quality assessment matrix (Table 12) is obtained. According to quality parameter values, object quality is: High (QC1), if quality parameter value is excellent – appertains to the set of values QPnVS1. Medium (QC2), if quality parameter value is good – appertains to the set of values QPnVS2. Low (QC3), if quality parameter value is bad – appertains to the set of values QPnVS3.

Table 12. Object Quality Assessment Matrix

Object quality class		Quality parameters value set
High	1st quality class (QC1)	QPnVS1
Medium	2nd quality class (QC2)	QPnVS2
Low	3rd quality class (QC3)	QPnVS3

The main principle of using the quality evaluation matrix – an object corresponds to its quality class, which the worst quality parameter value belongs to.

Land parcel quality class 'LP_QC' (Fig. 3) depends on the lowest quality parameter quality class (Formulae 17).

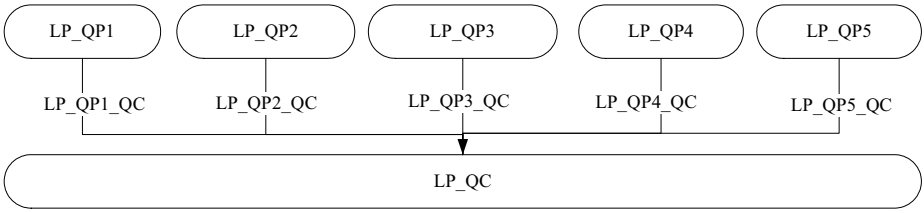

Fig. 3. Land Parcel Quality Class

$$LP\_QC = MAX(LP\_QPn\_QC), \quad (17)$$
$$LP\_QPn\_QC = 1, \text{ if } LP\_QPn \in QPnVS1;\ 2, \text{ if } LP\_QPn \in QPnVS2;$$
$$3, \text{ if } LP\_QPn \in QPnVS3,\ n=\{1..5\}$$

In its turn, quality parameter LP_QPn, n={1...5} is calculated according to Formulae 3 – Formulae 7.

Building quality class 'BD_QC' depends on the lowest quality parameter quality class (Formulae 18).

$$\begin{gathered} BD\_QC = MAX(BD\_QPn\_QC), \\ BD\_QPn\_QC = 1, \text{ if } BD\_QPn \in QPnVS1;\ 2, \text{ if } BD\_QPn \in QPnVS2; \\ 3, \text{ if } BD\_QPn \in QPnVS3,\ n=\{1..4\} \end{gathered} \quad (18)$$

In its turn, quality parameter BD_QPn, n={1...4} is calculated according to Formulae 8 – Formulae 11.

Encumbrance quality class 'EB_QC' depends on the lowest parameter quality class (Formulae 19).

$$\begin{gathered} EB\_QC = MAX(EB\_QPn\_QC), \\ EB\_QPn\_QC = 1, \text{ if } EB\_QPn \in QPnVS1;\ 2, \text{ if } EB\_QPn \in QPnVS2; \\ 3, \text{ if } EB\_QPn \in QPnVS3,\ n=\{1..2\} \end{gathered} \quad (19)$$

In its turn, quality parameter 'EB_QPn, n={1,2} is calculated according to Formulae 12, Formulae 13.

Part of land parcel quality class 'PLP_QC' depends on the lowest quality parameter quality class (Formulae 20).

$$\begin{gathered} PLP\_QC = MAX\ (PLP\_QPn\_QC), \\ PLP\_QPn\_QC = 1, \text{ if } PLP\_QPn \in QPn\ VS1;\ 2, \text{ if } PLP\_QPn \in QPnVS2; \\ 3, \text{ if } PLP\_QPn \in QPnVS3,\ n=\{1..3\} \end{gathered} \quad (20)$$

In its turn, quality parameter 'PLP_QPn', n={1...3} is calculated according to Formulae 14 – Formulae 16.

Cadastral map quality class (Fig. 4) depends on the lowest cadastral map object quality class (Formulae 21).

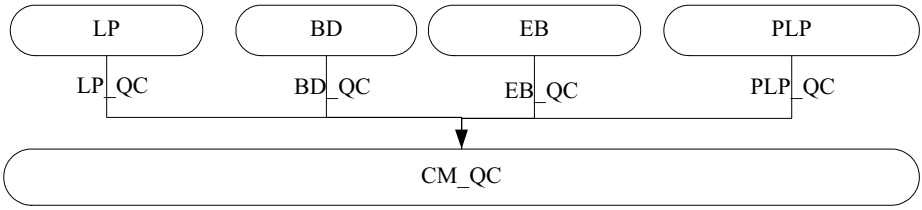

Fig. 4. Cadastral Map Quality Class

$$CM\_QC = MAX(\ LP\_QC;\ BD\_QC;\ EB\_QC;\ PLP\_QC) \quad (21)$$

Now we can evaluate quality of the chosen CM, because we have defined quality parameters (Table 4, Table 7, Table 8, Table 9) and sets of quality parameter values (QPnVSk) (Table 3) and Formulae 2 - Formulae 16, as well as object quality assessment matrix (Table 12) un Formulae 17 - Formulae 21 to calculate quality classes.

3.3 Cadastral Map Quality Evaluation Steps

The purpose of cadastral map quality evaluation is to define which quality class a cadastral map belongs to and what purposes the cadastral map cannot be used for. Cadastral map quality depends on the quality of its objects (Fig. 4), that is, on land parcel, building, encumbrance and part of land parcels quality classes (Formulae 21).

