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THE USE OF UNMANNED AERIAL VEHICLES IN THE MONITORING OF AGRICULTURAL LAND IN THE STAVROPOL TERRITORY

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Abstract

Modern technologies allow remote monitoring of the quality of agricultural land using unmanned aerial photography. This process is less expensive, more mobile and more efficient and provides accurate and detailed information on the required object. The use of high-resolution cameras from 5 cm / pixel allows you to quickly examine large arrays of fields. The organization of monitoring is most effective when there is a service of geoanalytical data (space images) and in this case, monitoring is carried out from the problem areas.

Monitoring of agricultural lands in the Stavropol Territory with the help of UAV showed that the processes of land degradation tend to increase and solving this problem is one of the top priorities in land management. Negative processes develop both on arable land and on natural forage lands due to an increase in anthropogenic load. Since a large plowing of the territory and uncontrolled grazing of agricultural animals contribute to the development of various types of land degradation.

The timely identification of new foci of erosion processes and their development helps to solve the problem of agricultural land degradation, which is achieved through the use of remote technologies. Inventory of land using UAV is much more accurate and productive than current methods of bypassing the field on the contour or drawing on satellite data. Therefore, this work and the scheme for identifying degraded lands with the help of UAV can be the main document for working out the methodology and developing working projects to eliminate local causes of agricultural land degradation.

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Key words: land monitoring, unmanned aerial vehicles.

Introduction

Relevant and accurate data about the processing area for each field - a fundamental basis of modern agriculture. The accuracy of information about the field area directly affects the accuracy of calculating the cost of processing it. For example, the discrepancy between the 70-80-s map and the actual state can reach 20%, which means that the same error will be present when calculating the cost of buying seeds and pesticides, as well as inaccurate data on yields (D. A. Shevchenko, at all, 2016). Inventory of land using UAV is much more accurate and productive than current methods of bypassing the field on the contour or drawing on satellite data.

Furthermore, in some application such as monitoring of the individual trees structure, the high resolution satellite imagery still cannot fulfill this (Niethammer, U., S., at all, 2010).

Good precision information in agro-industry management will affect the production function of the farm, such as (Whelan, B. and James T., 2010). Instantaneous yield monitoring (e.g. every week or every few meters); (Rokhmana, C. A, 2010) Density/salinity/yield mapping; (Clark, A. F., at all, 2010) Weed mapping; and (Eisenbeiss, H., 2008) Topography and boundaries. In the exact plantation area, the map products are needed for some purposes such as monitoring the vegetation and its health condition, terrain analysis for hydrology, and biomass volumetric calculation. Some of the precise parameter measurements capabilities are needed such as the trees high, the canopy diameter, and the slope of terrain. This paper demonstrates the use of low-cost precise agriculture mapping system to answer some measurement problems. The system should have characteristics such as (Whelan , B. and James T., 2010) good GSD (Ground Sampling Distance) less than 20 cm; (Rokhmana, C. A, 2010) portable and easy in operation by local staff; (Rokhmana, C.A, 2010) produce stereo viewing; and (Eisenbeiss, H., 2008) good accuracy in sub-meter level. This system utilizes some hobby products, such as aero-modeling plane and digital point and shoot camera for reducing the cost. The challenge is to enhance its capabilities and the processing to become close to the professional instruments.

In the use of unmanned aerial photography for agricultural purposes, the following are the most promising directions: the construction of digital terrain models (Trukhachev V. I. at all, 2001), the analysis of the heterogeneity of land fertility by spectral characteristics (Tskhovrebov V.S. at all, 2017), the monitoring of drainage systems, the variability of crops in vegetation indices, and the detection of damage to vegetation from external influences.

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Materials and methods

The use of high-resolution cameras from 5 cm/pixel allows you to quickly examine large arrays of fields. The result of the survey will be a photo book or orthophoto. The organization of monitoring is most effective when there is a service of geoanalytical data (space images). In this case, monitoring is carried out in an addressable manner, starting with problem areas.

