UDC 332.36

DRAINED LANDS STRUCTURE OF VOLYN REGION AS ECOLOGICAL AND ECONOMIC FACTOR : PRACTICAL ASPECT

Lishchuk N.M., *PhD student**
National University of Life and Environmental Sciences of Ukraine

Land-use structure comparative analysis of Volyn region drained lands was done with the help of satellite imagery data and national land cadaster database. Ecological stability and economic productivity of ameliorative complex were estimated. Crop structure and its impact on agricultural production of the region were analyzed.
Keywords: *Land-use structure, drained lands, remote sensing (RS), ecological stability index, ameliorative land fund.*

Problem formulation

Efficient land-use is one of the most urgent tasks of land management. Ameliorative land exploitation intensity has become lower for the last decades. Drained lands condition has become worse. We can observe violation of agricultural work technologies. As a result, there is production decrease on reclaimed lands. Serious anxiety is caused by irrational and misuse of reclaimed lands, those which have big drained plots [1]. That is why search of the ways for rational land-use and land protection should become as priority direction of economic and ecological policy [2].

An important factor that affects ecological conditions and economic effectiveness of drained land-use is their structure. Ameliorative land fund structure optimization is a balance between biotic (agricultural lands, forests, water bodies) and abiotic elements (ameliorative infrastructure, urban territories). It is key factor for sustainability of natural and manmade system [3].

Previous research and publications analysis

Existing drained land structure effectiveness usually evaluate with help of variety of indexes. In particular , V. Zharinov and S. Dovgan consider evaluation should reflect natural and technical importance of drained lands and should be based on fertility and economic potential [4]. V. Dobrynin take land-use structure as an effective management factor [5].

F. Zuzuk, L. Koloshko, Z. Karpiuk research present land condition, waterlogged level and geographic specifics of Volyn region drained lands [6]. They had made analysis of the separate drainage systems land-use structure. That is why there is a need for complex analysis of land-use structure.

Aim of the research – structure, ecological stability and productivity of Volyn region drained lands analysis with the help of RS data that gives actual information and its comparison with state land cadaster data which has official information about land-use.

Results of the research

There were found differences between official resources data and scientific researches after unification and systematization information about natural and managerial conditions that gives possibility to assess changes in environment [6, 7]. That is why there is the need for fair estimation of real land management changes in Volyn region. Land use parameters identification is possible with the help of remote sensing data. Methodology includes three steps:

1) Volyn region reclaimed lands scanned maps of scale 1:200 000 linking to topographic maps of scale 1:100 000 and digitizing drainage systems boundaries;

2) geometric and radiometric correction of multispectral satellite image Landsat-5 TM (07.06.2010 p.). Two images cover the territory of the research. The choice of Landsat-5 TM is stipulated by accessibility in wide time frame.

3) Unsupervised classification of land classes on the image.

We have picked out 4 main land classes during the research. They are presented more widely on satellite images: forests and perennial plants water bodies, arable lands, hayfields and pastures. The structure does not include urban area of rural sides, because their part is very small and one pixel can include agricultural land and household. This territories are classified as agricultural lands on satellite image Landsat-5 TM (30 m resolution).

Then we perform unsupervised classifications of the multispectral image (green, red, near and middle infrared bands) using the ISODATA algorithm (ERDAS Imagine™ software). The method takes into account spectral distances changes, requires interpretation of the results after classification, eliminates uncertainty that brings investigator to the supervised classification [8]. The number of clusters to be discriminated is initiated by the user and set to 15. After the classification process, 15 clusters are grouped by photo-interpretation from Google Earth into more general classes, and are labeled.

400 random points were selected with the help of ArcGIS Create Random Points tool for the classification accuracy assessment of drained lands. Accuracy assessment consists in calculation of correctly defined points and their real amount inside each class (producer's accuracy) and obtained during recognition (user's accuracy) (table. 1). Statistically accuracy was checked with the help of error matrix [9]. Then we verify real land conditions data and classification data.

ISODATA algorithm is the most accurate for water bodies, forests and perennials detecting. The most difficult is to differentiate hayfields and pastures. Their spectral characteristics often close to some types of crops. User's accuracy indicates the amount of points on the image that corresponds to the real conditions on location. It is 65,5% for hayfields and pastures, 92% for arable lands. Mean accuracy of the land classification is 88,35%.