To evaluate the quality of the chosen cadastral map, the following steps are made (Fig. 5):

The first step: find out, which objects forms the cadastral map and obtain the binding cadastral map data of the textual part. A cadastral map can be formed by four objects maximum: land parcel, building, encumbrance, and part of land parcel (i={1…4}). The defined method does not depend on cadastral map size – you can choose a cadastral map, which is formed of one land parcel and evaluate it, or choose all possible cadastral maps and evaluate them. Wherewith a cadastral map can be formed by several objects of one type, for example, several land parcels, buildings, etc. Object quality depends on the quality of each object item. Prior to cadastral map evaluation, obtain the number of object items: number of land parcels in the cadastral map 'CM_LP_count', in the textual part 'TP_LP_count', number of buildings in the cadastral map 'CM_BD_count', in the textual part 'TP_BD_count', number of encumbrances in the cadastral map 'CM_EB_count', in the textual part 'TP_EB_count' and number of parts of land parcels in the cadastral map 'CM_PLP_count', in the textual part 'TP_PLP_count' (Fig. 5, P1a, P1b).

The second step: evaluate each object quality by the parameters (Table 4, Table 7, Table 8, Table 9) and obtain object quality class (LP_QC, BD_QC, EB_QC, PLP_QC):

a) check the eligibility of object to quality criterions (Table 3), obtain the number or list of ineligible items QPn_count' or 'QPn_list' (Fig. 5, P2a),

b) obtain object quality class:
   - calculate quality parameter QPn values (Formula 3 – Formula 16), obtain QPn (Fig. 5, P2b),
   - determine, which quality parameter value set (Table 10) the obtained value belongs to. Obtain QPnVSk (Fig. 5, P2c),
   - determine, which is the class of a quality parameter QPn (Table 12), obtain QPn_QC (Fig. 5, P2d),
   - determine, which quality class an object corresponds to (Formulae 17 – Formulae 21), obtain LP_QC, BD_QC, EB_QC and PLP_QC. (Fig. 5, P2e).

The third step: determine cadastral map quality (Fig. 4), which depends on the lowest object quality class (Formulae 21), obtain CM_QC (Fig. 5, P3).

For demonstrating the approach for CM evaluation let's choose a map, which contains 19 land parcels, 7 buildings, 2 encumbrances and 1 part of land parcel (Fig. 6). Data in the CM and TP are shown in Table 13- Table 16.

Let's evaluate the quality of land parcels in the chosen CM. We have: five quality parameters for land parcels LP_QPn, n=1…5 (Table 4), three sets of values for quality parameters LP_QPn_VSj, n=1…5, j=1…3 (Table 10) and three land parcel quality classes – high, medium, low LP_QCm, m=1…3 (Table 12), CM and TP data, which are given in Table 13.

Evaluation of a land parcel consists of the following steps:

1st step – acquire the number of land parcels in the chosen CM (Fig. 5): the number of CM land parcels is 19, CM_LP_count=19. Also in the TP the number of land parcels for the chosen region is 19, TP_LP_count=19.

2nd step –

a) calculate how many land parcels do not comply with the proposed criterions, the result is 'LP_QPn_count' or 'LP_QPn_list', n=1...5.

b) then calculate LP_QPn- how many percents it is (Formulae 3 - Formulae 7) and using the sets of values for quality parameters (QPnVSk) and the quality assessment matrix (QAM), acquire quality parameter quality class LP_QPn_QC, n=1...5. Finally, get LP_QC (Formulae 17) (Fig. 3).