It has already become apparent that aerial photography with UAV in comparison with space and traditional has the following advantages:

- relatively low flight altitude (allows to shoot at altitudes from 100 to 3700 m);
- high resolution on the terrain (the smallest details of the relief and objects even a centimeter in size are visible);
- the possibility of creating panoramic images (satellite and traditional aerial photography do not have this capability);
- detailed shooting of small objects is possible; the technology of aerial photography with UAV makes it possible to carry out aerial photography of small objects and small areas where it is unprofitable to do other types of aerial photography, and in some cases technically impossible;
- the ability to select weather conditions and time of day for aerial photography;
- efficiency (the whole cycle from the exit to the shooting until the final results takes several hours in one day);
- low cost (much cheaper than traditional methods of aerial photography);
- ecological safety (electric motor is used for work, which ensures practical quietness and ecological cleanliness of flights).

The use of drones greatly simplifies the collection of necessary information on the state of crops. Unlike satellite, drones are more mobile tool, with more detailed data.

Due to the fact that the height of the drone flight is usually within the range of 100 to 300 meters above the ground, it is possible to obtain pictures with a resolution in centimeters per pixel. Drones allow you to collect a huge amount of information in the shortest time. On average, one crew is able to process up to 2,500 hectares per day. The processing of fields by drones must be carried out by a "snake".

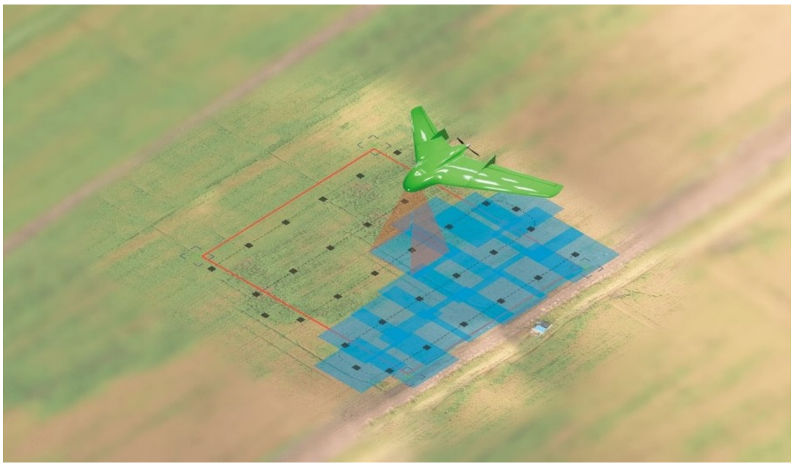

Figure 1. Flyover the field along a compiled route

Dron makes photographs with overlapping - later such pictures are stitched together into one detailed orthophoto. The drones are photographed on a pre-planned route, which requires permission to fly. Drone control is carried out automatically from a ground station.

Here it is necessary to mention that for the purposes of agriculture different types of UAV are used: aircraft type with a fixed wing, drones-copter with 4, 6, 8 screws. The main differences between UAVs with fixed wings and copters lie in the range and stability characteristics of the flight, the lift weight, the method of launching and landing, the price, etc.

The main analysis of the state of crops occurs at the stages of planting and harvesting. In this assessment and monitoring of the intermediate state of plants is given less time. Accordingly, a large layer of important information is missing, which could help increase yields.

Switching to the use of drones will save farmers from grueling walks in the field with special measuring instruments, and also help with the collection of data on the state of crops at any time. Provided services for unmanned aerial photography can declare certain services, but the agricultural producer is primarily interested in the economic feasibility of using unmanned technologies. And this question is relevant both for foreign farmers and for domestic farmers.

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The land area of the Stavropol Territory is 6615982 hectares. The main part of the territory is occupied by agricultural land (92.32%), which is used by various organizations, enterprises and citizens for various agricultural production. The main type of agricultural land is the arable land (plowland, fallow).

