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Quantitative Analysis of Land Use Classification in Agricultural and Forest Areas

Abstract: The article deals with the research on the quantitative classification of land use, which directly affects the amount of land use data collected in the real estate cadastre.

For the purpose of this article, the cadastral systems of seven European countries – Austria, Bulgaria, Estonia, Spain, Lithuania, Germany and Poland – have been examined, taking into account how detailed is the classification in agricultural and forest areas. The research covered the provisions of legal acts applicable in the researched seven European countries and made available in national languages by the government bodies.

The article asks the following three questions:

1) whether the researched countries adopted the same approach to isolating classes of items related to agricultural and forest areas;
2) whether the researched countries feature the same number of classes of items recorded at various levels of detail;
3) what is the percentage of the distinguished item classes of land uses in the agricultural and forest areas in relation to all of the distinguished item classes at all the levels of detail.

The conducted research can be used as a material supporting works consisting of the modernization of the functioning of land registration in the real estate cadastre in Poland.

Keywords: land use, land cover, cadastre, land use / land cover registration, agricultural areas, forest areas

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1. Introduction

The proper management of the Earth's resources is of crucial significance for human life [1]. The Food and Agriculture Organization (FAO) has defined land and land resources as the part of the Earth's surface referring to a designated area of the land surface, encompassing all the attributes of the biosphere immediately above or below that surface, including climate, soil and landforms, hydrology, plant population and animals, the model of human settlement and the physical effects of past and present human activities [2]. The changing climatic situation and the negative impact of external factors on land use have initiated activities aimed at planning and rational management of land resources based on reliable knowledge in the field of land use. Concern for the environment, and the proper use and management of land, has led to many national [3] and international initiatives related to environmental protection and setting the rules for determining the range of land use. The most important of the global initiatives are Agenda 21 [4] and Agenda 2030 [5], the aim of which is to define the principles of environmental protection and sustainable development of the space around us. Monitoring the implementation of the 2030 Agenda Sustainable Development Goals (SDGs) is directly dependent on access to reliable and high-quality data that will be directly relevant in the decision-making process and ensuring responsibility for the implementation of the 2030 Agenda.

The need to overcome the problem of the deteriorating condition of the environment, loss of agricultural land and degradation of forest areas initiates activities aimed at expanding knowledge in the field of Land Use and Land Cover [6]. This knowledge allows the identification of land with favorable conditions for agricultural production, and plays an important role in the process of land use planning [7]. This view is shared by Xie [8], who states that achieving sustainable land use is one of the most important ways to achieve sustainable socio-economic development.

For this purpose, attempts have been made to develop a single global system for classifying land use, land cover.

An important research topic is land use / land cover, which are related to global changes [9–11]. Currently, research is being carried out on the collected data on land use and land cover, and their interrelationships for the purposes of making national decisions.

One of the systems for collecting this type of data is the CORINE land cover classification system proposed by the European Environment Agency (EEA) [12]. CORINE is based on 13 main classes, which are further detailed according to the type of use, particularly in agriculture, and covers a total of 44 land cover classes across Europe.

Another classification system is the land use / cover classification system (LCCS) proposed by FAO [13]. This classification is a typical general classification system.

This classification consists of two basic levels of detail. The first level of detail of the land cover classification is defined by the eight main types of land cover. At the first level of detail of the classification, are cultivated areas with plants, natural areas covered with plants, surfaces of arable waters or flooded areas, natural vegetation of water or flooded areas, artificial land surfaces, naturally unspoiled land surfaces, artificial water surfaces, natural water surfaces. In the second level of detail, the user assigns a series of classifiers to the object. Increasing the detail of the land cover description is related to the increase in the number of classifiers used. Thus, the second level of detail of the classification is a multi-layer classification system.

The problem of developing a land use classification system used globally has been discussed in many studies. Jansen et al. indicated new directions of land use classification [14]. The proposed concept for the future development of databases was based on the use of standard classifications as a reference database, the purpose of which was to facilitate the comparison of land cover data on a uniform basis. The authors assumed that data obtained in this way would be available to users and could be widely used. Letourneau et al. [15] also proposed a new way to classify and model land use using land use systems (LUS) classification of land cover and global land use models.

These studies, however, did not become the basis for the creation of a commonly accepted classification system.

When considering the need for effective land use registration systems, it is first necessary to conduct research on uses of the land collected in the land register which are currently in place in European countries.

The information contained therein plays an important role at every stage of economic development of each country. Continuous changes in the scope of collected information on land use are aimed at increasing the efficiency of land use and its protection against inappropriate land development.

