

Analysis of the agricultural land use in Ukraine on the example of the united community

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Abstract: The purpose of this study is to analyse the use of agricultural land on the territory of united communities and their individual districts of Zhytomyr region as the smallest units of the administrative territorial division of Ukraine. The relevance of this study, due to current changes in national land relations, dictates the need to have information about agricultural lands, their owners, tenants and the lands status for planning agricultural production, the land-leases development, sale of land. The analysis of land use was carried out according to the following indicators: location of land plots of all owners within the community district and the whole community; their area; monetary evaluation; status of documents for each land plot, in particular the availability of lease, land cultivation presence. The initial data of the researches is the data of the state land cadastre database, and data of the real property rights register, both in general access and in need of special access. As a result of the research there were defined areas and location of lands of some landowners, who leased their lands and areas of lands not leased, also there were defined areas of lands, used illegally, without any documents on land use, defined areas of lands, used or owned by agricultural producers (farms, physical persons, legal entities). A cartographic core was created for the purpose of convenient planning of agricultural land use and land management within selected districts on the territory of the community.

Keywords: land planning, agricultural land, land cadastre, agricultural mapping, land organisation



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1. Introduction

The territory analysis based on cadastral data is based not only on certain figures characterizing land areas by certain indicators, but must also take into account the maintenance of the land cadastre as a whole. The information contained in the cadastre of Ukraine, as well as other countries, its visualisation, composition and completeness depend on the adopted laws in the field of land management and cadastre, the reforms undertaken and land relations in general (Jamil et al., 2013; Janečka and Souček, 2017). The land cadastre in Ukraine began its existence in 1991. The beginning of the establishment of the state cadastral system was challenging. The other countries' cadastrals were taken as an example. While in other countries cadastral systems started to use photogrammetric methods since 1960–1980 (Çete et al., 2010; Mjøs, 2020), in Ukraine only recently. A big obstacle in the establishment of a national land registry has been the total decline for almost a century. For decades, there was no land registration and no land ownership. The cadastre existed through a statistical record of agricultural land, which began with the land register of the collective farm and ended with data from the tables of the statistical state office. The introduction of the electronic cadastre started only in 2013 and it was not based on existing analogue cartographic materials as in other countries (Mika et al., 2020; Pivac et al., 2021), but only on newly created orthophotomaps. And the filling of the digital data was and is carried out by geodetic measurements of the boundaries of individual plots in current time as such work is commissioned by the plot owners. On the positive side, there are no errors and inconsistencies in the reconciliation of all analogue cartographic materials as a result of their vectorisation, and in the consideration of their relevance and correspondence to the terrain (Hudecová and Kysel', 2020; Roic et al., 2021).

Since independence and to this day, Ukraine has seen changes in land policy and land legislation. Land reform, which began back in 1990, is continuing. The reform opened up land rights to Ukrainian citizens that they had been deprived of for decades. During the first stage of the reform, the president signed a decree on land sharing. On the basis of this document, all the agricultural land was divided equally among the farmers. This involved all the land surveyors to draw up maps all over the state. This information is still up-to-date today. It is available both in hard-copy land surveying documents, and in electronic form, where the boundaries of all plots have been mapped with their coordinates. The same data is contained in the State Land Cadastre ([Public cadastral map of Ukraine, 2021](#)). Thus, during agricultural use of land in Ukraine, land management is taken into account not of separate land masses, but of land parcels given into ownership to citizens during the first stage of the land reform in Ukraine. The problem is that the boundaries of these land shares exist only on maps. A very small percentage of such land has been allocated in the territory since the beginning of the reform. For the most part, farms have been formed on these lands. As a rule, these are small plots, taking into account that the average size of a land share in Ukraine is 4 hectares. When family farms were established, it was common practice to combine the land shares of the whole family into one plot. At the same time, the size of a field could be 20–30 ha. Currently, there is no tendency of farmers or their relatives wishing to demarcate the boundaries of their land parcels and

use them for growing products. Neither do they want to sell them. Now all these plots are actually used by tenants, who sign lease agreements with the landowner. At the same time, landowners do not always know the location of their land and its quality. However, the demand for leasing land for agricultural production is high (Fedchyshyn et al., 2020). The tenants are individuals, entrepreneurs, other farms and legal entities.

