FUTURE OF AGRICULTURAL LAND MONITORING IN THE CONTEXT OF CLIMATE CHANGE - UNMANNED AERIAL VEHICLES

D. Bulysheva1, O. Varfolomeyeva1, O. Panasyuk1

Odesa State Agrarian University 65012 Odesa Ukraine

ABSTRACT

Climate change is a major global problem that threatens the existence of both humanity and biodiversity on Earth. In connection with the abovementioned, research proves the indisputable relevance of monitoring studies of erosion processes, control of plant growth phases, pests and soil conditions, crop yield forecasting, identification of unused and irrationally used land. As object of research agricultural lands as complex systems that require constant monitoring of their condition are defined. The subject of research is the processes of topographic and geodetic support for the monitoring of agricultural lands. The aim of the study is to develop proposals for improving integrated monitoring of agricultural lands, taking into account the use of unmanned aerial vehicles (UAVs) as the main tool for aerial photography. Methods of topographic and geodetic support of monitoring of agricultural lands and stages of assessment and forecasting of a qualitative condition of agricultural lands are investigated. The relevance of the UAV's use for monitoring the development of agricultural land has been proven. It has been determined that the use of UAVs is many times more efficient from different points of view. The advantages of using UAVs in monitoring the state of the agricultural sector are shown - accuracy, mobility, high efficiency, environmental safety, relatively low cost. Possibilities as a result of UAV's application in the agricultural sector of the country are identified.

Keywords: Monitoring of agricultural lands, unmanned aerial vehicles, climate change, topographic and geodetic works, UAV data processing.

INTRODUCTION

Climate change is a major global problem that threatens the existence of both humanity and biodiversity on Earth. The main cause of global warming is growing concentration of greenhouse gases generated by human activities: industry, transport, agriculture, fossil fuel combustion and forest fires. Given the corresponding trend, the world is currently on a trajectory that corresponds to an increase in temperature by about + 4 ° C by 2100.

Over the past 50 years, the cultivated area in the world has increased by 12%. During the same period, the area of irrigated land has doubled. This, first of all, explains the net increase in the area under crops. At the same time, the volume of agricultural production increased by 2.5–3 times due to a significant increase in the yield of major agricultural crops. By 2050, food production is projected to increase by almost 70% globally and by almost 100% in developing countries [1]. Growing demand for food, along with competing demand for agricultural products in other areas of its use, will create unprecedented pressure on many agricultural production systems around the world. These "risk systems" face increasing competition for land and water resources and are often constrained by unsustainable agricultural practices. Therefore, they require close attention to themselves, as well as implementation of specific actions to correct the introduction of new technological processes while monitoring the state of the resources.

The object of research is defined agricultural lands as complex systems that require constant monitoring of their condition. The subject of research is the processes of topographic and geodetic support for the monitoring of agricultural lands. The aim of the study is to develop proposals for improving integrated monitoring of agricultural lands, taking into account the use of unmanned aerial vehicles (UAVs) as the main tool for aerial photography.

To solve the problems of agricultural lands monitoring, modern methods and means of receiving, storing, processing and presenting of various information are required. As well as means of information exchange are needed. They include methods for collecting a significant amount of data on a variety of indicators from large areas. Then it is necessary to present the collected data in digital form suitable for use in information, including geographic information systems. These systems should integrate spatial geographic data, aerial and satellite imagery and thematic data on a variety of agricultural parameters presented in cartographic and tabular forms. Such systems can be used to display large amounts of information on a screen or hard copy in user-friendly forms. It is possible to obtain a secondary derived cartographic material of analytical properties by superimposing received and collected data on the collected information (such as soil quality, irrigation conditions, meteorological information, phytosanitary observations, field agricultural research data, satellite monitoring data, etc.) On its basis, one can judge the degree of development of plant crops in a given area and at a certain time. This is perhaps the most optimal way to monitor the state of vegetation cover, crops and pastures, as well as their productivity, identify degradation of crops or soil, predict the yield, etc.

The advantage of monitoring as an integral tracking system is quite obvious, since soil and agrochemical studies are often carried out on the basis of unilateral programs that provide for a limited set of studied parameters and the use of different methodological and methodological approaches.