For the purpose of rational land management, local and government administration bodies undertake numerous initiatives to promote extending knowledge as regards the gathered information on land use [16, 17].

The scope of the recorded land use information and the terminology used in land administration vary among the countries and depend on the legal regulations applicable in such countries and the level of detail of such regulations [18–20].

The article presents registrations of agricultural and forest land use, land cover existing in selected European countries. For the purpose of the research, the number of levels of detail and the number of items recorded at each level of detail of land use registration have been determined. The approach of individual countries to the way item classes related to agricultural and forest areas are isolated has also been analysed, i.e. whether one isolated class contains items which are functionally related to agricultural and forest areas or whether separate classes of items related to agricultural and forest areas have been isolated. In addition, whether

the study countries show a similarity in the quantitative scope of the distinguished classes of features and demonstrate a similarity in the percentage share of the distinguished item classes at each level of detail related to agricultural and forest areas in comparison to all of the isolated classes of items at each level of detail will be examined.

The subject of the research is the quantitative characteristics of land use and land cover in seven European countries: Austria [21, 22], Bulgaria [23], Estonia [24, 25], Spain [26], Lithuania [27, 28], Germany and Poland [29].

2.   Data and Methods

Research on land classifications operating in seven European countries has demonstrated that these classifications were based on various source data [30]. They were influenced by such factors as historical background and geographical location.

The examination of the source material showed that in Austria, actual use is recorded within the cadastral unit the parcel relates to is registered in the border cadastre. In Austria, there is a separate land and mortgage register and a separate land rights register.

Land use is recorded in terms of spatial planning in Bulgaria. In Bulgaria, there is a universal register, i.e. a register containing data on land and rights to a plot of land.

In contrast, the intended use of the cadastral unit is recorded in Estonia. In Estonia, land use is recorded for the entire plot. It is worth noting that the purpose of the cadastral unit applies to the entire plot and determines the purpose of the plot, among others agriculture and forestry. For example, a plot of land for agricultural or forestry production may consist of different types of land, e.g. arable land, natural grassland, orchards, forests, shrubs, etc. All land in Estonia is divided into different land types, but this is not related to the intended use land (intended use of the cadastral unit). This is another aspect of land classification. Therefore, in the land classification, we do not distinguish the second level of detail. In Estonia, there is a separate land and mortgage register and a separate land register.

In Spain, there is a land use register. Databases represent all typologies of objects located on the site. In Spain, there is a separate land and mortgage register and a separate land rights register.

In Lithuania, there are land use groups with a land and mortgage register. Land spatial data contains information about the actual land use and its structure. Various land uses are registered on the plot. In Lithuania, there is a universal register, i.e. a register containing data on land and rights to a plot of land.

In Germany, the actual land use is recorded and various land uses can be registered within the plot boundaries. Germany has a separate land register and a separate land rights register.

A similar registration system is in place in Poland. The actual land use is also recorded and various land uses can be registered within the plot boundaries. As in Germany, the land and mortgage register and the real estate rights register are separate. In order to explain the functioning of the various land use registers for the purposes of the study, two countries were discussed, Poland and Lithuania, with an indication of what land data are recorded in the registers operating in these countries.

As already mentioned, there are two registers in Poland:
1) the register containing data on land and buildings (real estate cadastre),
2) land and mortgage registers recording the legal status of real estate.

The register of land and buildings is kept by Starosts and is an information system ensuring the collection, updating and sharing, in a uniform manner for the entire country, information on land, buildings and premises as well as their owners and other entities that own or manage these lands. In the land and building register, in relation to land, the number of the plot, area, type of land use and the identification of the document confirming the ownership title are recorded. The land and mortgage register is the one that confirms the right to dispose of the real estate. The land and mortgage register is a legal register. The land and mortgage register kept for real estate may constitute one plot or multiple plots of land registered in the land and building register.

The land and mortgage register contains four sections, of which:
1) the first includes the designation of the property and entries related to rights with her property;
2) the second includes entries on ownership and perpetual usufruct;
3) the third is intended for entries on limited property rights, with the exception of mortgages, for entry of restrictions on the disposal of real estate or perpetual usufruct and for entries of other rights and claims, except for claims relating to mortgages;
4) the fourth is intended for mortgage entries; land registers are kept by District Courts determined by the Minister of Justice.

