ECONOMIC ASPECTS OF SPACE INFORMATION TECHNOLOGIES FOR THE RATIONAL USE OF LAND RESOURCES

Экономические аспекты космических информационных технологий для рационального использования земельных ресурсов

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Abstract: *The use of space information technologies (GIS) will optimize production through sustainable use of natural (land) resources, environmental protection and control of agricultural operations. Space information technologies are the basis for resource saving and ecological organic agriculture. The necessity of environmental monitoring to improve agricultural production using space information technologies of agricultural lands is defined. The values of GIS implementation are calculated. The main advantages provided by them are determined.*

KEYWORDS*: SPACE INFORMATION TECHNOLOGIES, LAND RESOURCES, ELECTRONIC AGROTECHNOLOGICAL MAPS, AEROSPACE PHOTOS, SPACE LAND MONITORING.*

1. Introduction

The transition of world agriculture on an intensive path of development requires that farmers increase the effectiveness while decreasing the cost of production. At present, the only way to control the profitability of agricultural production is the introduction of new technologies that allow maximizing the use of available resources. Among these technologies should be allocated space information technology to improve the efficiency of land use.

The main purpose of land use is ensuring the effective and rational use of lands of the society through regulation of land relations and the application of methods of organization and use of land resources. This commits the government to sustainable development of land use on the modern level with the use of achievements of world science and the latest technology in land management.

Particular urgency of these issues in terms of market transformation, when legislatively fixed different forms of land ownership. For many decades land use in the Ukraine was economically unnatural, sometimes destructive. For exterior lighting this problem, the knowledge of the laws and features of development of land use appropriate to note that absolute state ownership of land resulted in the delimitation of the environmental priorities in land use. It has become obvious that the methods of land management those have developed in the conditions of domination of state ownership of land and are still used to this day, do not meet modern requirements of market economy, do not meet the needs of economic entities on earth.

The efficiency of agricultural enterprises depends on awareness of the condition of crops and the ability to control the effects of operations and activities [1, p. 181]. The use of information technologies will enable the optimization of production through rational use of natural resources, protection of environment and control of agricultural operations. Space and information technologies are the basis of resource-saving and ecological organic agriculture.

Modern information technologies in agricultural production is not only the monitoring of natural and resource potential with a view to its rational use, but also timely adjustment of farming systems using technologies of precision farming. Based on information about the heterogeneity of physical and chemical indicators of soil nutrient content within a field, status, development and yield of crops. The use of such technology allows providing efficiency of the agricultural sector through increasing the economic impact from business activities and through the optimization of anthropogenic load on the natural environment.

2. Retrospective application of remote sensing technology to agricultural land

Information technology sensing of agricultural land started to be applied in the 30-ies of XX century in the United States, when planes were photographing fields to determine the exact acreage of crops and the monitoring of the quality of the soil cover [2, p. 55]. In the 60-ies of the last century began a new stage of development of these technologies, which created the preconditions for the progressive development of space technologies, which is still going on [3]. Since 1978 year, in the United States launched a program space removal – a Foreign Agricultural Service (FAS), whose task is monitoring and forecasting the gross yield of agricultural crops [5, p. 6].

In Europe in 1988, the EU Council of Ministers adopted a 10-year program using data of remote sensing for improving the statistical accounting in agriculture. Now this program acts as the project Monitoring Agriculture by Remote Sensing (MARS). It allows you to determine the area and condition of crops, to predict the yield of different crops within individual countries, administrative territories and farms [6].

In recent time, space and information technologies are increasingly used in the practice of management of the post-Soviet countries. In Kazakhstan the project "the national system of space monitoring of agriculture", which is based on European technology of state monitoring of agricultural production. In Russia, the popularity of satellite monitoring system to obtain timely information on crop areas, control over the timely conduct of agricultural activities, forecasting of losses and productivity.

3. Information technology sensing of agricultural land in Ukraine

In Ukraine, the research of remote monitoring of agrarian resources started since 1980. In the system of the Ministry of agriculture of the former USSR were established all-Union scientific-research center "agricultural resources" and the corresponding branch of the Institute in Ukraine [8].

Institute of Agroecology and environmental management NAAS and SE "Dniprokosmos" State space Agency of Ukraine (SSAU) developed the Concept of scientific-technical program "Monitoring agricultural resources and forecasting their status using remote sensing data" (Agrokomos) and created a lot of scientific-methodical and normative documents for the creation and dissemination of space information technology in the production practice, the domestic agricultural industry. With the support of the

Ministry of agrarian policy and food of Ukraine, State space Agency of Ukraine, institutions of NAS of Ukraine and company RapidEye AG implemented the pilot project "Monitoring agricultural resources using data from the RapidEye satellite system" (AGRO-UA) [8].