Figure 1 shows the part of Volyn region land-use structure map that is a result of satellite image interpretation**.**

1. Classification accuracy using satellite image Landsat-5 TM

Class title	Amount of control points		correctly delineated	Accuracy, %	
	Base points	according to delineation		producer's accuracy	user's accu-racy
1. Arable land	185	171	157	84,9	91,8
2. Hayfield and pasture	100	119	78	78	65,5
3. Forest and perennial plants	107	102	98	91,6	96,1
4. Water bodies	8	8	8	100	100

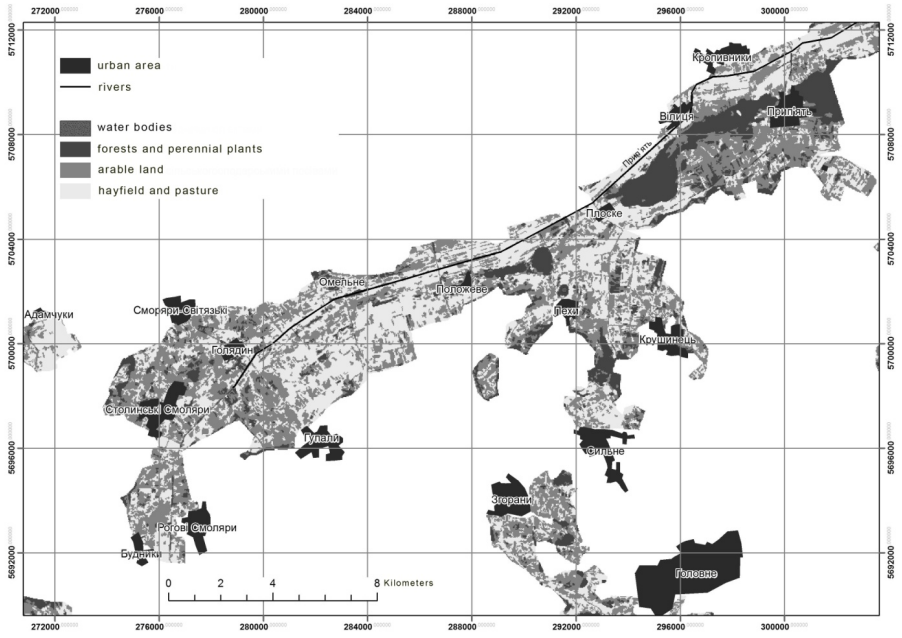

Fig. 1. Part of Volyn region land-use structure map with urban overlay

The land-use structure of drained lands was analyzed by spatial characteristics of fragments shape and composition and is shown in table 2. The structure is characterized by next indexes: Land area, ha (AREA); percentage of percentage of land occupied by class, % (PLAND); Largest Patch Index, % (LPI); total length of edge involving class type, m (TE); edge density, m/ha (ED).

Free software Fragstats v4 was used for calculating indexes from the classified raster received on the previous stage.

Largest patch index (LPI) equals the area (m2) of the largest class patch of the corresponding patch type divided by total drained lands area (m^2), multiplied by 100 (to convert to a percentage). It ranges from 0 to 100%. If the largest land patch is relatively small

then LPI is almost 0. If the class has only 1 patch than LPI becomes 100. Analysis shows that the largest patch has 4,01% from the total forest class area, 1,01% from arable lands covered by crops. Hayfields and pastures have the largest patch 0,54% of total class area. Water bodies covers relatively small plots (up to 0,03%). They are lakes and ponds.

2. Volyn region drained land structure (based on RS data)

Land class title	Index				
	AREA	PLAND	LPI	TE	ED
Forests and perennial plants	116855,91	28,0	4,01	20124270	48,25
Arable land	201171,24	48,2	1,01	45249270	108,5
Hayfield and pasture	97476,39	23,4	0,54	28814880	69,09
Water bodies	1552,05	0,4	0,03	283440	0,68

Total edge perimeter (TE) equals the sum of the lengths (m) of all edge segments in the drained lands landscape. If a landscape border is present, than it should be included into perimeter. It is mainly calculated for ED index, or as comparative criteria for the same territory on time span.

