

ELECTRONIC AGRICULTURAL MAPS FORMATION ON THE BASIS OF GIS AND EARTH REMOTE SENSING

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Abstract

The article is dedicated to the introduction of mapping methodology of the use of agricultural lands based on GIS and Earth remote sensing from space. In the article, the theoretical and methodical positions and features of complex agricultural mapping are formulated, the method of geo-information mapping of agricultural land holdings and land uses with the use of data of Earth remote sensing from space is developed. It is proved that the technological scheme of creation of electronic agricultural maps represents a complete cycle of creating maps and includes the following stages: the preparatory stage, the stage of fieldwork, the stage of map creation. Particular attention is paid to the stage of map formation, in which the content and database of created maps are developed. It is established that work on map layout may be performed after the steps of forming layers, processing of map symbols libraries, development, and filling of databases, and also the formation of layers of thematic elements. The content of agricultural maps is a collection of agricultural complexes, objects associated with them for agricultural development of the territory of the agricultural business, and thematic elements, used to create a complex agricultural map. An approximate content of thematic elements of the agricultural complex map, consisting of agricultural complexes and agricultural infrastructure is defined on the basis of the development of theoretical foundations. A complete list of the semantics of layers of a complex agricultural map is presented.

Key words: *geo-information, technologies, agricultural land use, complex agricultural map, semantic database.*

INTRODUCTION

Agricultural land is the most valuable resource for Ukraine. The condition and methods of using agricultural lands are very rapidly changing; therefore, the creation of a mapping database of agricultural land-use becomes more relevant. Mainly, electronic land-use maps are created using a variety of sources, including cartographic, statistical, data of Earth remote sensing and other source data.

To increase productivity, quality and stable development of agricultural production in Ukraine is possible only on the basis of modern technologies. A successful solution to this problem requires agricultural mapping, which is the main tool for displaying the state of agricultural infrastructure and the results of agricultural inventory. That is why the paper presents a methodology and technology for the creation of complex electronic agricultural

maps using GIS-technologies and Earth remote sensing from space.

Methods of geo-information mapping of data of Earth remote sensing from space are reflected in the works of many Ukrainian and foreign scientists: T.V. Vereshchaka, Yu.F. Knyzhnykov, S.S. Kokhan, Yu.O. Moskalenko, A.A. Aliabiev, O.V. Barladin, A.S. Belward, Dr. Kuldeep Pareta and others. The methodology of geo-information cartography is fully developed by M.N. Mers, Yu.O. Karpinsky, S.M. Polchyna, I.S. Kruhlov, R.I. Sossa, J.D. Vitec, M.S. Reed and others. The theory and methods of agricultural mapping are considered in the works: O.M. Berliant, Yu.S. Bilych, E.L. Bondarenko, T.I. Kozachenko, D.M. Kurlovyh. Regarding the mapping of land at the level of administrative-territorial units, we note the works of V. V. Razov, I.P. Kovalchuk, S.N. Serbeniuk, L.A. Shuaib, I.P. Williamson.

The activity of the above-mentioned scientists of Ukraine and the world shows the important role of the maps of natural resources as information support in solving problems in the field of economic planning and rational use of territories. However, the issue of integrated mapping of agricultural land uses still remains unexplored.

The state of cartography of agriculture in Ukraine demonstrates the lack of integrated agricultural maps that reflect the interconnection of agricultural land uses and objects with natural and socio-economic conditions. In addition, agricultural maps of analytical type are insufficiently presented reflecting the qualitative and quantitative indicators of agriculture in Ukraine. Thus, the development of the content and technology of creating agricultural maps becomes especially relevant to the tasks of thematic mapping. Solving this problem requires the development of a modern scientific and practical basis for optimal compilation and operational updating of cartographic works, as well as the creation of up-to-date databases for management by agro-industrial complex.

MATERIALS AND METHODS

The study is based on data provided by the Ministry of Agrarian Policy and Food of Ukraine, in particular, planning-cartographic materials, including agricultural maps, geographical coordinates of objects of agriculture and other.