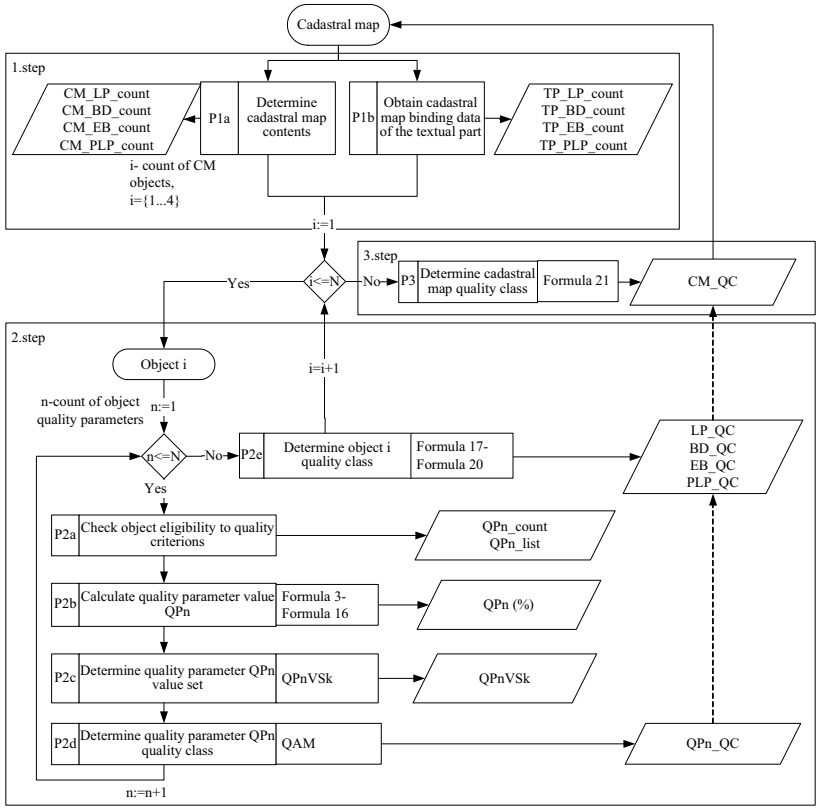

Fig. 5. Cadastral Map Quality Evaluation

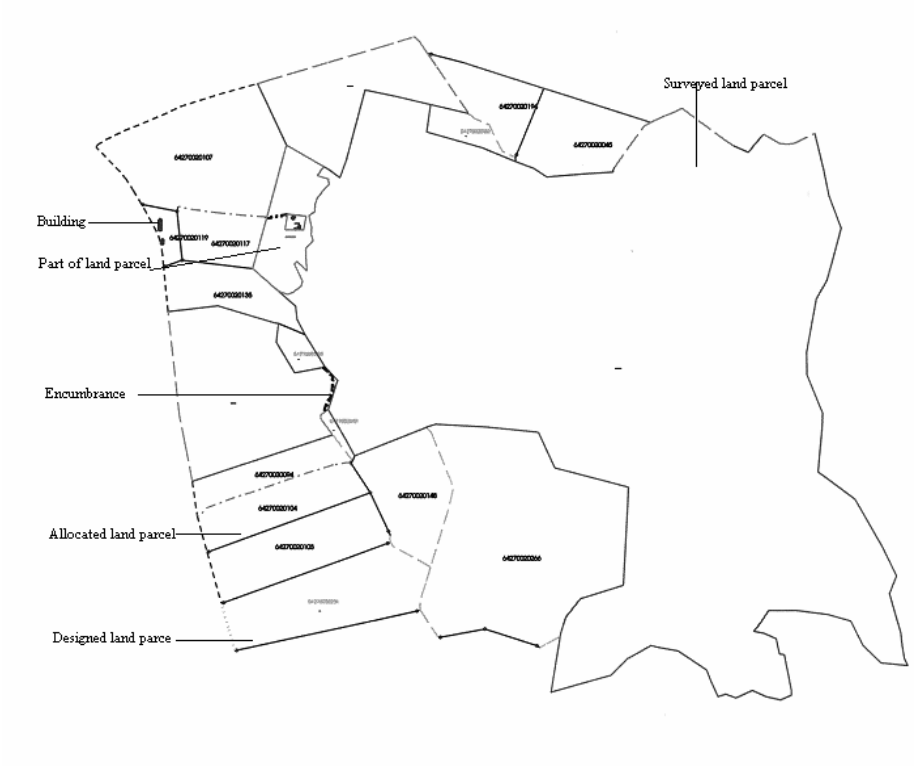

Fig. 6. Detail from the *Durbe* Country Cadastral Map

Table 13. Land Parcels CM and TP data

CM				TP			
Nr	Cadastral number of land parcel	Survey type	Graphical land area m2	Nr	Cadastral number of land parcel	Survey type	Legal land area m2
1	64270020045	allocated	73349	1	64270020045	allocated	82000
2	64270020094	allocated	43925	2	64270020094	allocated	51000
3	64270020103	allocated	91950	3	64270020103	allocated	91000
4	64270020104	allocated	65236	4	64270020104	allocated	59000
5	64270020107	allocated	163022	5	64270020107	allocated	158000
6	64270020117	allocated	40520	6	64270020117	allocated	38000
7	64270020119	allocated	12563	7	64270020119	allocated	15000
8	64270020135	allocated	54089	8	64270020135	allocated	64000
9	64270020146	surveyed	192035	9	64270020146	surveyed	192100
10	64270020148	allocated	81174	10	64270020148	allocated	82000
11	64270020151	surveyed	121532	11	64270020151	surveyed	121600
12	64270020189	designed	19453	12	64270020189	designed	18000

13	64270020190	designed	12905	13	64270020190	designed	13000
14	64270020191	designed	4411	14	64270020191	designed	4000
15	64270020194	allocated	49874	15	64270020194	allocated	53000
16	64270020200	surveyed	2114825	16	64270020200	surveyed	2115500
17	64270020251	designed	119254	17	64270020251	designed	119000
18	64270020266	allocated	322332	18	64270020266	allocated	320000
19	64270020317	surveyed	2690	19	64270020317	surveyed	2700

Table 14. Building CM ant TP Data

CM				TP		
Nr	Cadastral number of building	Survey type	Cadastral number of land parcel	Nr	Cadastral number of building	Cadastral number of land parcel
1	64270020119001	Vectorized	64270020119	1	64270020119001	64270020119
2	64270020119002	Vectorized	64270020119	2	64270020119002	64270020119
3	64270020119003	Vectorized	64270020119	3	64270020119003	64270020119
4	64270020119004	Vectorized	64270020119	4	64270020119004	64270020119
5	64270020195001	Vectorized	64270020317	5	64270020195001	64270020317
6	64270020195002	Vectorized	64270020317	6	64270020195002	64270020317
7	64270020195003	Vectorized	64270020317	7	64270020195003	64270020317

Table 15. Encumbrance CM ant TP Data

CM			TP		
Nr	Cadastral number of land parcel	Encumbrance code	Nr	Cadastral number of land parcel	Encumbrance code
1	64270020200	050301 001	1	64270020200	050301 001
2	64270020146	050301 003	2	64270020146	050301 003

Table 16. Part of Land Parcel CM ant TP Data

CM			TP		
Nr	Cadastral number of part of land parcel	Graphical land area m2	Nr	Cadastral number of part of land parcel	Legal land area m2
1	642700202008001	58766	1	642700202008001	55800

LP_QP1_QC acquisition (Fig. 7):

a) check, how many land parcels are not in the TP. After the check let us make sure that all land parcels in the CM are also in the TP, therefore LP_QP1_count=0 (Fig. 7, P1, P2),

b) calculate the rate LP_QP1=LP_QP1_count/CM_LP_count*100= 0/19*100=0% (Formulae 3) (Fig. 7, P3). Using the QPVS we see that LP_QP1 value appertains to the set of values LP_QP1_VS1 (Fig. 7, P4) and using the QAM, the value corresponds to the High class LP_QC1, we acquire that LP_QP1_QC=1 (Fig. 7, P5).

LP_QP2_QC acquisition:

a) check, how many land parcels in the TP of the chosen area are not marked in the CM. After the check let us make sure that all land parcels of the TP are marked in the CM, therefore LP_QP2_count=0.

b) calculate the rate: P2_QP2=LP_QP2_count/TP_LP_count*100= 0/19*100=0% (Formulae 4). Using the QPVS we see that LP_QP2 value appertains to the set of values LP_QP2_VS1 and using the QAM, the value corresponds to the High class, LP_QP2_QC=1.