ED is calculated as the ratio of patch boundaries perimeter (TE) to the area of the drained land class. The index (ED $\geq$ 0) characterizes the fragments length per unit area. It is used to compare drained landscapes, in our case, land plots of various sizes and use purposes. Particular attention should be paid to the index within agricultural land, where the size and configuration of the field affects the efficiency of cultivation. Average boundary density index of fragments is 108,5 m/ha for reclaimed arable land of Volyn. The index is 69,09 m/ha for pastures and hayfields. This confirms the fact that pastures and grasslands cover large territory and have a uniform structure.

Structure analysis of reclaimed land shows that the largest share have agricultural lands (71,6%). Forests and perennial plants occupy 28 % of the territory. Gardens and shrubs are also included in this category. According to official cadaster of 2010 agricultural land covers 83,3 % of the total area, 14.1 % - perennial plants, forests and wooded areas. This gives us the background to assume that part of the reclaimed land in economic reality is not used, overgrown with shrubs, reforestated, but official is considered to be agricultural. In terms of the spectral characteristics this land may belong to both pasture and perennial crops.

Division of land in Ukraine leads to excessive land parceling and creating very small land plots. The large number of small plots causes cost of cultivation growth. Difficulties with the implementation of land assessment measures of degradation processes, increases in the area of transport infrastructure (roads, passage) arise from parceling. It affects the physical properties of the soil (e.g. compaction) and further impairs its suitability for cultivation. Small land plots cannot be used in big scale agricultural production.

It is important to know not only land structure, but also characteristics of each element, considering the stability of natural and economic system of Volyn region reclaimed lands. Land structure by administrative division according to the cadastral data is pre-

sented in table 3. Ecological stability index of the territory and analysis of the land structure was done according to it.

3. Structure of Volyn region reclamation land fund*

Administrative district	Area, thou. ha	Structure, %					
		Urban area, roads	Arrable land	Perennial plants	Hayfields	Pastures	Forest
Volodymyr-Volyns'kyy	22,76	0	40,6	0,1	32,2	13,5	13,5
Horokhivs'kyy	3,35	1,0	10,6	0	71,8	16,4	0,2
Ivanychivs'kyy	6,34	2,8	50,9	0	27,1	19,1	0,0
Kamin'-Kashyrs'kyy	37,04	0,8	43,1	0	23,8	23,5	8,7
Kivertsivs'kyy	26,82	0,5	37,4	0,1	23,4	17,8	20,9
Kovel's'kyy	46,88	0,2	36,6	0,1	23,6	33,3	6,1
Lokachyns'kyy	4,01	0	25,0	0	18,5	51,1	5,3
Luts'kyy	4,55	0	51,0	0	30,2	18,6	0,1
Lyubeshivs'kyy	23,93	0	33,1	0	34,7	30,7	1,6
Lyuboml's'kyy	36,51	0,1	33,3	0,1	18,8	24,7	23,1
Manevyts'kyy	42,95	0,2	30,2	0	16,6	15,1	37,9
Ratnivs'kyy	49,30	0	39,4	0	19,3	20,9	20,4
Rozhyshchen-s'kyy	29,36	0	49,1	0	22,6	25,4	2,9
Starovyzhiv-s'kyy	27,01	0,6	41,6	0	29,7	25,1	3,1
Turiys'kyy	29,92	0	39,6	0	24,3	31,6	4,4
Shats'kyy	16,58	0	20,9	0	21,6	17,5	40,0

*Source: Volyn regional water resources administration data

Natural and economic system is a complex set of interrelated components from environmental point of vie., So, it is important to assess their resistance to anthropogenic influences. Resistance to the human impacts of reclamation land was estimated by the ecological stability index (K_c):

$$K_c = \frac{\sum_1^n S \cdot k_1 \cdot k_2}{\omega},$$

where: S – area of land class, ha; k_1 – land ecological stability coefficient (urban area - 0, arable land – 0,14, perennial plantations – 0,43, hayfield – 0,62, pastures – 0,68 , forests – 1); k_2 – geological and morphological stability of a relief coefficient (for Volyn – 0,7); ω – total reclaimed land area. [1]

The evaluation of environmental sustainability index is shown on figure 2. Ecological stability assessment is based on the following scale: K_c<0,33 – unstable land, 0,34<K_c<0,50 – land use is insufficiently stabile, 0,51<K_c<0,66 – moderate stability, K_c >0,66 land-use is stable.