NSC "Institute for soil science and Agrochemistry im. A. N. Sokolovskiy", Kharkiv national agrarian University and National University of life and environmental Sciences of Ukraine started monitoring various characteristics of soil, erosion, degradation and methodology of soil survey using remote sensing and practical application of materials in economic activities.

Ukrainian scientific-research Institute of forecasting and testing techniques and technology. L. Pogorely is implementing a project on introduction of the European system of forecasting of productivity of MARS/CGMS developed by the joint research centre of the European Commission.

However, despite the significant volume of scientific studies, their findings remain fragmented, uncoordinated and not brought to the technological system used in industrial activities. According to the materials of the meeting of the Interdepartmental scientific Council of NAS of Ukraine and NAAS on the use of technology ERS APK (01.03.2011), Ukraine still has not developed a unified state system of remote (space) monitoring of agro-resources and information support of management in the agricultural sector [8].

At present, the use of information technologies for monitoring agricultural land in Ukraine is insufficient, although the legal basis of land monitoring provided for by article 191 of the Land code of Ukraine. Monitoring of land vested in the Central Executive body's national, regional and local level, carrying out state policy in the sphere of land relations and environmental protection [4].

In Ukraine adopted a Concept of implement the state policy in the field of space activities for the period up to 2032, in which developed the nation-wide target scientific and technical space program for 2013-2017, the goal of which is to improve the efficiency of use of space potential for solving urgent tasks of socio-economic, environmental, cultural, informational and scientific and educational development of society, ensuring national security and defense, protection of geopolitical interests of the state [7]. However, in this program little attention is paid to technologies of sensing of land for agricultural purposes.

4. Space technology to monitor the status of agricultural lands

The use of space technologies for monitoring agricultural land has a number of advantages, in particular, they provide:

- high accuracy and actuality of data;
- a wide range of the study area;
- a high frequency of new information;
- the possibility of collecting, storage, generalization and standardization of information [9, p.18].

The main sources of information used to monitor the status of agricultural land are aerospace imagery, topographic maps and agrotechnological e-cards.

Satellite images provide information about the change in the optical properties of the surface soils and are characterized by high data visualization. With their help it is possible to draw some conclusions about the nutrient content of the soil, to determine the sensitivity of crops to moisture of soil, the quality of crops within a single field that can be used as inputs to predict their yields.

Regarding space surveys, the main parameters determining the quality of the results of sensing are: the resolution and frequency of removal, spectral resolution and bandwidth scanning [9]. In addition to the space images for monitoring of land use topographic maps, charts, land maps and data agrochemical certification of fields, schema, sequence rotation, a cartogram of agricultural industrial groups of soils, which allow to achieve high accuracy and reliability of the results [10, p.5].

Today the most famous space providers of information technologies are the follows foreign companies: Cropio (USA / Germany), eLeaf (Netherlands), Precision Agriculture (Australia), Astrium-Geo (France), Vega (Russia), and national company MapExpert [11]. Most companies use in their practice accumulated by spacecrafts archive data of different exposure qualities, such as: SPOT 2, SPOT 4, Landsat 4, Landsat5, Landsat 7, IRSP6 LISS-3, ALOS, TerraASTER, IKONOS, QuickBird ObrView-3 , EROS and others. The resolution quality of photos and map scale determine the level of suitability of space photos of these devices (Table 1).

Moreover, such informational data to an archive database over a period of more than 20 years and can be used for analysis of land condition in the past, ensuring the land use of agricultural crops.

Table 1

Quality of space photos used for mapping of agricultural technologies [12]

Spacecraft	Resolution, meters	Map scale
IKONOS	4	1:20000
Landsat 7	30	1:150000
IRS – 1C	23,5	1:117000
IRS – 1C	5,8	1:29000
SPOT 1-4	20	1:100000
SPOT 4	10	1:50000
SPOT 5	5	1:25000
EROS A	2,4	1:12000
EROS B	0,7	1:3500
QuickBird	1,0	1:5000
ObrView-3	4,0	1:20000

Topographic maps are a picture of relief with the ability to determine the level of soil erosion and obtain information about a possible deposit of ground water level and so on. However, the maps present static condition of the land, without showing the real, dynamic migration processes and soil erosion caused by natural processes and anthropogenic activities. In General, the use of satellite images and topographic maps combine to give a complete picture of the field condition and level of development of crops.