LP_QP3_QC acquisition:

a) check, how many land parcels in the CM have surveying type different from the surveying type in the TP. In the result let us make sure that surveying types in both databases are the same, therefore LP_QP3_count=0.

b) calculate the rate: LP_QP3=LP_QP3_count/CM_LP_count*100= 0/19*100=0% (Formulae 5). Using the QPVS we see that LP_QP3 value appertains to the set of values LP_QP3_VS1 and using the QAM, the value corresponds to the High class, LP_QP3_QC=1.

LP_QP4_QC acquisition:

a) check, how many of surveyed land parcels in the CM have graphical land area larger/smaller than the acceptable difference from legal land is (Table 17):

- calculate the acceptable difference between graphical land area and legal land area (Table 6),
- calculate the actual (fact) difference,
- compare the acceptable difference with the actual area difference. In the result let us make sure that acceptable differences of graphical land area for all land parcels in the CM are within permissible limits, therefore LP_QP4_count=0.

b) calculate the rate: LP_QP4=LP_QP4_count/4*100= 0/4*100=0% (Formulae 6). Using the QPVS we see that LP_QP4 value appertains to the set of values LP_QP4_VS1 and using the QAM, the value corresponds to the High class, LP_QP4_QC=1.

LP_QP5_QC acquisition:

a) calculate, how many land parcels are surveyed in the CM and acquire that LP_QP5_count=4.

b) calculate the rate: LP_QP5= LP_QP5_count/CM_LP_count*100= 4/19*100=21.05% (Formulae 7). Using the QPVS we see that LP_QP5 value appertains to the set of values LP_QP5_VS2 and using the QAM, the value corresponds to the Medium class, LP_QP5_QC=2.

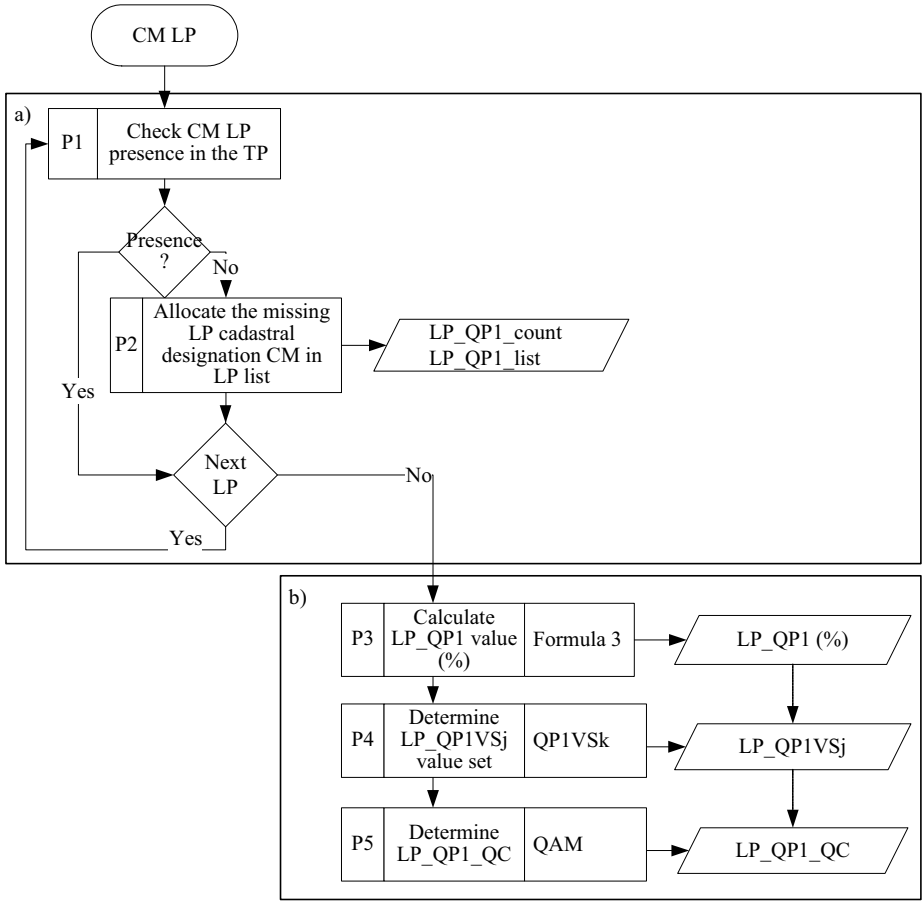

Fig. 7. Quality Parameter LP_QP1 Quality Class

Table 17. Calculation of the Difference between Graphical and Legal Land Area

Nr.	Cadastral number of land parcel	Graphical land area(a) ha	Legal land area (b) ha	Difference (ha)		Result
				Acceptable ($\pm x\sqrt{b}$)	Fact ABS(a-b)	
1	64270020146	19.20	19.21	1.10	0.01	Acceptable
2	64270020151	12.15	12.16	0.87	0.01	Acceptable
3	64270020200	211.48	211.55	4.36	0.07	Acceptable
4	64270020317	0.27	0.27	0.05	0.00	Acceptable

Finally, land parcel quality depends on the lowest quality class in every quality parameter: LP_QC=MAX (LP_QPi_QC), i=1…5 (Fig. 3, Formulae 17) and it is Medium class LP_QC=2 - CM (taking into account land parcel quality only), it is

permitted to use it for making decisions (Table 11), by ascertaining that land units, which were not surveyed, do not influence the decision. However, if CM usage purpose is not connected with it or land parcels are surveyed (do not take into account LP_QP5, therefore it is not a necessary requirement to be surveyed), then quality of the CM is already High class – LP_QC=1.

If CM usage purpose is connected with involvement of all the objects, it is necessary to evaluate the quality of the other objects. The quality of the other objects is evaluated in a similar way as the quality of land parcels. The quality evaluation of all the objects is given in Table 18.