Lessees also use plots that do not have lease agreements if they are found in masses amongst the formalised land, even if the landowner has not expressed a desire to enter into such an agreement. It is not the landowners who initiate the contracts, but the lessees, as a kind of mediator-brokers. They search for owners and advertise their services. Consequently, in order to draw up lease agreements and the subsequent use of agricultural land, the future lessee needs to have data on the location of the land shares, the names of their owners and the size of the plots. This is where field surveying and the formation of cadastral information on these plots come into play. In this context, to facilitate the work of the farmer, paid electronic services of interactive mapping information ([21] Vkursi Zemli, 2021) are being formed. These can contain data on land areas, field locations, field cultivation, fertilisers and other information that can be easily applied on the ground due to the available geodetic coordinates of certain areas within the fields.

Non-state (private, commercial) resources through ortho-rectified space imagery are used to analyse the existing land use in Ukraine. Consolidated or analysed data from such monitoring does not exist within the country at all, but only in the form of individual studies by foreign scientists (Stefanski et al., 2014). In Ukraine, as for example in the Baltic States, not all land is used. Part of the area can be classified as unused and bush-covered land or as unmanaged land areas, which have not been transferred to anyone, with privatised and formed land plots in between (Drebot et al., 2018). This situation in terms of the location of the plots entails a land use problem (Gaudesius, 2021).

One of the problems with the land cadastre in Ukraine is the incomplete data on land plots or its absence due to the filling in of cadastral data. Since officials of the state land cadastre for the most part enter data on plots only when requested by the plot owner. In some cases, the local authorities are the ones that order the data to be entered into the cadastre system. A similar problem of “inactive” maintenance of cadastral data is present in the cadastre of Poland (Noszczyk and Hernik, 2019).

In general, the Ukrainian land cadastre has no data on land for which ownership documents have not been issued or these documents are out of date. The state cadastre is 73% complete, 43.8 million ha (according to the State Cadastre Service). Of this total, 32.3 m ha is agricultural land (Derzhgeokadastr, 2021) There are no data on plots whose owner has not formalised or updated the documents for them. The formation of data on plots in the cadastre began in 2013. At the same time, land documentation forms have been restored and compulsory registration of land in state registers has been introduced. The data composition of the state land cadastre, although constantly updated, is not as broad as in other countries (Tekavec et al., 2018; Kondratenko et al., 2020; Krigsholm et al., 2020). Most of the information is on individual land parcels. Information on the quality and development of the community area is lacking. There is also a lack of data on the boundaries of natural sites of special value. There are also problems in updating

cadastral data, characterising the relevance of the state cadastral system. For example, the cadastral system only displays configurations of data about properties when their borders change. Change of ownership is not always displayed, or is displayed with a significant delay. The reason for this is that there are separate and unconnected registers for land and real estate (Sydor, 2020).

The important thing is that all cadastral data is adapted to a specific land plot and does not contain generalised data on the territory of, for example, the community district, much less on the territory of a community or large administrative units of Ukraine such as districts or regions. In addition, it is impossible to use cadastral data without additional special software used by land surveyors. Therefore, the creation of an algorithm for working with such data is an urgent task. The focus must be on creating cartographic products with cadastral data on plots within a wide area. This is necessary for successful planning of field boundaries and use of agricultural areas, as well as for visualization of land rights turnover among owners and tenants. The present “interactive” map of communities in Ukraine presented on the official website (Ministry of Community and Territorial Development of Ukraine, 2020), has however a limited data set and contains only raster visual images of community boundaries and their names. Consequently, it cannot be used in any way to conduct land management or organize the territory of a particular community.

Thus, the setting-up of an informative service about the lands of Ukraine, in the context of all land changes and land relations development, is an illustrative issue.

2. Data and methods

The research was carried out on the territory of Radomyshl community of Zhytomyr region. The total area of the territorial community is 855.1 km². The community has a population of 24 328. Of them 9 980 people are rural population. The community includes 42 rural settlements and one town and consists of smaller territorial units – 19 community districts. For the presentation of materials 9 community districts were selected that most represent results and characterise the state of agricultural land use typical for the whole territory of the community.

The agricultural lands territory analysis was performed with the help of GIS functions based on the data of the land cadastre and the real property rights register.