There is a different method of registration in Lithuania. In Lithuania, there is a register that contains information on land and the rights to land. For the purposes of the study, this register was called the universal register. The register functioning in Lithuania is considered to be a legal and organizational unit and a technical means, intended for the entry of objects, including land, for the collection, storage, processing and sharing of registered object and subjective data. The land object data is the plot number, the way the land is used. This register is kept by the Center of State Enterprises Registers and supervised by the Ministry of Justice. In both surveyed countries, the land register operating in Poland, as well as the universal register operating in Lithuania, records land use methods, including arable land, pastures and meadows.

The research of source materials allowed to the following to be determined:
– the number of classification levels of detail,
– the number of distinguished classes of items in agricultural and forest areas,
– indications of similarity in terms of quantity of the distinguished classes of objects related to agricultural and forest areas,
– the percentage of the distinguished item classes in agricultural and forest areas in comparison to all of the isolated classes of items for seven European countries.

The land use classifications researched are based on a hierarchical approach. At the first classification level, agricultural, forest, urbanised and water areas are recorded [31]. A similar approach was adopted in an international project implemented by the UN Economic Commission for Europe [32]. The differences in the classification levels of detail depend on the established land use criteria and the definition of various uses of agricultural and forest areas. In order to achieve the stated research objectives, it was necessary to adopt action patterns which consist in finding items similar in terms of definition and function in the materials made available by seven European countries. The analysed materials had various structures and levels of detail some of them were in national languages.

The researched materials allowed us to:
– distinguish the classification levels of detail,
– distinguish item classes recorded at different levels of detail.

The study of the distinguished levels of detail of the classification was not limited only to the areas functionally related to agricultural land and forest areas. The limitation of the scope of research to agricultural areas and forest areas concerned only the number of classes of objects registered at each level of detail, e.g. in Spain, which distinguishes two levels of detail of the classification, only at level 1 are classes functionally related to agricultural and forest areas recorded.

Feature classes not related to agricultural and forest areas were excluded from the study.

For the purposes of the study, it was assumed that the concept of the level of detail should be understood as a description of the land development determined on the basis of the adopted classifiers. The individual levels of detail depend on the number of adopted classifiers describing the ways of land use or development. The adopted classifiers, and thus the level of detail in land use registration, result from the legal regulations in force in the analyzed countries. For the purposes of the study, three levels of classification detail were distinguished. The first level covers the basic classes of objects, e.g. agricultural land and forest land. The second level is a refinement of level 1. The refinement consists in the use of additional, more detailed classifiers that allow, in the group of basic land (level 1) to distinguish additional classes of objects defining the ways of land use or development. The third level of detail is a detail of level 2. On the third level of detail, additional classifiers were used to distinguish additional classes of objects.

Table 1. Distinguished levels of classification detail and distinguished classes of objects
related to agricultural and forest areas

Ord. no.	Country	1st level	2nd level	3rd level
1	Austria	– arable land	– arable land, meadows and pastures – fruit plantations, tunnel gardens – other areas related to agricultural areas	–
		– forests	– forests – alpine areas – forest roads	–
		– vineyards	–	–
2	Bulgaria	– arable lands	–	–
		– forests		
3	Estonia	– land used for agricultural or forestry production	–	–
4	Spain	– land used for agricultural or forestry production	–	–
5	Lithuania	– land used for agricultural or forestry production	– arable lands	– arable land – botanical garden – meadows and natural pastures
			– forests	–
6	Germany	– arable lands	– agricultural land – agricultural land – garden lands – agricultural land used for the cultivation of vines – agricultural area – heath – untreated area – area used for intensive fruit cultivation – orchards	– agricultural land – hops – meadow – garden – young trees – the area of fruit plants
			– forests – deciduous forest – coniferous forest – mixed forest – the area is covered with trees and shrubs	–

Table 1. cont.

Ord. no.	Country	1st level	2nd level	3rd level
7	Poland	– agricultural land	– agricultural land	– arable land – permanent meadows – permanent pastures – orchards – developed agricultural land – wooded and bushy land on agricultural land – soils under ponds – soils under ditches
		– forest, wooded and shrub land	– forests – wooded and shrubby land – soils under ditches	–

The structure of classes presented above stems from the original classification systems of the individual countries. The division into individual levels of detail and registered groups of uses was not subject to modification. For the purposes of the study, in the case of Lithuania, a unified nomenclature was used, consisting in replacing the name developed areas (in this group are registered lands agricultural and forest areas) with areas used for agricultural and forestry production. Research has shown that in Spain, at level 1, there are two types of land: built-up land and land functionally related to agricultural and forest areas. At the second level of detail, only areas functionally related to built-up areas, which are not the subject of the study, are registered. Therefore, the column on level II has not been filled in, as land functionally associated with agricultural land and forest areas is not registered at this level. In Germany, on the first level of detail, a class of objects is distinguished, agricultural land, which on the second level of detail is divided into two classes in which separate classes are registered functionally related to agricultural areas and separately classes functionally connected with forest areas.