The relevance of the research topic is caused by the need:

- creation of electronic maps of fields;
- inventory and detailing of agricultural land;
- control of the volume and quality of agricultural work;
- operational monitoring of the state of crops;
- yield forecast;
- environmental monitoring;
- fire safety;
- other broad opportunities that open up when using UAVs in the agricultural sector of the country, especially in the context of the development of precision farming technology.

RESULTS AND DISCUSSION

The best method for monitoring the condition of lands is photogrammetric method using unmanned aerial vehicles with small-format cameras or medium-format air cameras. Unmanned aerial vehicle (UAV, drone) is an aircraft designed to perform a flight without a pilot on board, the flight control of which is controlled by a special station located outside the aircraft, or in automatic mode.

Small unmanned aerial vehicles are composed of several objects, which can be divided into 2 groups: onboard radio-electronic equipment, structural mechanical parts.

Considering onboard radio electronic equipment - there are many different UAVs, but each of them must have: autopilot, sensors, navigation system, link, energy source, propulsion system.

When working with a UAV, the operator does not require special piloting skills and lengthy training, due to the complete automation of the complex control. One or two employees are enough to carry out regular surveys of territories.

Up-to-date information on the implementation of certain unmanned aerial vehicles is provided on the official electronic resources of manufacturers and distributors of unmanned aerial vehicles such as DJI, Smart Drones, People's Drone, and others. Sufficient attention has been paid to the general theoretical issues of UAV use in the military, law enforcement and economic sectors, but the problem of integrating the use of unmanned aerial vehicles in the field of monitoring the state of agricultural land requires further research.

Obtaining and using for research purposes aerial photographs of UAVs has become possible since the early 1990s due to the advent of digital cameras, the characteristics of which have made the opportunity for replacement of small-format aerial cameras. The popularity of UAVs is due to easy maneuverability, mobility, efficiency, low cost and the ability to use the payload to obtain ultra-high resolution spatial data. Aerial photography can be divided into manufactured by means of manned vehicles controlled by long-range UAVs and micro UAVs. Compared to other aerospace data, UAV images have ultra-high spatial resolution and high efficiency, but cover relatively small areas. The altitude and focal length of the camera determine the scale (m) of the resulting image.

The areas of UAVs' use are quite wide - from emergency forecasting, state border control, road monitoring - to atmospheric and meteorological observations, prevention of unauthorized deforestation and poaching in national parks and reserves [2]. They can be used for operational or round-the-clock monitoring of the state of technological objects, highways and railways, agricultural territories, airports and seaports, pipelines, etc.

Japan can be considered a "pioneer" in the use of unmanned aerial vehicles in agriculture. Back in the 1990s, Yamaha produced small R-50 and R-Max remote-controlled helicopters [3]. The latter was presented on the international market, and since 2015 is used in the United States for spraying vineyards. It can lift up to 28 kg of payload into the air, fly at speeds of up to 105 km / h and be in flight for up to one hour, but the main thing is to perform more accurate and economical spraying. Now according to mass media till the end of 2020, agricultural drone producer Tevel Aerobotics Technologies will complete $ 20 million funding round to launch a commercial project to launch fruit-harvesting drones. Tevel Aerobotics Technologies is developing autonomous drones equipped with one-meter mechanical claws that can pick fruit or be used for thinning and pruning trees in gardens. Tevel Aerobotics' drones are equipped with capabilities that allow them to identify fruit types and ripeness.

In recent years, such cameras are placed on agricultural drones. The images obtained with their help allow to reveal problems of growth of plants even before they become visible to the naked eye.

Based on field images in different ranges, specialized software packages analyze the volumes of nitrogen uptake in the soil, calculate the soil vegetation index and the normalized vegetation index. All this allows you to more accurately dose fertilizers, reducing their consumption and pollution of water bodies by flushing from the fields.

According to AUVSI (International Association of Unmanned Systems) [4], precision farming and public safety are the two most popular applications for commercial drones today. Together, these two segments make up about 90% of the total civilian drone market. AUVSI forecasts that annual sales of drones for agricultural use will be up to 150 thousand by 2025. Earlier, the association used a more conservative estimate of 100 thousand units.