The research included the following steps:

- 1) formation of the boundaries of the territorial community and the boundaries of its districts in a vector form;
- 2) vectorization of all agricultural land plots (for agricultural commodity production, private farming, farming and reserve lands) included within the boundaries of each community district;
- 3) formation of a register of cadastral numbers for each digitised plot. This number is used as an indicator of automatic downloading of electronic data on land plots into the cartographic software environment;

- 4) obtaining data from the state land cadastre and register of rights to immovable property by means of online services for each cadastre number of a land plot;
- 5) formation of a database and design of thematic maps on its basis with distribution of land plots by tenants;
- 6) analysis of the resulting data and formation of summary tables of datasets on agricultural land within each community district.

The first phase. The boundaries of community districts and communities are derived from the electronic land surveying materials of the state geodetic base. All pivot points of the boundaries have true geodetic coordinates. These boundaries served as the basis for a cartographic core for presenting of land use within the community and are the basis for carrying out the work for each district.

The second phase. Within each community district of the community, the boundaries of each agricultural land plot were established separately. The data from the state land cadastre on individual plots within the community districts were used. The data, available in the public access and requiring special access through land surveying organisations, were used. In addition, analogue cartographic materials of division of agricultural territories into land shares, the so-called “Projects of territory organisation”, were used as initial information for the conducted research. With the help of these maps the land parcels were also found which do not exist in the land cadastre data. Consequently, the location of the individual parcels corresponds to the analogue cartographic land use planning documents and the coordinates from the state cadastre.

The third phase. The formation of the register of cadastral numbers is done automatically by software functions and access to cadastral data.

The fourth phase. The data on the existence of another right in rem through a lease is obtained from the information separated from the cadastral register – the electronic register of rights in rem to immovable property. A commercial online resource was used.

The fifth phase. The database was generated in a GIS system. The cadastral number of the plot served as the basis for the creation of semantic information. On the basis of the latter, thematic maps were generated, reflecting the transfer of land for lease, the availability of plots without lease, and representing the boundaries of missing land in the cadastre.

The sixth phase. On the basis of the formed cartographic materials and registers of data on the plots the analysis of the territory within the community districts (rayons) with the presence of prevailing lessees and establishment of their number is carried out. The land areas leased by a specific lessee have been identified. The location and area of land plots missing in the state cadastre system were also identified. Presence of illegal land use for farming has been identified. The total number of lessees within each district and the amount of land not leased by the owners has been calculated. Presence of agricultural use of land was established using Sentinel public access satellite images. Analysis of geospatial location of data, formation of database tables, mapping was carried out using the Digitals software product containing the minimum set of GIS functions and the necessary software equipment for land surveyors in Ukraine. The software product supports the conversion of files to professional GIS, which makes it possible to work with the generated materials on different geoprocessing platforms.

Thus, the method of visualisation and thematic mapping of agricultural land distributed into land parcels within the community was applied. To create thematic information about the research objects, database tables were formed with the information obtained from the above-mentioned state registers were used. Here thematic mapping reflects the distribution of land shares by tenants. The aim is to visualise field boundaries for easy exchange of leased plots between tenants and to carry out land management of fields.

All the thematic maps generated, both within the districts and throughout the community, can be used in digital form as well as can be printed out and made available to the tenant for use. In general, all monitoring data are mapped (vector and printed raster) and contained as semantic information.

3. Results

3.1. Creating a map base

Constructed map of Radomyshl municipality borders includes all community districts and settlements (Fig. 1). The map is in the Digital software environment and contains information about the boundaries and area of its objects. As the formation of the community is very recent, the existence of this map is a prerequisite for planning the use of the territory of the community and it is relevant for the self-government of the community. Besides, the location of the turning points of the boundaries of districts and community as a whole in the local coordinate system, allows GIS users to upload the state cadastre graphical raster data of individual plots of land available for public use, as well as web mapping platform Google Maps and other mapping platforms that use satellite images, which cannot be done in the state cadastre service, despite the fact that the cadastre contains coordinates of district borders. In addition, this cartographic basis is the thematic maps base to organise territories, including agricultural land. Due to the visualisation of fields and individual plots of land, the cartographic core is formed and provides a convenient management of agricultural production for farmers who lease land in different community districts within the community.

The map of the boundaries of the community and its districts served as the basis for shaping the land boundaries of individual owners and users within each district. The cadastral map was used. On the cadastral map one can only see the areas that are in the cadastre, accordingly there are no boundaries of the areas that are not in the cadastre. At the same time, there are only areas not covered by the cadastral data (Fig. 2a).