Land type distribution in the region is not balanced (Fig. 2). Optimization of reclaimed land requires ecological stability consideration and negative impact of agricultural practices on biodiversity reduction. Arable land, hayfield and pastures are dominated in

the structure. If to take into account the natural environment and economic value arable land should be reduced by 18% to improve environmental sustainability. Ecological stability index should be at least 0,51.

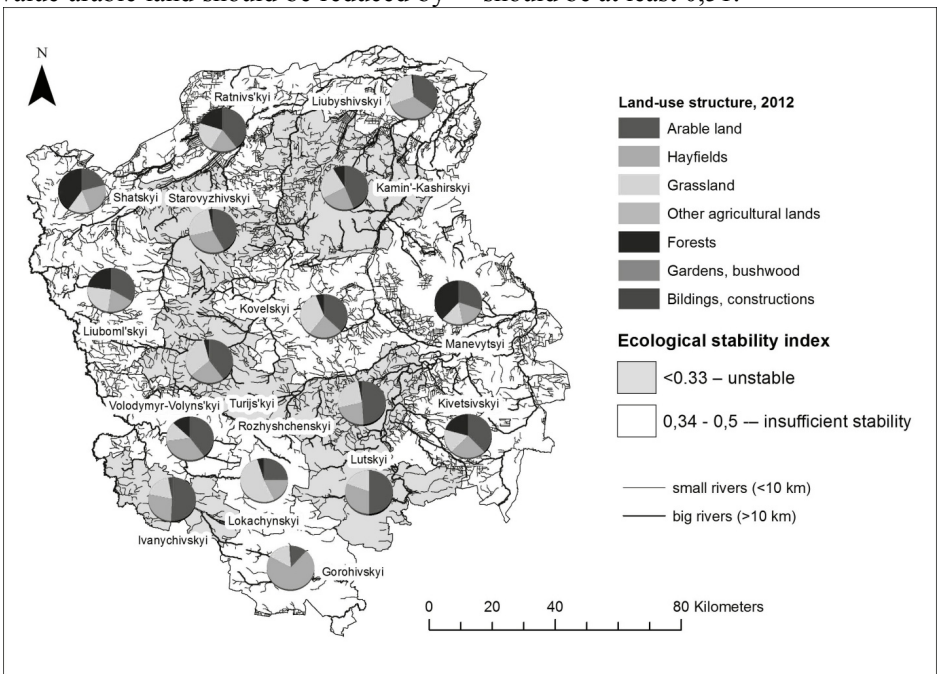

Fig. 2. Reclamation land-use structure and ecological stability index of Volyn region

Multifunctionality of land resources involves, on the one hand, use efficiency increasing, and on the other – execution of environmental ecological functions. Strengthening of the last mentioned, is essential for modern society. The results of the research show that Volyn region drained lands are ecologically unsustainable and unstable, because their structure has high proportion of arable land.

The financial situation of the farmers leads to the degradation of interfarm drainage systems. The other negative consequences are pesticide contamination, waterlogging and flooding of the reclaimed areas. Degradation processes are developed on drained lands. As a result, all this factors lid to decrease of land productivity, gross harvest reducing of crops. Over the past 20 years, the area under crops decreases by 40 thousand hectares per year (Figure 3.), which is 11,5 %. The largest decline occurred in 2009 (25,6 %). The main reasons for such dynamics are economic crisis, withdrawal of land from agricultural production, avoiding of degrading land usage.

When analysing structure (fig. 3, a) of agricultural crops that are grown on the drained lands in Volyn' region, we can see that around 50% of them were cereals (winter rye, wheat, barley, oats). The second place took industrial crops (oil radish, winter rape, sugar beet). Its production decreased significantly during crisis and did not recover until now. The same tendency is noticed for potatoes and vegetables.

Volyn region has never been main producer of those cultures. Usually, these crops are grown for self-consumption by local population. The fifth place took forage crops (maize, fodder beet, clover) – 3-4% of total production. Peat soils could function without use of nitrogen fertilizers with proper crop rotation. That is because mobile nitrogen compounds are formed by mineralization of organic peat matter. We can observe reduction of total area for crop production until 2009 (fig. 3, b). Agricultural sphere also started development after economy retrieval until 2012.