Usage of modern electronic agrotechnological maps of fields are also equally effective method of monitoring of agricultural land in which space-time fixed costs of resources for field works are fixed. These maps provide the efficiency of agrotechnological process at the appropriate time, taking into account soil and climatic conditions of certain fields. Under certain technical conditions electronic agrotechnological map allows to:

- provide an opportunity to record and control all agricultural operations based on accurate baseline data for their implementation;
- assist in carrying out of a detailed analysis of the conditions that affect the development and growth of plants on specifically chosen field;
- optimize the production process in order to maximize profits and simultaneous rational use of resources involved in a particular transaction.

5. Economic aspects of agricultural land

One of the main ways to improve the efficiency of land use should be the study of the potential of the land with the help of electronic maps of fields. For this purpose it is necessary to create a system AgroGIS for exploring spatial data of electronic maps of fields. Functional diagram AgroGIS for evaluating the economic efficiency of land use is shown in Fig.1.

However, services of creating an electronic map of the field cannot be called cheaper because now they can be used only by the large agrarian enterprises. The value and duration of the works on creating of the electronic maps is represented in Table 2.

Usually, a high value of introduction of precision farming (37.8 - 43.8 thousand dollars USA), especially the electronic maps of fields, is very costly innovative project. However, those agrarian enterprises, which, nevertheless, dare to use space information technology in their work, will be able to carry out intensive and sustainable agricultural production development in the future.

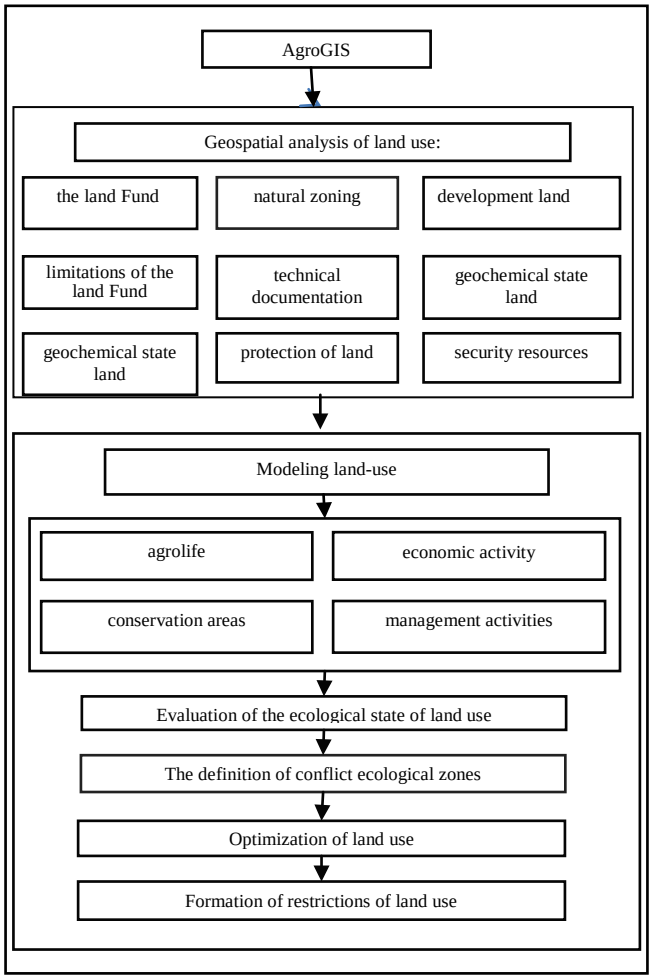

***Fig. 1** Functional diagram the use of geographic information systems to assess the effectiveness of land use*

Taking into account international experience (study of the American Institute of Precision Agriculture) and domestic realities the minimum amount of savings from the introduction of space information technologies has been calculated. According to Table 3 it is over 18 dollars USA per one hectare.

Table 2

The value of creating an electronic map of the field and duration of the works (for the area of 20 thousand hectares) [13]

Name	Value, dollars USA	Duration, days
High resolution space photo	3,200-6,200	over 30
Low resolution space photo	1,000-3,200	over 30
Hardware-software complex "HeoOblikovets"	10,000	60
Detour of field boundaries	10,000	20
Vectorization of field boundaries	2,400	20
Creation of electronic map	11,200	60

Reduction of fuel costs for inspection (detour) and processing fields and for fertilizer, reduction of staff costs will optimize resource costs, reducing the production costs, and thus increase the profitability of the production process.