A digital platform of cartographic data was created on a set of boundaries of individual land plots by vectorising the rasters and using cadastral data on the coordinates of the pivot points of the boundaries of each land plot. As a result, the location and number of such lands have been established (Fig. 2b) and a semantic database has been created based on them.



Fig. 1. Boundaries of the Radomyshl municipality by district



Fig. 2. Comparison of existing cadastral semantic information and cartographic data:
a) fragment of a cadastral map, b) vector map fragment

3.2. Content and analysis of semantic information

A database with cadastral information has been created for each plot: cadastral number (a unique number of the plot by which all information about the plot in the cadastre is identified), name of the owner, area of the plot, monetary value, lessee, dates of registration of rights to land, name of the lessee and term of the lease agreement. As part of this semantic information, about 10 % within each district there is no data on the owner and the date of formation of land rights, because such information is not available in the cadastral database (Table 1).

Table 1. Fragment of semantic information about land plots

Fragment of the cadastral plot number	Area (ha)	Name of the landowner	Date of registration of ownership	Tenant	Date of registration of the lease agreement in the state register of immovable property	Duration of the lease agreement	Valuation of a land plot, UAH
:0365	2.11	Owner 1	12.09.2016	Private tenant	04.07.2017	03.07.2027	46345
:0088	2.63	Owner 2	21.04.2020	Privat entrepreneur "Verlotske"	21.05.2020	14.05.2027	43218
:0019	2.63	Owner 3	22.05.2017	Privat entrepreneur "Verlotske"	20.10.2017	19.10.2024	23588
:0193	2.36	Owner 4	28.02.2019	Legal entity tenant "Nyva"	02.04.2015	01.04.2020	39963
:0026	2.63	Owner 5	14.03.2014	Legal entity tenant "Ahroviva"	28.03.2019	27.03.2026	44532
...

Analysis of the lease term data for each land plot showed that most owners have leased their land for 7–10 years. This lease expires depending on the date of the agreement in 2022–2028. However, there are cases of transfer of land plot for a longer term, in particular, 9 owners leased their land plot for 20 years, 2 owners – for 50 years and one owner leased his land plot of 4.2 ha for 100 years to Radomyshlskoe Co. Ltd. (Fig. 3).



Fig. 3. Duration of leases within the Verlotskyi district

Analysis of the data confirmed that all owners' plots are included in the cadastre database. The total area of territories missing from the state land cadastre database is more than 200 ha in certain districts of the community. According to the new Ukrainian legislation, these lands will become community property in 2025. Therefore the land cadastre base is now being actively filled with information about these lands. And the work done in the studies presented contributes to this process.

The mapping has shown that even those land plots that are not registered in the cadastral database are in use, and therefore no lease agreements have been drawn up for them. At the same time, there is also unused neglected agricultural land. The actual ploughing in many districts is less than the real possible ploughing, which we get if we add the area of registered and unregistered plots. At the same time, the worst plots are abandoned and not cultivated, long unused and in some places overgrown with shrubs or even woody vegetation. No cultivation is carried out even though these plots are leased out to agricultural enterprises, a situation which has been aggravated by the difficult economic situation in the country over the years. There is now a gradual renewal of agricultural production, even on fields with poor soils, as well as their uprooting.

The process also takes into account the existence of stock lands. Stock lands are the property of the community. The community can also lease them out to farmers or to individual citizens for horticulture. The area of stock land varies from district to district. There is a smaller area of stock land in those districts where more of it has been transferred to individual citizens (Table 2).

Table 2. Agricultural development of the individual community districts

District	District area (ha)	Agricultural land area according to the state cadastre (ha)	Number of land parcels in the cadastre (pcs.)	Actual area of arable land use (ha)	Actual ploughed area (%)	Stock lands (ha)	Agricultural areas missing from the cadastre (ha)
Borshchivskiyi	3359	2153	703	2249	100	99	96
Verlotskiy	2042	535	376	708	95	164	211
Zabolotskiy	2493	1480	490	1605	100	120	125
Kotivskiy	2436	1462	507	1566	100	35	104
Lutivskiy	3118	1019	910	734	70	174	30
Menkivskiy	4499	1765	1166	1481	80	36	87
Osyckivskiy	3564	1972	1473	1822	90	–	53
Pylypovychskiy	3755	2090	550	2131	100	294	41
Mirchanskiy	4054	2227	470	1879	82	39	65

The analysis of semantic information also found that the value of 1 hectare of land within the community ranges from about 8 000 UAH or about 270 EUR to 16 000 UAH (500 EUR). (500 EUR). The highest value hardly reaches 1 000 EUR per hectare. Monetary value of a separate land plot affects the land tax calculated as 1% of the monetary value of the land plot and is also taken as a minimum value of the land plot upon its purchase. The existence of a monetary value of a land plot is a prerequisite

for concluding a lease agreement for a land plot. Because the rent is calculated as a percentage of the value of the plot. The highest such percentage in the territory is 12% per year for the lease of the plot. The valuation data are contained in the database created and form a separate thematic layer of land valuation on the map created (Table 3).