Comprehensive study of the technology of creating agricultural maps involves the use of satellite data various spatial resolution and cartographic materials of the appropriate scale. This approach allows us to trace the characteristic flood processes at various levels of coverage – global, regional or local. Data of Earth remote sensing and geo-information systems (GIS) are the basis for the creation of integrated electronic agricultural maps. The method of creating such maps usually includes the following 4 steps: preparatory; fieldwork; data processing; map creation.

RESULTS AND DISCUSSIONS

The importance of geo-information mapping of land resources and administrative areas is conditioned by several reasons: 1. The need for obtaining a comprehensive information on the current land resources and administrative area, the nature of use, existing problems of land use; 2. lack of modern diversified information on the state and features of soils, natural resources and administrative districts complication of its obtaining; 3. dynamic changes that occur in the structure of land resources, their use at contemporary phase of social relations development [6]; 4. the necessity of information and analytical support (in the form of a complex atlas) of the rational use of lands protection against the degradation processes [6].

These problems are particularly important for most of the administrative districts of the state, in which the dominant type of land use is agro-industrial activity[9].

Currently, there is the problem of the mapping of land resources in Ukraine, primarily the territories of administrative districts, rural councils, agro-business, and different types of management and ownership forms. Most (more than 70%) of all cartographic materials of different scale were created 15-25 years ago and they are outdated [13].

Creation of complex agricultural maps is impossible without using GIS-technologies. Particularly, the application of GIS-package “Digitals Professional” and other software provides new opportunities for reflection of quantitative and qualitative information on the properties of soils and land and resource potential, the efficiency of its economic use, etc. The availability of specific programs and modules enables the introduction, analysis and visualization of diverse geospatial information on the state of soil lands, decoding aero and space images in order to study the structure of land use and its dynamics, create interactive models for the development of exogenous processes and soil contamination, generalize and visualize statistical data, manage geospatial data and geo-database, make adjustments and improve its electronic map model [7].

The preparatory stage for the creation of a complex electronic agricultural map: the

development of a map program is being conducted, its purpose is being formulated, and the collection of input data used to create agricultural maps is being done. After these actions, preparations are made for geo-information mapping, which requires the selection of software for laboratory work in the creation of a map, as well as the choice of mathematical basis (scale, projection, layout). In Fig. 1 the technological scheme of the preparatory stage during the creation of a complex agricultural map is demonstrated.

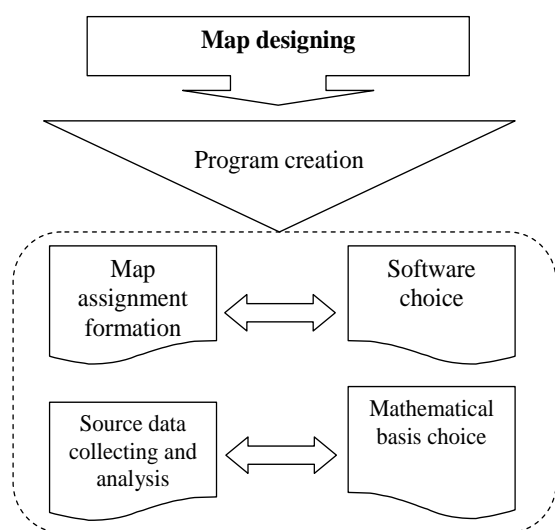


Fig. 1. Scheme of conducting the preparatory stage of creation of a complex electronic agricultural map
 Source: author's development.

The stage of the field work is carried out by coordination, filling out a field survey journal, photographing of objects on the locality, linking of the results of the field survey to the map (Fig. 2).

Coordination of objects on the locality is the getting of geographic coordinates in the selected coordinate system using the GPS (Global Positioning System) technologies that, when scheduled, have an accuracy of $0.005 \text{ m} + 1 \text{ mm} / \text{km}$, and at an altitude of $0.010 \text{ m} + 2 \text{ mm} / \text{km}$ at good weather conditions. This corresponds to the precision of the used topographic basis at a scale of 1: 100,000, while the selected system of coordinates USK-2000 is built into the set of coordinate systems of the device.