Research has shown that Austria has distinguished the object related to the cultivation of fruit plants, i.e. vineyards, as a separate class. Due to the nature of this area and its close link with agricultural areas, vineyards were included in the study.

The research carried out showed that the classification of land use in European countries is not extensive. It is characterized by a discrepancy in the number of distinguished levels of land use classification and a discrepancy in the number of distinguished classes of objects registered at individual levels of classification detail.

The statistical method was used to calculate the percentage of item classes functionally related to agricultural and forest areas in comparison to all of the distinguished item classes of land use isolated at particular levels of the classification level of detail.

3. Research and Results

The research demonstrated that the highest number of land use classification levels is to be found in Lithuania, Germany and Poland (three levels each), while their lowest number is in Bulgaria (Fig. 1).
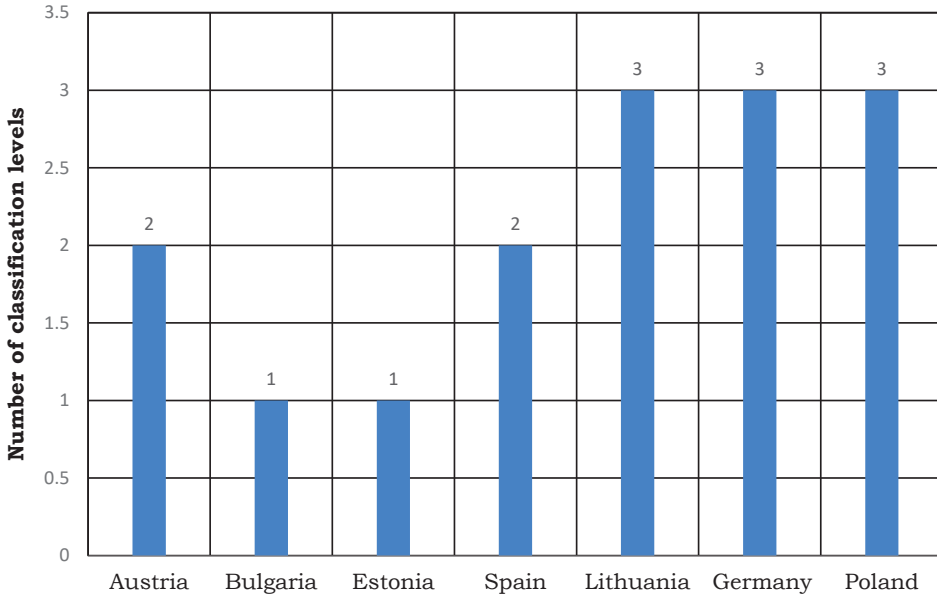

Fig. 1. The number of classification levels

An analysis of the scope of detail of the classification showed that two countries are characterized by a narrow scope of detail (Bulgaria and Estonia). On the other hand, the average level of detail is characteristic for five countries (Austria, Spain, Lithuania, Germany and Poland). The research has showed that the high classification level of detail was not found in any of the analysed countries. For the purpose of research, it was assumed that the research would not cover item classes not related to agricultural and forest areas. The adopted of detail related for the first level to agricultural and forest on areas assumptions are shown in Figure 2.

The next stage of the research was to distinguish classes of objects on the second level of detail related to agricultural and forest areas. The results of the study are shown in Figure 3. The study showed that only Austria, Lithuania, Germany and Poland have the second level of the classification.