Table 3. Plot value by district

District	Average size of an individual owner's plot (ha)	Average monetary value of the plot		Lowest cost per hectare in the district		Highest cost per hectare in the district	
		UAH	EUR	UAH	EUR	UAH	EUR
Borshchivskiyi	3,1	15841	519	6020	197	24965	818
Verlotskiyi	2,7	–*	–	–	–	–	–
Zabolotskiyi	3,0	16674	546	3680	121	25084	822
Kotivskiyi	2,8	14539	476	6529	214	29004	951
Lutivskiyi	1,1	–	–	–	–	–	–
Menkivskiyi	1,5	9545	313	95	3	21830	715
Osyckivskiyi	1,7	8104	266	1394	46	25084	822
Pylypovychskiyi	3,8	–	–	–	–	–	–
Mirchanskiyi	1,5	10095	331	1301	43	23543	772

*no baseline data available

3.3. Thematic mapping

The resulting database and map base can be used to visualise the above information both within the community and within individual districts. The visualisation of land leases is most interesting. Without such a map, it is not possible to plan fields and carry out land exchanges, nor is it possible to look for land without a lease, given that its boundaries are not marked in any way on the ground. This mapping material is also needed, as the fields cultivated by tenants include several dozen plots of individual owners.

A characteristic feature of all community districts is the “checkerboard” arrangement (Fig. 4) within the same field, not only of the plots of individual owners, but also of the plots of different tenants. Only on rare occasions does a tenant have a priority right to use plots in the same area. This forces tenants to swap or sublet such plots. The total number of tenants varies from district to district. There are districts with more than 10 tenants. And they have different areas in use: from one hectare to hundreds of hectares. Individuals, private enterprises, farms, legal entities lease land in the same district. For example, there is one tenant within the Borshchevkiyi community district, it is a private enterprise “Chaikivka”. Within Verlotskiyi district there are 3 citizens, 1 farm, 1 private enterprise, 3 limited liability companies; within Zabolotskiyi community district there are 4 citizens and 3 legal entities. The same data was received for the whole community. Within each district, the majority of land plots are given for use to legal entities, rarely there are relatively small areas of farms and individual citizens (Fig. 5).

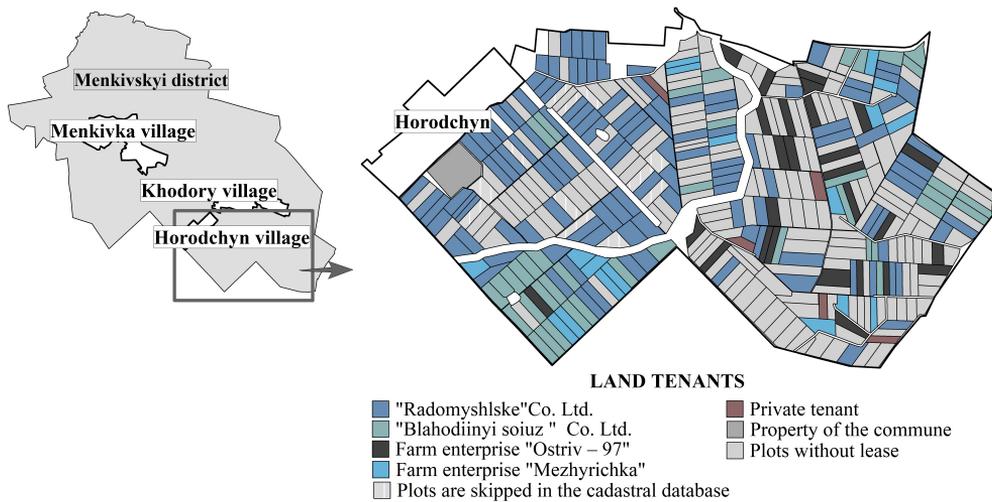


Fig. 4. Fragment of the thematic map (area distribution by tenants)

As a rule, within each district there is one predominant lessee with up to 70% of the land bank in use. Except for the Borschivskiyi district, where only one lessee leases land and has 83% of the arable land in legal use, but actually uses a larger area because there are areas within his fields for which no lease rights have been issued due to various circumstances. In addition, the land area used by individuals and farmers is very small. Apparently, economic entities such as limited liability companies, so-called legal entities, predominate. Their land bank is many times larger than that used by individual citizens and family-type farms (Table 4, Fig. 6).