The following information: number of points; data; the state of the field; coordinates of the

shot point; the number of the field photo; description of the object is provided in the field journal. To perform the linking of a field survey data to the map, the field journal is done in electronic format using software Microsoft Excel. The data table is filled in the same order as in the field journal. Next, the data table, using the software "Digitals Professional", is loaded into the computer and as to coordinates of points in the table, points are created on the map (in the system of coordinates USK-2000). The obtained result will have the Digitals Professional format with extension (* gbd). For the convenience of comparing field data with other data, the extinct result is exported to a file format (* in4), which makes it possible to use them in other GIS, in particular, "Digitals", "Geo-project", GIS, "Map", etc. [8]. The Digitals Professional program provides the ability to use various vector formats for export and import (* dxf, * mid / mif, * srr, * dgn, * txf, * tif, * bmp, * jpg) [2].

The technological scheme of the implementation of the stage of field work to create a complex agricultural map is presented in Fig. 2. The production stage includes a significant list of works for the creation of maps using GIS-programs. The work is carried out in GIS Digitals Professional and Geo-project. The scheme of implementation of the production stage is presented in Fig. 2.

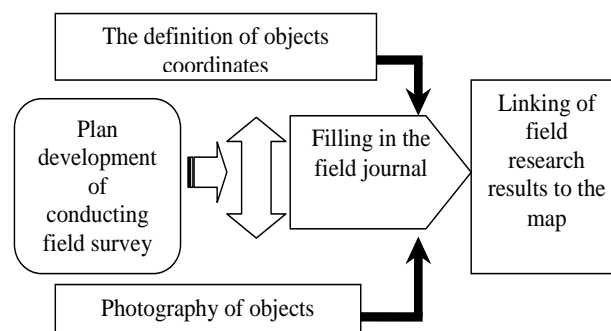


Fig. 2. Technological scheme of creation of complex electronic agricultural map at the stage of field works
 Source: formed by the author.

The stage of map formation includes a full range of works for its creation, which is carried out by GIS programs. These works are convenient to form in the GIS MapInfo

Professional and Geo-project. The technological scheme of the stage of map creation is shown in Fig. 3. A digital topographic map is created using the AutoCAD Map 3D 2011 program, which is a platform for creating and managing map data. In our case, for its use, it is necessary to convert the shape file (*.shp) into a format for further processing. To do this, the Mapinfo Professional program is used with the help of the FME Quick Translator tool; when converted, all graphical and attribute data of the topographic map are saved.

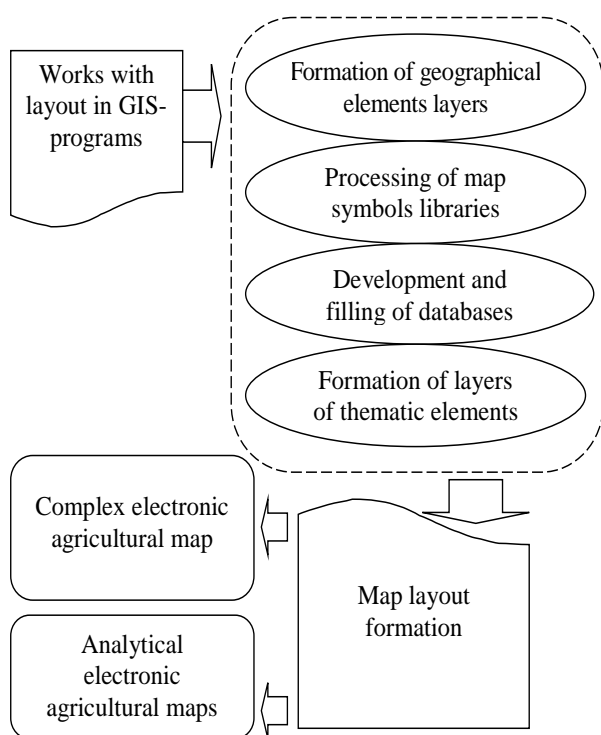


Fig.3. Technological scheme of the stage of map development in GIS programs.
 Source: formed by the author on the basis of data [1].