The same scheme of operation was adopted for the third level, i.e. the classes of objects functionally related to agricultural and forest areas were distinguished. The results of the study are shown in Figure 4. The study showed that the third level of detail is registered in only Lithuania, Germany and Poland.
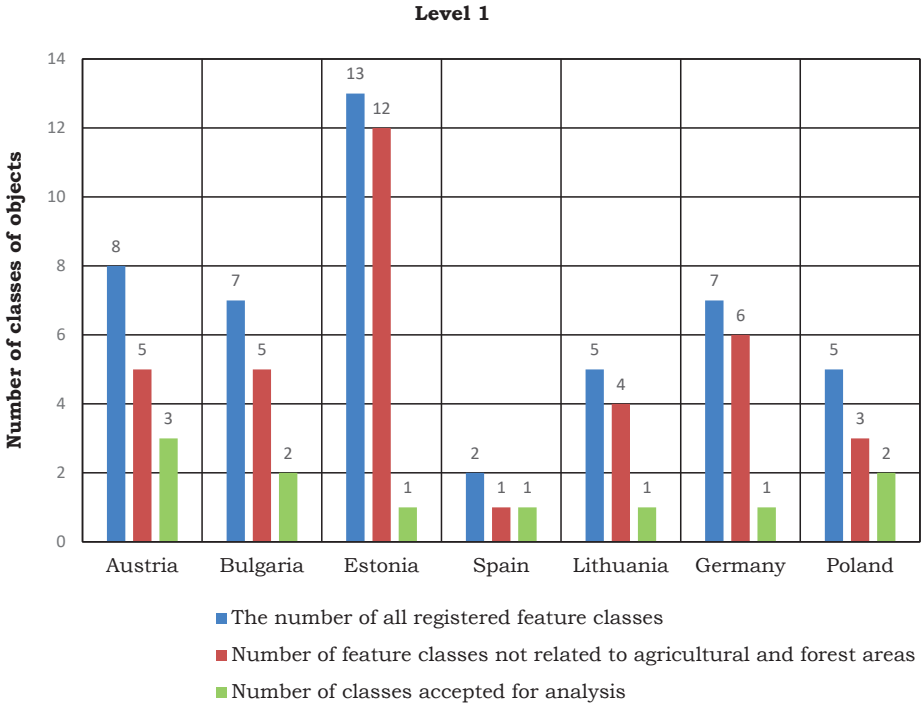
Level 1

Fig. 2. The number of feature classes distinguished at level 1 of detail
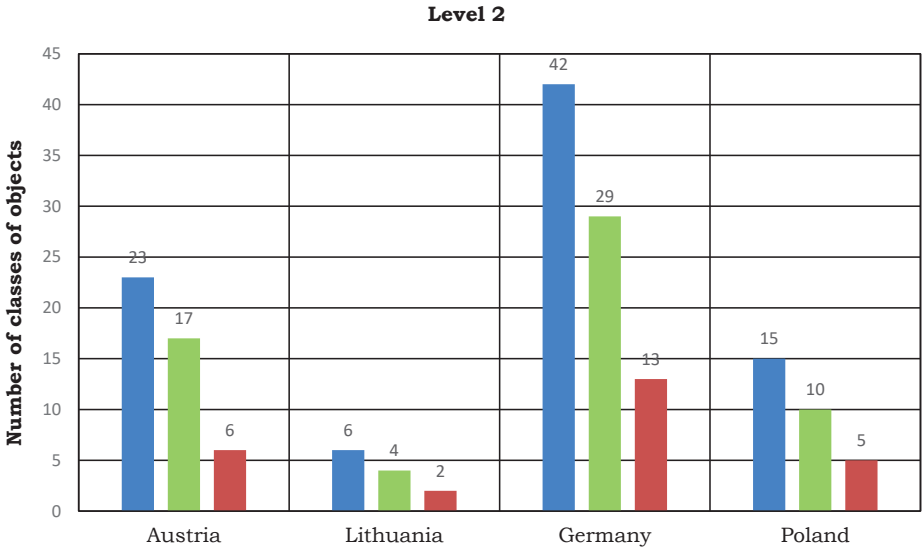related to agricultural and forest areas

Level 2

Fig. 3. The number of feature classes distinguished on the second level of detail
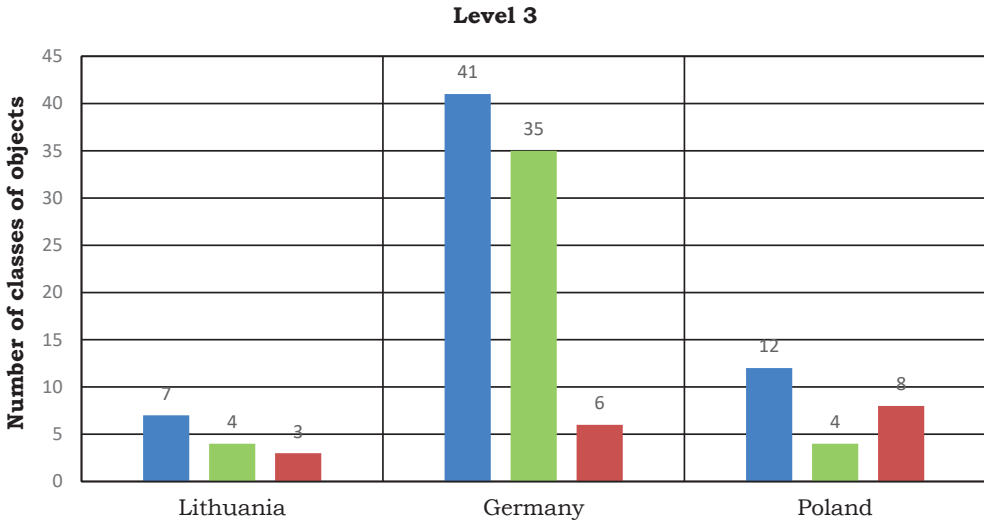related to agricultural and forest areas. Legend as in Figure 2