The use of drones, Big Data techniques and artificial intelligence technologies is becoming interconnected in agriculture. This combination allows field monitoring and maintenance of equipment much faster and with lower resource costs. Electronic maps, automatically created based on aerial photography are more accurate than manual measurements and satellite images [5]. They show more clearly the existing shortcomings of land use, giving the opportunity to focus on problem areas.

Powerful forecasting tools based on neural networks allow to pre-select the optimal strategy for all agricultural work, reduce costs and increase yields per hectare. In Japan, China, United States and a number of European countries, these are already current transformations of the agricultural sector.

UAV surveys allow quickly and accurately assess the area of agricultural land, and constant monitoring makes it possible to assess crop germination, control crop quality and identify cases of theft and damage to crops. All these data will help to respond quickly to changes in the state of crops, make timely decisions and, ultimately, increase the efficiency of agriculture.

In addition to high cost-effectiveness (dozens of times cheaper), UAVs have additional advantages over traditional aerial and space imaging:

- small height of survey - it is possible to carry out surveying at heights from 10 to 200 meters for receiving ultrahigh resolution (units and tens of centimeters) on the terrain;
- accuracy - the ability to take detailed pictures of small objects and small areas where it is completely unprofitable or technically impossible to do in other ways, for example, in urban areas;
- mobility - no aerodromes or specially prepared runways are required, UAVs are easily transported by cars (or carried manually), there is no complicated procedure for permits and flight approvals;
- high efficiency - the whole cycle, from the departure to the surveying and getting the results, takes several hours;
- ecological cleanliness of flights - low-power petrol or silent electric motors are used, practically zero loading on environment is provided [6].

It should be noted that the use of UAV survey data allows to create three-dimensional models of the area with high accuracy, which, of course, should be used as part of a comprehensive methodology for monitoring agricultural lands. Therefore, the technique of monitoring aerial photography materials allows to obtain high measurement accuracy and can be implemented using inexpensive equipment for aerial photography and widespread digital photogrammetric systems for processing aerial photography materials.

It is most appropriate to monitor the use of the photogrammetric method, which allows to determine the position and state of agricultural territories.

Agricultural land monitoring includes systematic observations of:

- the state and use of crop rotation fields, agricultural landfills and contours, as well as the parameters of soil fertility and development of soil degradation processes (changes in the reaction of the soil environment, the content of organic matter and nutrients, destruction of the soil structure, salinization, alkalinization, waterlogging, development of water and wind erosion, soil pollution with pesticides, heavy metals, radionuclides, industrial, household and other wastes, changes in other soil properties);

- changes in the state of the vegetation cover on arable land, fallow lands, hayfields and pastures (changes in the species composition, crop structure, types and quality of vegetation, the degree of resistance to anthropogenic loads).

When conducting the state monitoring of agricultural land, the following tasks are solved:

- timely identification of changes in the state of agricultural lands, assessment of these changes, forecast and development of recommendations for increasing their fertility, preventing and eliminating the consequences of negative processes;

- obtaining data on the basis of a systematic survey of soil fertility and observations of the quality condition and effective use of agricultural land as the main resource for agricultural activity using the geographical referencing of agricultural landfills and contours;

- monitoring of the state of agricultural land vegetation;

- maintaining a register of soil fertility of agricultural lands and recording their condition;

- formation of state information resources on agricultural lands in order to analyze, predict and develop state policy in the field of land relations (in terms of agricultural lands) and the effective use of such lands in agriculture, as well as use in statistical practice;

- providing access for legal entities and individuals to information on the state of agricultural land;

- participation in international programs (ensuring the fulfillment of international obligations).

Assessment and forecasting of the qualitative state of agricultural land with subsequent spatial-structural modeling of the predicted state of the study area consists in the sequence of operations which executors must perform:

1. Study of long-term dynamics of agricultural lands' state.
2. Parametrization of the qualitative and quantitative characteristics of the study area's state.
3. Assessment of the current state of agricultural land.
4. GIS modeling.
5. Continuous monitoring of the potential development of agricultural land.

Analyzing the data processing process, it should be noted that in general, the process of adaptation of any remote sensing data obtained from the air consists of the stages of pre-processing, photogrammetric processing and subsequent decoding. However, each type of survey has its own characteristics (Fig. 1).