Table 4. Land bank of predominant tenants within the Radomyshl community

District	Predominant tenant	Area under lease (ha)	% of total agricultural land area	Area under lease by the predominant tenant	Total number of tenants within the district	Area without lease (ha)
Borschivskiyi	Private enterprise "Chaikivka"	1791	83	1791	1	262
Verlotskiyi	Private enterprise "Verlotske"	434	81	304	8	171
Zabolotskiyi	"Radomyshlske" Co. Ltd.	1066	72	701	7	291
Kotivskiyi	"Agroviva" Co. Ltd.	1073	73	917	2	389
Lutivskiyi	"Radomyshlske" Co. Ltd.	564	55	477	4	454
Menkivskiyi	"Radomyshlske" Co. Ltd.	930	52	650	6	49
Osyckivskiyi	Joint limited liability company "Osyckiy"	965	48	965	2	1003
Pylypovychskiyi	"Radomyshlske" Co. Ltd.	1915	91	1022	3	204
Mirchanskiyi	Farm enterprise "Mezhyrichka"	1450	65	1020	7	733

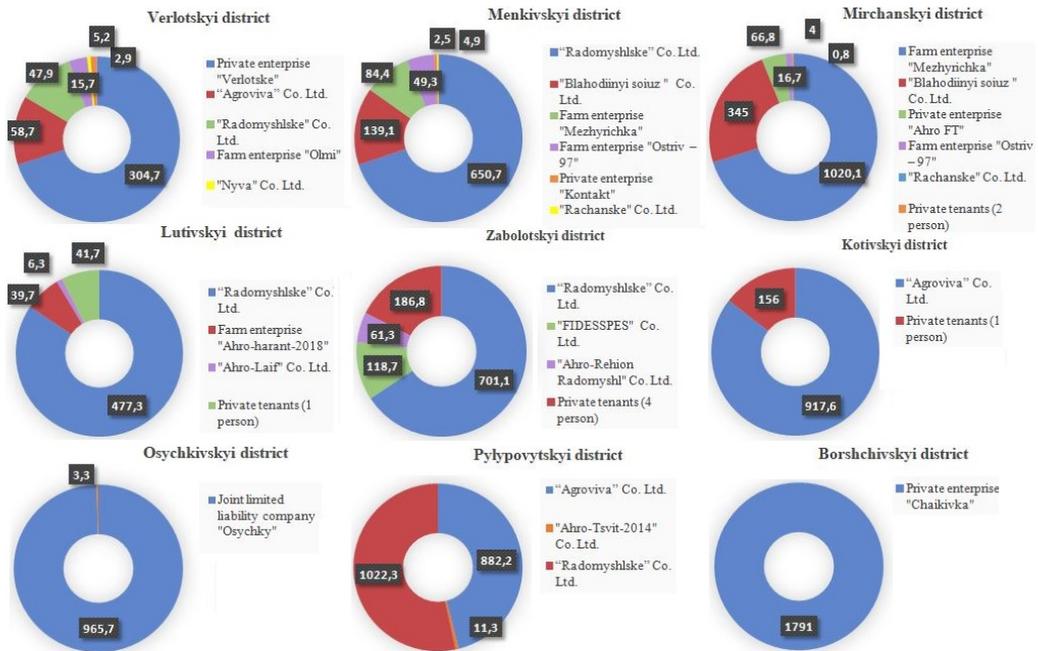


Fig. 5. Distribution of the districts by agricultural land tenants

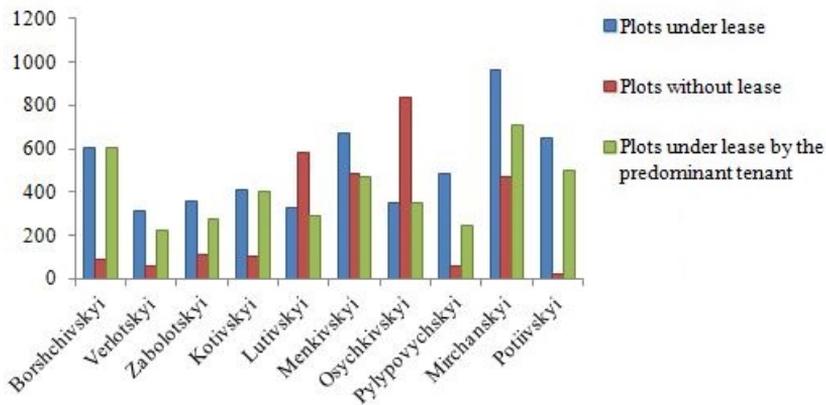


Fig. 6. Monitoring of the number of land plots within the Radomyshl municipality districts

Considering the revival of land lease turnover between different lessees, the beginning of agricultural land use recovery that is taking place in some areas of the community, it should be taken into account that this land distribution is not permanent. The data are constantly updated: the areas without leases are decreasing, landowners change, and tenants change at the expiry of the land lease. In some tarostynskiy districts, there is a noticeable reduction in the amount of stock lands transferred to citizens' ownership or use by citizens, farms or legal entities.

4. Conclusions

The practical value of performed research has been confirmed under constant changes in land legislation, land relations in Ukraine and the strengthening of the agricultural land lease movement. The data of the conducted analysis of land use on the basis of the formed semantic information shows a large number of people willing to lease land plots and to cultivate them. There are up to 15 different lessees within individual districts. There are often several different tenants renting land within the same field. The visualisation of the boundaries of the individual landlords' plots is necessary for the convenience of drawing up lease agreements. When purchasing a plot of land, the use of the proposed map base is a handy tool. After all, the data obtained not only represents the location of each plot, but also all rights to it. In general, there are between 300 and 800 owners within each district of the community. However, among the landowners there are none who cultivate their plots, they are all rented out. There are a small number of tenants in the districts of the community. Among them there are very few farms and individuals. Legal entities prevail. Some of them have significant areas under lease (about 2 000 ha) and lease land plots in several districts of the community.