Table 18. Object quality classes

Land parcel	Building	Encumbrance	Part of land parcel
LP_QP1_QC = 1	BD_QP1_QC = 1	EB_QP1_QC = 1	PLP_QP1_QC = 1
LP_QP2_QC = 1	BD_QP2_QC = 1	EB_QP2_QC = 1	PLP_QP2_QC = 1
LP_QP3_QC = 1	BD_QP3_QC = 1		PLP_QP3_QC = 1
LP_QP4_QC = 1	BD_QP4_QC = 3		
LP_QP5_QC = 2			
LP_QC = 2	BD_QC = 3	EB_QC = 1	PLP_QC = 1

Evaluation for the chosen CM (Fig. 5**,** 3rd step**)** is acquired taking into account the lowest quality class of each object: CM_QC= MAX(LP_QC, BD_QC, EB_QC, PLP_QC) (Fig. 4, Formulae 21).

As a result we obtain that quality class of the given CM (taking into account quality of all the objects) is the Low class – CM_QC=3 and it cannot be used for making decisions, it can be used to get primary information.

The evaluation method is based on object usage purpose and 1) if CM usage purpose does not depend on whether a building is surveyed (quality parameter BD_QP4 is not taken into account), then CM quality is of Medium class – CM_QC=2 and it can be used for making decisions, 2) if CM usage purpose does not depend on survey of land parcels and buildings (quality parameters LP_QP5 and BD_QP4 are not taken into account), then quality class is High class - CM_QC=1 and the CM and be used for any purpose.

3.4 Cadastral Map Quality Evaluation Software

Cadastral map quality is evaluated according to the defined quality parameters (Table 4, Table 7, Table 8, Table 9) and formulae for calculating their values (formulae 3 – Formulae 16) and used 22 data types (Table 19).

To provide fast and effective data quality evaluation, software for data quality evaluation is developed, which provides:

1) obtainment of data necessary for quality evaluation,
2) quality evaluation according to the defined quality parameters,
3) preparation of data for analysis and quality improvement

As the basis when elaborating data quality evaluation software (DQES) is taken Cadastral Information System Graphical Software (CISGS), which offers the following possibilities (Table 19):

1) make reports (R) on cadastral map and textual part objects,
2) check (C) data quality,
3) search (S),
4) create SQL queries (SQL),
5) save the selected data in MS Excel file.

Functionality of CISGS practically ensures the first step of cadastral map quality evaluation – obtain data about cadastral map content, including data from the textual part (Fig. 5, 1st step). This is provided by CISGS report creating function (report 'CAD7'). In the report 'CAD7' only textual part data about encumbrances are not used, because in the report there are all the textual part encumbrances for the chosen area, but for evaluation only servitudes are necessary (Table 9). That's why number of textual part encumbrances (servitudes) is obtained by applying an SQL query.

CISGS provides almost all the necessary quality checks (Fig. 5, 2nd step P2a) and selects items ineligible to quality criteria, which can be saved in MS Excel file, but the number of the surveyed objects can be obtained by creating reports 'CAD1_LP' and 'CAD1_BD'. CISGS does not offer two encumbrance quality checks: cadastral map encumbrances not included in the textual part (EB_QP1_list, EB_QP1_count) and textual part encumbrances not included in the cadastral map (EB_QP2_list, EB_QP2_count).

Table 19. CISGS Data

Nr	Data type	Quality parameter	CISGS	Name of data type	Formula
1.	Number of LP in CM	LP_QP1, LP_QP3-LP_QP5	CAD7 (R)	CM_LP_count	3,5-7
2.	Number of LP in TP	LP_QP2	CAD7 (R)	TP_LP_count	4
3.	Number of BD in CM	BD_QP1, BD_QP, BD_QP4	CAD7 (R)	CM_BD_count	8, 10, 11
4.	Number of BD in TP	BD_QP2	CAD7 (R)	TP_BD_count	9
5.	Number of EB in CM	EB_QP1	CAD7 (R)	CM_EB_count	12
6.	Number of EB in TP	EB_QP2	TP_EB_list (SQL)	TD_EB_count	13
7.	Number of PLP in CM	PLP_QP1, PLP_QP3	CAD7 (R)	CM_PLP_count	14,16
8.	Number of PLP in TP	PLP_QP2	CAD7 (R)	TD_PLP_count	15
9.	List of cadastral map land parcels, which are not in the textual part	LP_QP1	LP_QP1_list (C)	LP_QP1_list LP_QP1_count	3
10.	List of land parcels in the textual part, which are not in the cadastral map	LP_QP2	LP_QP2_list (C)	LP_QP2_list LP_QP2_count	4
11.	List of cadastral map land parcels with different survey type	LP_QP3	LP_QP3_list (C)	LP_QP3_list LP_QP3_count	5
12.	List of cadastral map land parcels with different area	LP_QP4	LP_QP4_list (C)	LP_QP4_list LP_QP4_count	6
13.	Number of surveyed cadastral map land parcels	LP_QP5	CAD1_LP	LP_QP5_count	7

Nr	Data type	Quality parameter	CISGS	Name of data type	Formula
14.	List of cadastral map buildings not included in the textual part	BD_QP1	BD_QP1_list (C)	BD_QP1_list BD_QP1_count	8
15.	List of textual part buildings not included in the cadastral map	BD_QP2	BD_QP2_list (C)	BD_QP2_list BD_QP2_count	9
16.	List of cadastral map buildings, which land parcel designations do not match with the designations of land parcels in the textual part, to which it is attached	BD_QP3	BD_QP3_list (C)	BD_QP3_list BD_QP3_count	10
17.	Number of surveyed cadastral map buildings	BD_QP4	CAD1_BD (R)	BD_QP4_count	11
18.	List of cadastral map encumbrances not included in the textual part	EB_QP1	CM_EB_list (S)	EB_QP1_list EB_QP1_count	12
19.	List of textual part encumbrances not included in the cadastral map	EB_QP1	TP_EB_list (S)	EB_QP2_list EB_QP2_count	13
20.	List of parts of land parcels in the cadastral map not included in the textual part	PLP_QP1	PLP_QP1_list (C)	PLP_QP1_list PLP_QP1_count	14
21.	List of parts of land parcels in the textual part not included in the cadastral map	PLP_QP2	PLP_QP2_list (C)	PLP_QP2_list PLP_QP2_count	15
22.	List of parts of land parcels in the cadastral map with different area	PLP_QP3	PLP_QP3_list (C)	PLP_QP3_list PLP_QP3_count	16

R- report, C- check , S - search functionality of CISGS

Although CISGS provides the data necessary for quality evaluation and performs almost all quality checks, the software does not provide data quality evaluation.