When forming the legend of geographic objects and complexes, a standardized library of map symbols applied to create topographic maps with a scale of 1: 100,000 is used. When forming legends of thematic content, the ESRI library of map symbols, implemented in the ArcGIS 10.1 program, is used [11].

The development of the content of a complex electronic agricultural map is the main process of mapping. The content of the map is a system of vector layers of the forming map. The complex electronic agricultural map

consists of two groups of layers: geographic and thematic. Thematic layers of a complex agricultural map are the main element that includes three large groups of complexes and objects: agricultural holdings, economic indicators of agriculture and agricultural infrastructure. The agricultural activity is closely linked to the geographical environment, and, accordingly, its reflection on agricultural maps is fully grounded.

It should be noted that the development of agricultural maps begins with the creation of a geographical basis to provide the necessary accuracy of the spatial localization of the map elements, as well as for orientation and identification of the features of the placement of elements and complexes that will be reflected on the map [2, 3, 11]. In this case, it is possible to identify the connections between cartographic complexes and objects with the geographical environment. In this regard, the geographical basis of agricultural maps includes the following elements: administrative boundaries, hydrography, settlements, road network.

Technologies for creating a complex agricultural map using the data of Earth remote sensing from space are some common geographic elements derived from the automatic classification of space images. These elements will be used in the map to be created as constantly updating information of the topographic map of the studied territory. And those elements that can not be obtained from data of Earth remote sensing from space (due to the insufficient number of space images) will be got from the results of the conversion of elements of the topographic map. The set of thematic elements used to create a complex agricultural map is obtained from a variety of data. So, the subjects of agricultural activity are the main object of the automatic classification of space images, and information on agricultural infrastructure will be obtained as a result of the analysis of sectoral and departmental data (Fig. 4).

One of the main stages of creating a complex electronic agricultural map, which is being developed in GIS programs, is the replenishment of the database. The database of a complex electronic map includes a

system of layers, each containing a table with geospatial and attributive data. It can be applied when compiling the atlas of agriculture of the territory, and it can also be

used to study the territory for the purpose of sustainable development of the region. The semantics of the layers of a complex agricultural map is presented in Table 1.