Fig. 4. The number of classes of features distinguished on the third level of detail related to agricultural and forest areas. Legend as in Figure 2

The research concerned the number of distinguished item classes for agricultural areas and for forest areas. The number of distinguished item classes at each level of detail is presented in Table 2.

Table 2. The number of item classes at each level of detail related to agricultural areas and forest areas

Ord. no.	Country	Number of classes at the 1st detail level	Number of classes at the 2nd detail level	Number of classes at the 3rd detail level
1	Austria	2	3	0
		1	3	
2	Bulgaria	1	0	0
		1		
3	Estonia	1	0	0
4	Spain	1	0	0
5	Lithuania	1	1	3
			1	0
6	Germany	1	8	6
			5	0
7	Poland	1	2	8
		1	3	0

In Table 2, the cells in yellow are related to the distinguished item classes used exclusively for agricultural purposes, while the cells in green are related to the classes associated with forest areas only. Orange is used to mark entries in the table that distinguish one class of objects, which applies to both agricultural and forestry use. With regard to Austria, Bulgaria and Poland, on the first level of detail, the division into two colors (yellow and green) was used, distinguishing countries in which two separate classes of features are distinguished related to areas used for agriculture and separately used forests. The same scheme for marking classes of objects related to individual types of use was used at the second level of detail for Austria, Lithuania, Germany, and Poland, and at the third level of detail for Lithuania, Germany, and Poland.

The results of the similarity test of land use records, i.e.:

– in which countries there is a separate class of agricultural land,
– in which countries there is a separate class of forest land,
– in which countries there is one class of agricultural and forest land

at all three distinguished levels of detail are shown in Figures 5–7.

The research has shown that on the first level of detail, three countries – Estonia, Spain and Lithuania – are characterised by one isolated class of items which includes areas used for agriculture and those used for forests. Austria, Bulgaria, and Poland have separate classes for agricultural land and forest areas. A special case is Germany, which registers one class related to agricultural areas at the first level of detail. At the first level of detail the same number of isolated item classes related to agricultural areas are registered by Bulgaria, Germany and Poland (1 class of items). The research showed that three European countries, Austria, Bulgaria and Poland, show similarity in the number of items related to forest areas (1 class of items) at the first level of detail. Estonia, Spain, and Lithuania show similarities in terms of a single class functionally related to agricultural land and forest land.

At the second level of detail, four of the seven countries – Austria, Lithuania, Germany, Poland – show similarities in terms of registering separate classes of features related to agricultural and forest areas. The study does not show any similarity in the number of distinguished classes of features related to agricultural areas. With regard to forest areas, on the second level of detail, the similarity in the number of registered objects is shown in Austria and Poland (three classes of objects each). In other cases, the countries surveyed do not show similarities in the number of distinguished classes related to forest areas.