As a result of the above actions, the technology of obtaining a digital terrain model is reduced to creating a polygonal model in software packages for photogrammetric processing (Agisoft Photoscan, Pix4D, UAVMaster), which is connected to ground reference points. Then the cloud of dense points and polygonal models are edited and processed in geographic information software packages, which create a digital terrain model.

Thus, we consider it appropriate given the accuracy, mobility and an economic point of view recommend to use aerial photography during monitoring the condition of agricultural land by UAVs with subsequent processing of aerial photographs and construction (if necessary) of a digital terrain model or topographic plan.

Aerial photography in agriculture is one of the most important sources of information when carrying out land work. UAV technology allows you to record and monitor the state of agricultural land, which consists of monitoring and optimization of water consumption, calculation of the optimal amount of fertilizers and chemicals applied, creation of an electronic map of the fields, forecast of the yield of agricultural crops, planning the laying of drainage systems etc.

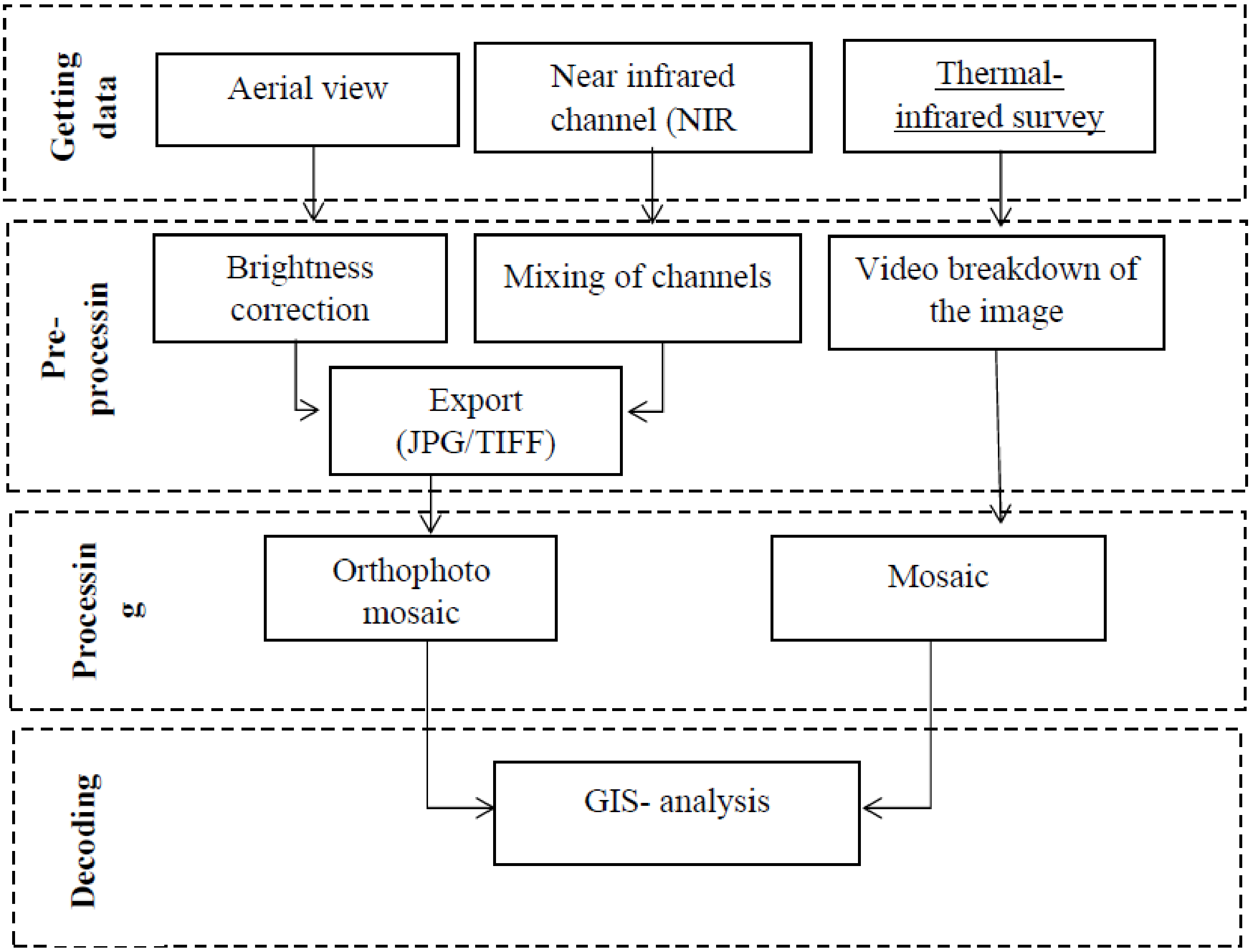

Figure: 1. Scheme of processing tribute from the UAV

With the help of unmanned aerial vehicles, it is possible to determine the terrain, the size of the fields, the boundaries of water bodies (lakes, rivers, swamps) and roads. Using this technology, stakeholders can get images to analyze the state of the sowing, its density and uniformity. The use of multispectral imaging allows to detect changes in a culture during its growth. The data obtained show the development and growth of plants in the visible near infrared spectrum. Based on the change in the tonality and color of the spectrum, it is possible to draw a conclusion about which part of the sown area requires this or that additive.

The use of UAVs for agriculture helps to solve the following tasks:

- creation and updating maps and plans of cultivated land in electronic form;
- accounting of agricultural land;
- sowing planning for production sites;
- control of the volume and quality of field work;
- conducting operational monitoring of the state of crops;
- assessment of crop germination;
- crop yield forecast;
- quality control of harvesting;
- economic assessment;
- monitoring of erosion conditions;
- construction of maps of vegetation indices etc.

One of the advantages of UAVs used in agriculture is the acquisition of images in two formats. The first is with real color reproduction, the second is in the near infrared range.

Thanks to the images with artificial infrared colors, experts calculate the NDVI (NormalizedDifferenceVegetationIndex) vegetation index, which allows to:

- quantify the state of vegetation (both in the entire field and in its individual areas);
- calculate the yield;
- identify cultures;

- assess the germination and growth of plants;
- analyze the productivity of land.

It has already become obvious that aerial photography from UAVs has the following advantages over space and traditional:

- relatively low flight altitude (allows surveying at altitudes from 50 to 3700 m);
- high resolution on the territory (the smallest details of the relief and objects can be seen, even a centimeter in size);
- ability to create panoramic images (satellite and traditional aerial photography do not have this opportunity);
- detailed shooting of small objects is possible;
- technology of aerial photography from UAVs allows aerial photography of small objects and small areas where it is unprofitable to do it with other types of aerial photography, and in some cases it is technically impossible;
- ability to choose weather conditions and time of day for aerial photography;
- efficiency (the whole cycle from start of surveying to obtaining the final results takes several hours within one day);
- low cost (much cheaper than traditional methods of aerial photography);
- environmental safety (an electric motor is used for operation, this ensures practical noiselessness and environmental friendliness of flights).

Such devices are a modern information and control tool with broad functionality for stakeholders in agricultural sector. The use of UAVs for monitoring agricultural land will optimize information components related to cultivated areas. On the basis of the accumulated information, an optimal strategy for managing the production processes of field cultivation can be built.

CONCLUSION

Nowadays the study of the state of agricultural lands is acquiring special relevance, since the indicators of their qualitative state are low (soil degradation, deterioration of fertility, low organic matter content etc.).

Of great importance are the issues of land protection and their rational use, systematic monitoring of the state of land for the timely detection of changes, their assessment, prevention and elimination of the consequences of negative processes.

Very important monitoring criterion is to obtain and improve methods for collecting information on agricultural land for the purpose of real increasing production efficiency in terms of living standards, quality and standard of living, economic security and especially food security of the population.

State regulation of such complex processes makes it possible to resolve many contradictions in conditions of socio-economic, scientific& technical, intellectual&informational crisis of society, especially it can help the sphere of organization and management of agricultural production.

As a result of the research, it was determinated, that unmanned aerial vehicles can be used to perform the following tasks: creation and updating maps and plans of cultivated land in electronic form; accounting of agricultural land; planning of sowing operations by production sites; control of the volume and quality of field work; conducting operational monitoring of the state of crops; assessment of the germination of agricultural crops; forecast of crop yields; quality control of the harvest; economic assessment; monitoring of erosion conditions; building maps of vegetation indices.

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