Given the cost of creating of electronic maps of the field in 20 thousand hectares (37,800 dollars USA) and the possible amount of savings for the same area of agricultural land (36,480 dollars USA), the costs of enterprises for the implementation of space technologies in production can be considered as justified.

These information technologies allow to intensify agricultural production, increase productivity, increase efficiency of use of production assets and circulating assets, to achieve the highest level of productivity due to the dosed application of fertilizers and pesticides and reduce the anthropogenic influence on the ecological situation.

Table 3

Savings in production costs using space information technologies [11]

Cost items	on 1 hectare/year	on 1,000 hectares/year	on 100,000 hectares/year
	dollars USA	dollars USA	dollars USA
Fuel, spent on the detour of field territory	0.15	150	15,000
Wages to employees	0.8	840	84,000
Fertilizers	1.4	1,400	140,000
Control measurements and analyzes	1.28	1,280	128,000
Insurance	0.17	170	17,000
Control of mortgaged crop for the loan	0.2	200	20,000
Costs from too late identifying of weaknesses	8.7	8,700	870,000
Costs of low yields	5.5	5,500	550,000
Total	18.2	18,240	1,824,000

Cost estimation for implementation of space information technologies on the basis of precision agriculture is proof of the need for reorientation of agricultural enterprises on the latest technology of agriculture that will achieve the rationalization of the process of agricultural production and enhance competitiveness of crop production. It is therefore advisable to distinguish several stages of implementation of systems of land monitoring using space technologies, namely:

1. Collection and acquisition of geospatial databases – digitization of the boundaries and contours of the field, build maps, create satellite images.
2. The build routings for rotoorangi, sowing, application of fertilizers and plant protection means.
3. Direct work in the field with the use of auto GPS navigation system.
4. Mapping productivity with the use of satellite images and sensor yield and moisture, which are installed on tractors or combine harvesters.
5. Agronomic, economic and environmental assessment of effectiveness of introduction of new farming technologies. Agronomic and environmental effect is to make the right decisions regarding the amount of fertilizers and means of plant protection that will boost crop yields and reduce negative impacts on soil. The economic effect is to reduce the cost of cultivation of agricultural plants.

6. Conclusions

Implementation of latest achievements in information technologies of land cultivation and crop production is quite problematic for domestic enterprises and pose a threat to the technological security of agricultural sector. The main problems are:

- the lack of clear government policy concerning the space activities in the agricultural sector;
- problems in the creation of effective developments in technologies of remote monitoring of agrarian resources;
- necessity of modernization of machine and tractor fleet;
- significant value of space land monitoring;
- long payback period (5-10 years) of creating of electronic agrotechnical maps of fields;
- low readiness of domestic farmers to change of technical and technological support of agriculture and crop production.

In our view, the removal of these problems is possible only through the development of space activities through interdepartmental coordination of research of the National Academy of Agricultural Sciences, the Ministry of Agrarian Policy and Food

of Ukraine and the National Space Agency. This work will contribute to solving the problems of rational use of agricultural land, revealing weaknesses in agricultural landscapes, defining the status of crops and agricultural ecosystems.

The advantage of such cooperation in that the government by attracting domestic scientific staff promote the development of not only the space industry, and actively develop agriculture, with much lower costs and greater synergistic effect. In addition, such projects may be subject to foreign direct investments that are interested in maintaining ecosystems.

Thus, the use of modern space technologies is an objective requirement for successful agricultural practices, because information technologies:

- provide detailed monitoring of land resources and state of crops;
- help to form reasonable management decisions to the prevention of negative consequences of economic activity;
- can improve the efficiency of the use of land and quality of growing of agricultural plant;
- ensure the increase of productivity and reduce of production costs through rational use of fertilizers, pesticides, fuels and lubricants and so on.

In general, space information technologies ensure compliance with requirements of technological, environmental and economic security of the agricultural sector and the environment.

Among the priority scientific researches in the sphere of land use are: development of legal documents on creation of automated cadastral registration system; preparation of scientific and methodical bases of land-cadastral surveys using GPS; remote sensing of the earth.

The use of space technologies, the transition to automated land cadastre will provide the opportunity of building an effective national land administration system; promote the formation in Ukraine of an effective system of regional geographic information systems. Using them for the management of land resources will allow solving the problems of development of regions.

GIS technology can monitor the environment, intensify agricultural production, increase its productivity, improve efficiency of assets, and achieve higher levels of crop capacity due to dosage applying fertilizers and pesticides, which reduce the human impact on the environment. Considering the minimum amount of savings from the introduction of space information technologies, it can be concluded about the feasibility of their implementation in modern conditions in Ukraine.

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