At the third level of detail, three countries – Lithuania, Germany, and Poland – register items which are functionally related to agricultural areas. The research does not show similarities as regards the isolated classes of items at the third level of detail. The research has demonstrated that none of the examined countries registers objects related to forest areas at the third level of detail of the classification.
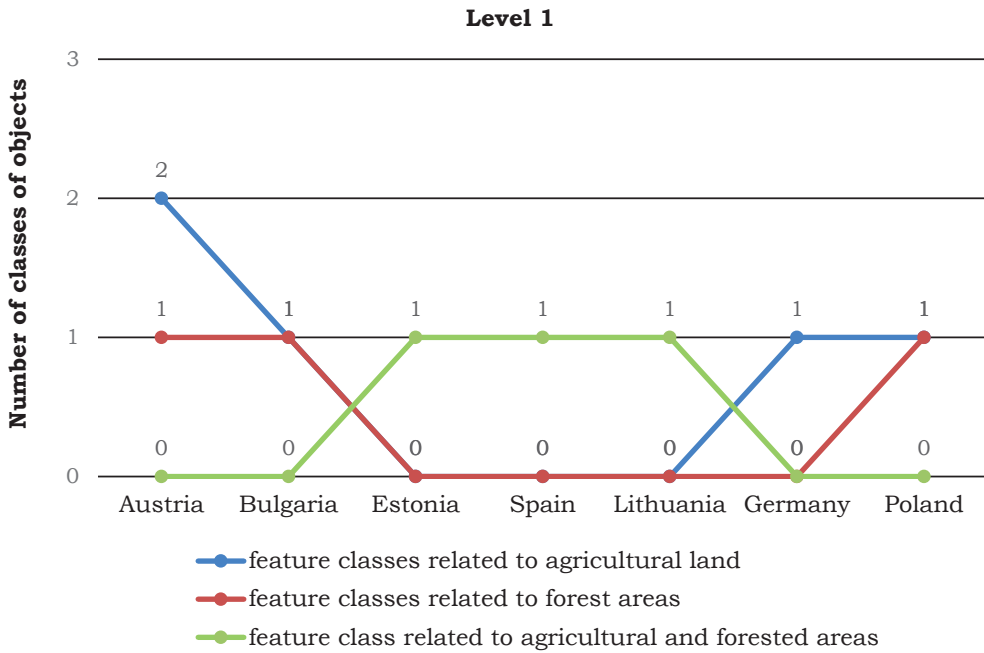
Fig. 5. Examination of the similarity of land use records at the first level of detail
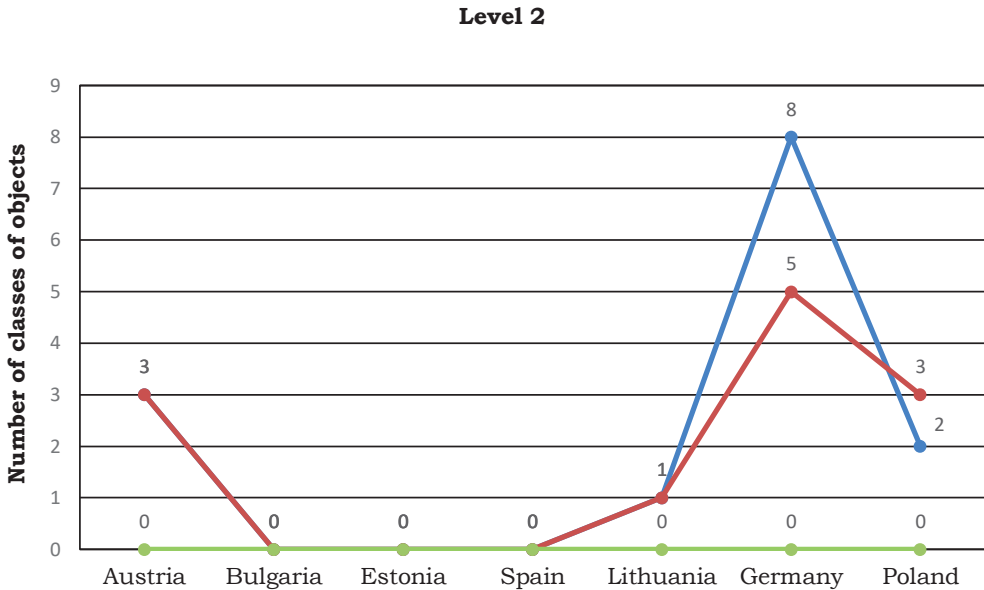

Fig. 6. Examination of the similarity of land use records at the second level of detail.
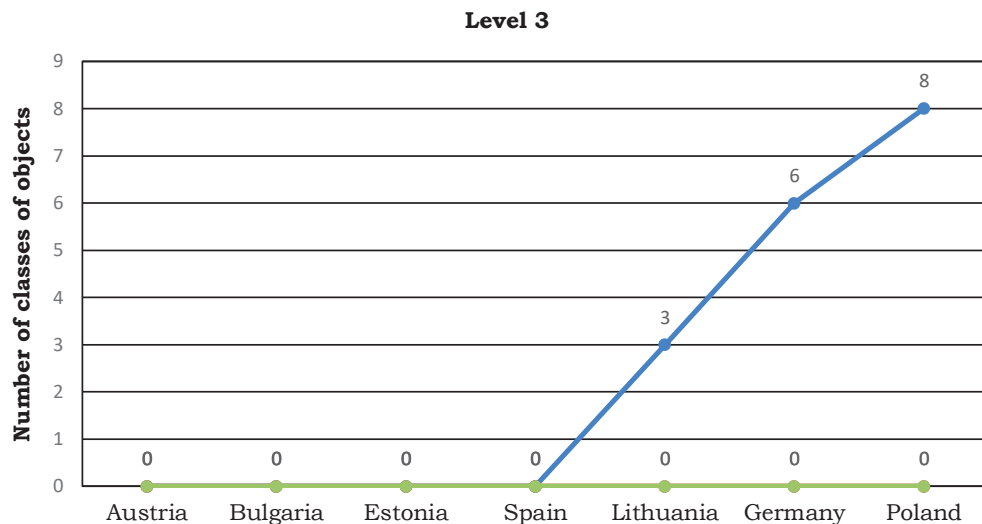Legend as in Figure 5