According to the present situation, obtain, that DQES tasks are (Fig. 8):

1) to import data to DQES data base,
2) to make encumbrance data quality checks,
3) to evaluate cadastral map quality according to quality parameters and quality evaluation matrixes (Fig. 5, 2nd step P2b. – P2e, 3rd step) and to display them in MS Excel file,
4) to prepare data in MS Excel file for analysis and improvement of quality.

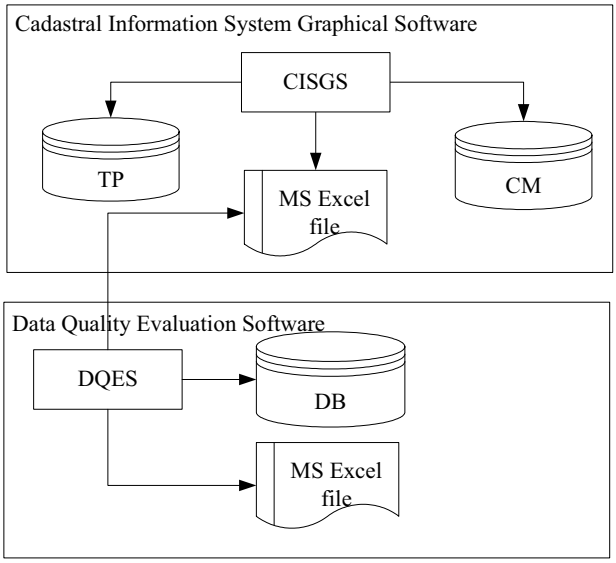

Fig. 8. CISGS and DQES

3.4.1 Data Import and Quality checks

CISGS offers to save data selected in reports, checks, searches and SQL queries in MS Excel file. For data import, using DQES, strictly keep to the definite folder structure (Fig. 9): 1) As cadastral map quality evaluation data (Table 19) are taken on the same date, they are stored in a folder with a name: YYYYMMDD, 2) for each cadastral map object – LP, BD, EB, PLP and the report 'CAD7' a folder is created, into which MS Excel files created with CISGS are placed. The number of files depends on the size of the chosen area and data errors. Work with a cadastral map in SLS is organised in regional departments and department offices. Within offices cadastral maps are created for cadastral areas and cadastral groups. This principle for work with cadastral maps is introduced into CISGS and the data necessary for evaluation are obtained through cadastral areas. For example, information about the *South Kurzeme* regional department can be obtained from CISGS from up to 79 MS Excel files: LP -22, BD -15, EB -24, LPL -15 and CAD7-3.

Prior to data import DQES processes encumbrance data: replacing the number of encumbrances in the textual part in 'CAD7' report with the number of encumbrances in the textual part, which is necessary for evaluation, as well as encumbrance checks. Thus, in the data base are stored only the data, which are necessary for evaluation process. DQES DB imported data are stored in 15 tables respectively.

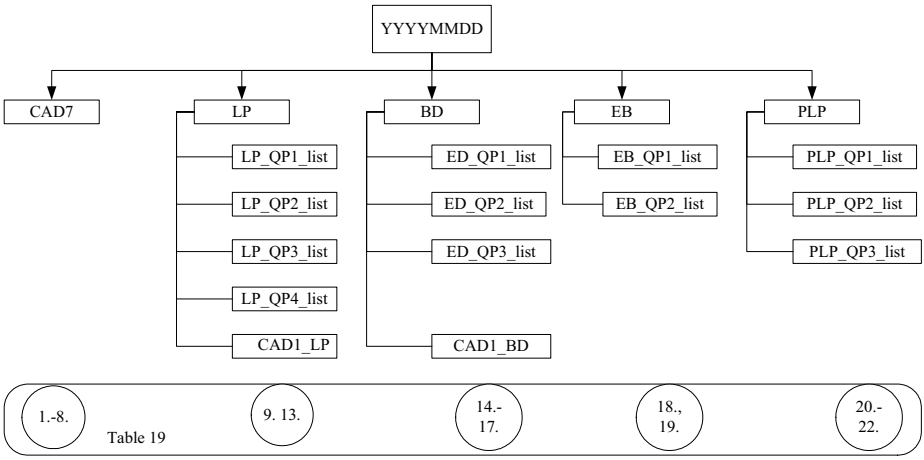

Fig. 9. Folder Structure for Data Import

3.4.2 Data Quality Evaluation and Mapping of the Results

DQES provides cadastral map quality evaluation according to the definite quality parameters (Table 4, Table 7, Table 8, Table 9), formulas (Formulae 3 – Formulae 16), determines object quality classes according to quality matrix (Table 12) and formulas (Formulae 17 – Formulae 21).

The obtained evaluation results DQES maps in MS Excel file, in the worksheet for each cadastral map object (Table 20), which can contain various cadastral areas,

- horizontally (as object item) displayed:
  1-cadastral area code and title,
  2-for each quality parameter (QPn) three data types are displayed: number of items eligible/ineligible to criteria (Count), according to formulae calculated percents of parameter value (%) and the class corresponding to the obtained value (QC),
  3-cadastral area quality class (QC) that depends on each quality parameter quality class,
- vertically (as quality parameter QPn) displayed:
  4-each quality parameter quality class (QPn QC)
  5-object quality class (QC)

Table 20. Structure of Evaluation Data Mapping

Cadastral map territorial code and name	Quality parameter QP1			..	Quality parameter QPN			Quality class
1	2’			2’’	2’’’			3
	Count	%	QC	...	Count	%	QC	Cad. ter. QC.
...	...	...	...	...	...	...	...	...
			4’ QP1 QC	4’’			4’’’ QPN QC	5 Object QC

The maximum a file can contain is 4 worksheets with quality evaluation data – a separate worksheet for each object (LP, BD, EB, PLP).