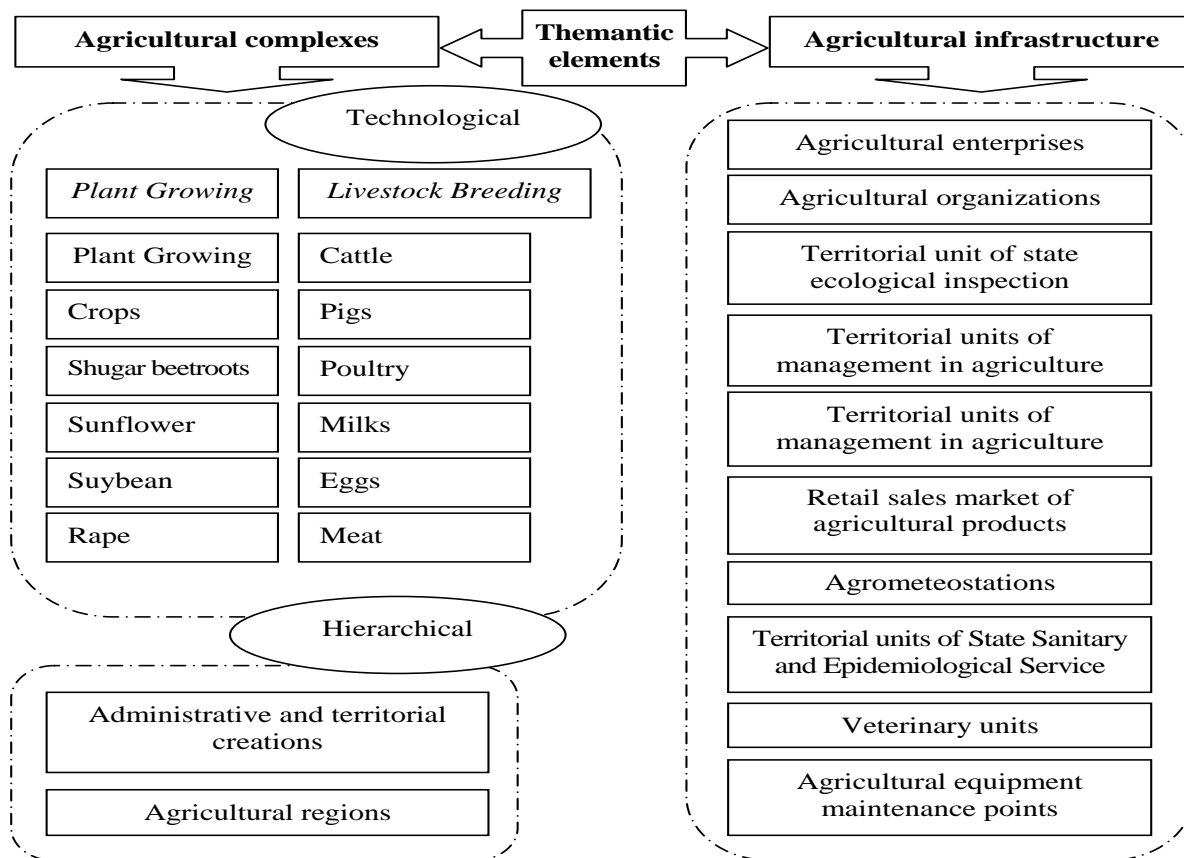


Fig. 4 Approximate content of thematic elements of the complex agricultural map
 Source: formed by the author on the basis of data [5, 12].

Table 1. Semantics of layers of a complex agricultural map

The name of the layer	Information characteristics
Plant Growing	Layer name, proper name, location, coordinates, area, state
Hydrography	The name of the layer, proper name, location, coordinates, area, state
Relief	Layer name, object name, location, absolute height, origin, character of the breed
Settlements	Layer name, object name, proper name, coordinates, area, population, state
Road Network	Layer name, object name, object type, proper name, location, length, width, state
Boundaries	Layer name, object name, territorial units, length
Agricultural lands	Layer name, object name, proper name, location, coordinates, area, state
Objects of agricultural infrastructure	Layer name, object name, proper name, location, coordinates, destination, state
Livestock Farming	Layer name, object name, time, number of livestock farms, number of animals

Source: formed by the author on the basis of data [13].

As it can be seen from Table 1, a complex agricultural map will consist of the following layers: plant growing, hydrography, relief, settlements, road network, borders, agricultural land, agricultural infrastructure objects, livestock farming. Geospatial data for the creation of the complex agricultural maps is information that identifies the geographic location and properties of objects on the locality. Attributable data include the object identifier, any descriptive information of the database, images, etc. [4, 10]. Analysis of these data makes it possible to create new analytical agricultural maps.

CONCLUSIONS

In this way the technological scheme of the creation of agricultural maps is a complete cycle of creating maps and consists of successive stages of work: preparatory stage, stage of fieldwork, the stage of laboratory work, the creation of maps. Much attention is paid to the stage of the laboratory work, where it is necessary to develop the content and database of the maps to be created. The content of agricultural maps represents a set of vector layers, the display of agricultural complexes, objects and features for the development of agriculture in the investigated territory. The semantic database of agricultural maps can be used in the management of the agricultural activity of the researched area.

The results of the research in the perspective can be applied in the development of methodological documents for the mastering agricultural land-use and web-oriented technologies for creating agricultural maps in related industries. The development of scientific researches is aimed at improving the content of agricultural maps of complex and analytical types and extending the use of the developed technology for the creation of such maps in agriculture in Ukraine.

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