Fig. 7. Examination of the similarity of land use records at the third level of detail. Legend as in Figure 5

The study of the percentage share of the number of classes of objects related to agricultural land at individual levels of detail in relation to all distinguished land use classes shown is in Table 3.

Table 3. Percentage share of the number of classes of objects at particular levels of detail in relation to all distinguished classes of land use

No.	Country	Number of classes at the 1st level of detail [%]	Number of classes at the 2nd level of detail [%]	Number of classes at the 3rd level of detail [%]
1	Austria	25	13	0
		12	13	
2	Bulgaria	14	0	0
		14		
3	Estonia	8	0	0
4	Spain	50	0	0
5	Lithuania	20	17	43
			17	0
6	Germany	14	19	15
			12	0
7	Poland	20	13	67
		20	20	0

In Table 3, the cells in yellow are related to the distinguished item classes used exclusively for agricultural purposes, while the cells in green are related to the classes associated with forest areas only. Cells in orange are related to the distinguished item classes used for agricultural and forestry use.

The research has shown that similarity terms of the percentage share of the distinguished classes of objects with regard to agricultural and forest areas in relation to all distinguished classes of objects at the first level of detail shows:

– Bulgaria (14% of classes of items related to agricultural areas and 14% of classes of items related to forest areas);
– Poland (20% of classes of items related to agricultural areas and 20% of classes of items related to forest areas).

At the second level, Austria and Poland (13% each) show the similarity in the percentage share of the distinguished classes of objects related to agricultural areas in relation to all distinguished classes of utility objects.

At the second level of detail, the similarity in terms of the percentage share of the distinguished classes of objects with regard to agricultural and forest areas in relation to all distinguished classes of objects is shown by:

– Austria (13% of feature classes related to agricultural area and 13% of feature classes related to forest areas);
– Lithuania (17% of feature classes related to agricultural land and 17% of feature classes related to forest areas).

In the remaining cases, the examined countries do not show similarity in terms of the percentage share of the number of distinguished classes of objects related to agricultural and forest areas in relation to all distinguished classes of objects.

At the third level of detail of the classification, the classes of objects related to agricultural areas registered in Lithuania, Germany and Poland do not show any similarity in the percentage share of the number of distinguished classes of objects related to agricultural areas in relation to all distinguished classes of utility objects.

4. Conclusions

The registration of agricultural and forest land use is not analysed in isolation from the specific nature of local conditions, in particular environmental and landscape conditions.

The research carried out has shown that there are no two countries that adopt an identical approach to land use registration.

First, there are differences in the way land use is registered in the way the feature classes are named. In Estonia, agricultural land is called land used for agricultural or forestry production, while in Lithuania, the class of features associated with agricultural and forest areas is called developed areas. With regard to the

remaining countries, Austria, Bulgaria, Spain, Germany, Poland, the land use names are similar.

Secondly, there are differences in the number of distinguished levels of detail of the classification related to agricultural and forest areas. Studies have shown that Bulgaria, Estonia and Spain register level 1 detail for the classification. In Austria there are two levels of detail, while in Lithuania, Germany and Poland there are three levels of detail for the land use classification.

Thirdly, of small similarity in land use can be noticed in the number of distinguished classes of objects registered at different levels of detail of land use registration between the analyzed countries. Fourthly, the research allowed to state that in seven European countries there are discrepancies in the percentage share of the distinguished classes of objects functionally related to agricultural land and forest land in relation to all distinguished classes of objects. The countries studied show very little similarity in this respect.

The study showed that in order to create a global land use registration, it would be reasonable in the first stage to standardize the land use registration in terms of the distinguished levels of detail and land use classes at individual levels of detail. The detail of land use registration would depend on the number of classifiers used.

It should be emphasized that a great deal of work has been done on a land use / land cover classification system worldwide. Currently, no standardized globally acceptable classification system is available.

The classification systems currently functioning in the studied countries are adapted to the needs of various users, regions, and data sources.

The problem presented in the article may be used to support works in the field of modernization of the method of land use registration in the real estate cadastre functioning in Poland.

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