As an example for land parcel evaluation data mapping (Fig. 10) are given data from *South Kurzeme* regional department in *Liepāja* office for towns cadastral territorial land parcel quality evaluation on August 9, 2007.

Cadastral territorial		LP_QP1			LP_QP2			LP_QP3			LP_QP4			LP_QP5			LP_QC
Code	Name	Count	%	LP_QP1_QC	Count	%	LP_QP2_QC	Count	%	LP_QP3_QC	Count	%	LP_QP4_QC	Count	%	LP_QP5_QC	
1700	Liepāja	0	0	1	7	0.09	2	3	0.04	2	11	0.14	2	6338	82.64	2	**2**
6405	Aizpute	0	0	1	0	0	1	0	0	1	3	0.25	2	830	71.43	2	**2**
6407	Durbe	0	0	1	0	0	1	1	0.59	2	0	0	1	97	58.43	2	**2**
6409	Grobiņa	0	0	1	4	0.33	2	2	0.17	2	3	0.25	2	813	71.44	2	**2**
6413	Pāvilosta	0	0	1	0	0	1	2	0.25	2	2	0.25	2	553	70.54	2	**2**
6415	Priekule	0	0	1	0	0	1	0	0	1	0	0	1	428	63.79	2	**2**
				1			2			2			2			2	**2**

Fig. 10. *Liepāja* Office for Towns Land Parcel Quality Evaluation

3.4.3 Data Preparation for Analysis

Quality evaluation data for analysis are displayed in charts. DQES prepares two types of charts: charts describing charts for cadastral map object quality parameter values (%) and charts describing cadastral map and its object quality classes.

For object quality parameters (Table 4, Table 7, Table 8, Table 9) can be 7 charts maximum: PLP – 1, EB – 1, but LP and BD have 2 charts each, because quality parameter LP_QP5 and BD_QP4 value sets (Table 10) are different from other quality parameter value sets, as well as the chart, in which are given quality parameter values, which describe objects – LP_QP1, LP_QP2, BD_QP1, BD_QP2, EB_QP1, EB_QP2, PLP_QP1, PLP_QP2.

As an example of land parcel analysis data mapping are given the data of *South Kurzeme* regional department *Liepāja* office for towns cadastral area land parcel evaluation on August 9, 2007 by parameters LP_QP1, LP_QP2, LP_QP3, LP_QP4 (Fig. 11) and LP_QP5 (Fig. 12).

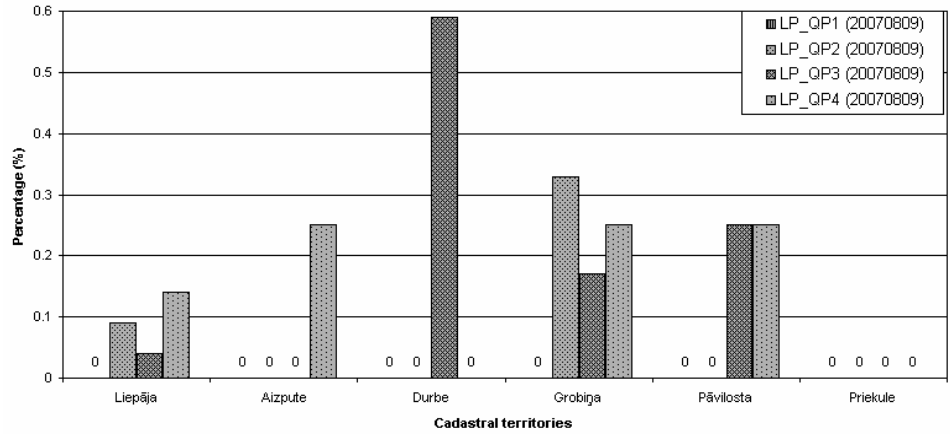

Fig. 11. *Liepāja* Office Land Parcel Analysis Data

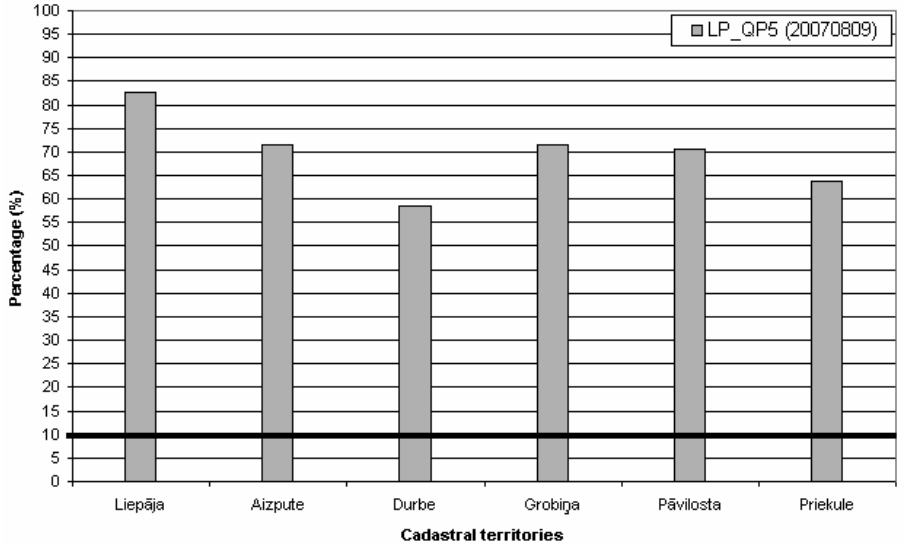

Fig. 12. *Liepāja* Office Land Parcel Analysis Data

For quality parameter quality classes can be 5 charts maximum: each cadastral map object quality parameter quality classes and cadastral map quality classes.