The analysis of the area has made it possible to visualise the location of the individual landowners' plots and their limits. Such data are necessary for a lessee to see the boundaries of his fields, which consist of the leased plots of individual owners. After all, the boundaries of one field include between 20 and 50 plots of land of different owners. In addition, the potential lessee, using the data from the conducted territory analysis, can see the names of the owners and offer them to sign a lease agreement. A lessee can also use the monitoring data to identify plots within his field that are leased by another lessee and negotiate the exchange of plots or the transfer of lease rights to sublease. Data on plots that have not yet been leased are also valuable. Which is interesting enough for those who are planning to expand their fields, or even explore land in other districts in the community. And when creating the same map for other areas it's possible to be done for other communities.

The approaches developed for development of the data obtained do not require much cost to collect important information about the land within a sufficiently large area. It is possible to work with the data both in the GIS software environment and using printed cartographic thematic materials regarding land owners or tenants. In addition, the approach used to generate data on land within the whole district can be applied to any territory of Ukraine without going to the field.

Commercial significance. The customers of such an area analysis are potential tenants, including international, and local governments. Lessees are offered a visualisation of their fields and a database of land owners. The local authorities of the communities need information on the location of state owned land, which under the new legislation is being transferred to communal ownership of the communities. Also the results serve as the basis for community land inventory and organization of their territories. At the same time, it is important to identify areas that do not exist in the state cadastre base. Since such land plots are transferred into community ownership in the absence of an owner and are potential for leasing them out to farmers.

Thus, the performed analysis was is the basis for making decisions about the agricultural land use of the community. The proposed data visualization provides the opportunity to present existing cadastral data as well as data not available in the cadastre, which allows grouping and analysing land information according to the purpose of land use and illustrating the state of land use.

Author contributions

Conceptualization: O.D. and O.Z.; Methodology development: O.D., O.Z., V.H. and N.S.; Writing – original draft: O.D. and O.Z.; Writing – review and editing: H.K., V.H. and N.S.

Data availability statement

The raw/processed data required to reproduce these findings cannot be shared at this time as the data also forms part of an ongoing study and also because part of the initial data was obtained from state-owned specialized and paid commercial services, which is generally not widely available.

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