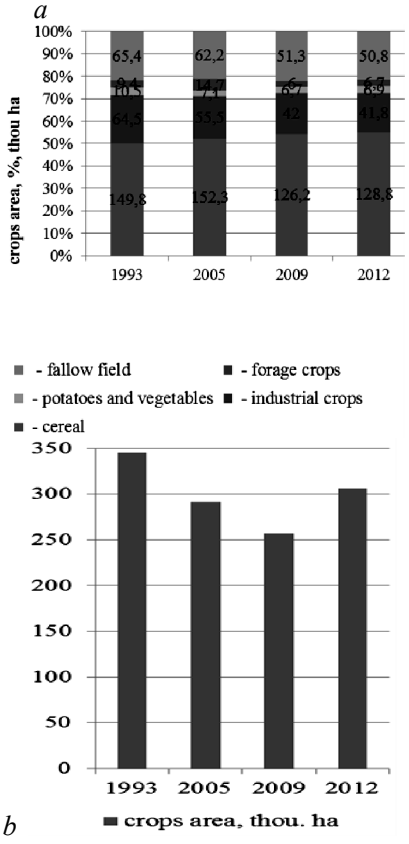

Fig. 3. Distribution of crops used in agricultural production (a) – structure, (b) – available amount)

Conclusions

Land structure analysis of Volyn region reclamation fund confirms the need to find ways for land-use structure optimization and evaluation adequate methods.

It is necessary to increase the amount of land that is environmentally stable (forests, pastures) and reduce the share of environmentally unstable degraded lands to improve resistance of reclaimed land to anthropogenic impact.

The real land-use structure of Volyn region drained lands obtained from satellite imagery indicates discrepancy with state land cadastre data. Part of the agricultural land is not used according to its intended purpose, consequently overgrown with shrubs and forests.

Reference

1. *Айдаров И. П.* Перспективы развития комплексных мелиораций в Росии. / И. П. Айдаров, А. И. Корольков. – М: Агропромиздат, 2003. – 104 с.
2. *Хвесик М. А.* Інституціональне забезпечення землекористування: теорія і практика : Монографія. / М. А. Хвесик, В. А. Голян – К. : Книжкове вид-во НАУ, 2006. – 260 с.
3. *Мошинський В. С.* Методи управління продуктивністю та екологічною стійкістю осушуваних земель : [Монографія]. / В. С. Мошинський – Рівне : НУВГП, 2005. – 250 с.
4. *Жарінов В. І.* Агроекологія : термінологічний та довідковий матеріал. [Навчальний посібник]. / В. І. Жарінов, С. В. Довгань – Вінниця : Нова книга, 2008. – 328 с.
5. *Добрынин В. А.* Актуальные проблемы экономики агропромышленного комплекса. [Учебное пособие] / В. А. Доб-

рынин. – М. : Изд-во МСХА, 2001. – 162 с.
6. *Зузук Ф. В.* Осушені землі Волинської області та їх охорона : монографія / Ф. В. Зузук, Л. К. Колошко, З. К. Карпюк. – Луцьк : ВНУ ім. Лесі Українки, 2012. – 294 с.
7. *Природа Волинської області* / Під ред. К. І. Геренчука – Львів : Вища школа, 1975. – 147 с.
8. *Мышляков С. Г.* Картографирование почвенного покрова по данным многозональной космической съемки / С. Г. Мышляков // Земля Беларуси. – 2006. – № 3. – С. 15–21.
9. *Congalton R.* Assessing the Accuracy of Remotely Sensed Data: Principles and practices / R. Congalton, K. Green. – NY, 2008. – 183 p.

** * **

Проведен сравнительный анализ структуры земель мелиоративного фонда Волынской области по данным спутниковых снимков и материалам государственного земельного кадастра. Определена экологическая стабильность и экономическая продуктивность мелиоративно-хозяйственного комплекса. Проанализирована структура посевов мелиорированных земель в сельскохозяйственном производстве.

Ключевые слова: *структура мелиорированных земель, дистанционное зондирование Земли, коэффициент экологической стабильности территории, земли мелиоративного фонда.*

** * **

Проведений порівняльний аналіз структури земель меліоративного фонду Волинської області за даними супутникових знімків та матеріалами державного земельного кадастру. Оцінена екологічна стабільність та визначена економічна продуктивність меліоративно-господарського комплексу. Проаналізована структура посівів на меліорованих землях у сільськогосподарському виробництві області.

Ключові слова: *структура меліорованих земель, дистанційне зондування землі, коефіцієнт екологічної стабільності території, землі меліоративного фонду.*