As an example of land parcel quality parameter quality class analysis data mapping are given the data of *South Kurzeme* regional department *Liepāja* office for towns cadastral area land parcel evaluation on August 9, 2007 by parameters LP_QP1, LP_QP2, LP_QP3, LP_QP4 and LP_QP5 quality class (Fig. 12).

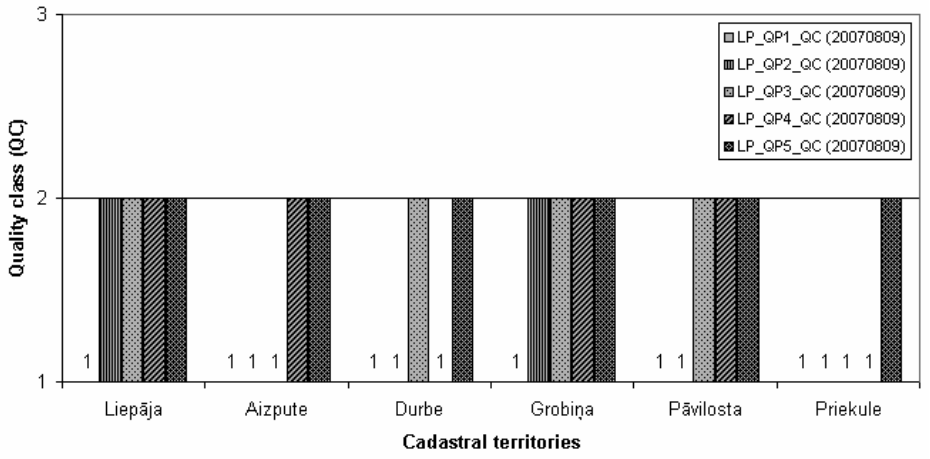

Fig. 13. *Liepāja* Office Land Parcel Quality Parameter Quality Classes

As an example for cadastral map object quality class analysis data mapping are given the data of *South Kurzeme* regional department *Liepāja* office for towns cadastral area land parcel evaluation on August 9, 2007 (Fig. 14).

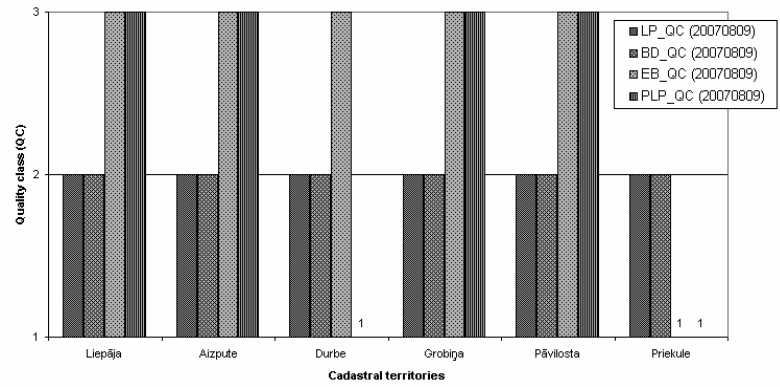

Fig. 14. *Liepāja* Office Cadastral Object Quality Classes

3.4.4 Storage of Quality Evaluation Data

DQES maps quality evaluation data and analysis data in MS Excel file. The file, if it is necessary, can be stored in the chosen location and name.

In general MS Excel file created by DQES can contain 16 worksheets maximum: 4 worksheets with quality evaluation data, 7 worksheets with charts for object quality parameter values and 5 worksheets with charts for quality classes (object quality parameter and for the cadastral map.

For development of DQES such tools are chosen: My SQL, MS Visual Basic and MS Excel. DQES DB contains 30 tables (15 data tables, 6 classifiers, 4 data quality evaluation result tables and 5 support tables), the interface consists of 5 display forms, but program code contains approximately 4300 rows. Software specification and design are made by A.Jansone, but code is made by K.Grietēns.

The defined method does not depend on the size of each cadastral map – you can choose a cadastral map with one land parcel with existing objects- and evaluate it, as well as you can choose all the cadastral maps in the data base and evaluate them.

4 Conclusion

The described approach can be applied to any CM. Quality assessments can be obtained not only for CM of small territories but also for big areas, e.g., cities, regions. The example given in this paper is an assessment of a portion of the Latvian country *Durbe* and reveals where the weaknesses of the map may be.

The insights gained from this analysis are varied. For example, lists of land parcels for which data quality is poor and where data quality needs to be improved in order to be useful for given purposes. In particular, approximate calculations can be done to estimate the time and financial commitment required to bring a CM to a desired quality; for example, to carry out border adjustments in particular territories.

The elaborated method can be used for quality evaluation of objects of any type and the main steps of the method are: firstly, from experiments obtain subjective opinion about object quality descriptive parameters - which value depends on object usage

purpose. Secondly, perform structuring of expert subjective opinion and define object quality parameters and their values, according to object binding normative documents and existing IT solutions in the company. Thirdly, together with experiments define object quality classes depending on object usage purposes and what quality parameter values create each quality class, consequently, obtain object quality evaluation matrix, which is used to evaluate the use of an object for the chosen purpose.

This paper presents an object corresponding to the lowest quality parameter quality class - "hard" principle for object evaluation. Other principles (for example, "soft" principle) are going to describe in coming research papers.

In order to make everyday use of a cadastral map easy and simple, support software (Data Quality Evaluation Software) is elaborated for calculating values of quality parameters and for quality class determination, as well as for obtaining charts to analyse data and to elaborate a plan for improving data quality. If without DQES data quality evaluation of one regional unit (i.e. *South Kurzeme* regional unit) required 2-3 days, now the needed time is 1-2 hours. DQES data quality evaluation algorithms tested in practice can be used for supplementing CISGS.

Continuing research is aimed at identifying more quality parameters and ensuring that extracted quality parameters conform to the initial subjective opinions of experts.

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