Results and discussion. In the structure of agricultural land in the Stavropol Territory, arable land (69.5%) and pastures (27.,97%) occupy the maximum area. The same situation develops in all regions of the region, except in the eastern part of the region (Levokumsky and Neftekumsky), where more than 50% of agricultural land is occupied by pastures. The plots of hayfields and pastures occupied by sowing pre-crops are not included in the plowland, plowed for the purpose of radical improvement, as well as between rows of orchards used for planting crops.

For many areas of the Stavropol Territory is characterized by a very large area of arable land, which negatively affects the overall environmental situation in these areas. So it can be seen from the table that in such areas as Blagodarnenskiy, Kirovskiy, Novoaleksandrovskiy and Novoselitskiy, arable land occupies more than 80% of the territory in the structure of the land fund. Arable land also varies from 70% to 80% in many areas. This indicator significantly exceeds the possible limits, which leads to serious negative consequences and deterioration of the quality of agricultural land.

The area of arable land in the Krai for the period under review has increased and is currently 3946303 hectares (Table 1).

Table 1. Dynamics of arable land in the Stavropol Territory

Name	2000		2006		2012		2018	
	ha	%	ha	%	ha	%	ha	%
Agricultural land, including	5561472	100	5659580	100	5657080	100	5657352	100
Arable land	3893263	70.0	3929023	69.42	3931250	69.49	3932325	69.5
The deposit	11726	0.21	14614	0.26	13978	0.24	13978	0.24
Total arable land pas	3904489	70.21	3943637	69.68	3945228	69.73	3946303	69.74

Analyzing the table, it can be noted that the area of arable land for the analyzed period is constantly increasing, but the area of agricultural land is also increasing, so the share of arable land in percentage terms is decreasing. For 16 years the arable land area has increased by more than 39 thousand hectares, and the area of the deposit is 2252 hectares. This increase was due to the transfer of land reserves in agricultural land. It should be noted that the area of the deposit has also increased, but in comparison with 2012 it remained unchanged. Arable land is the main agricultural land and its area remains the most stable, both at the edge as a whole and in separate regions.

Arable land in the region is used as efficiently as possible, but the arable land in most areas and in the province as a whole exceeds the permissible ecological limit (40% of the area). As we have already noted, in some regions of the region this indicator exceeds 70-80%, which leads to disastrous consequences, since this indicator is achieved due to plowing of sloping lands with a complex relief. All this leads to the development of water and wind erosion, activation of landslide processes and imbalance in agricultural areas. Abandoned croplands on the territory of Stavropol absent as such.

Arable land is the kind of land that is subject to the greatest anthropogenic load and, accordingly, to a large extent, to the influence of various negative natural factors. Dynamics of development of negative processes in arable land is presented in table 2.

Based on the data presented in the table, it can be concluded that in the analyzed period, a significant increase in the area of deflated lands (+ 96712 ha), lands subject to joint effects of water and wind erosion (+ 31460 ha) and solonetsous and solonets of land (+ 53354 ha). At the same time, there is a decrease in the area of arable land subjected to water erosion (-21,397 hectares), overcatching (-33795 ha), bogging (-2542 ha), stony (-32495 ha) and salinization (-37847 hectares). As for the deposit, then for this type of land there is a negative dynamics of the development of degradation processes and an increase in the area of degraded land (6).

The reduction of the area of degraded lands is due to the fact that in many farms of the region, complex anti-erosion measures were developed and implemented. The laying of new protective forest belts was carried out, soil protection crop rotations were introduced, and reconstruction of drainage systems was carried out.

Despite the development of negative processes, arable land is a particularly valuable agricultural land and their use should be made taking into account the characteristics of landscapes and quality conditions.

Natural fodder lands play a significant role in the balance of agrolandscapes and, unfortunately, we can state that in the Stavropol Territory they are not located on very high-quality land.

Fodder lands in the region are concentrated mainly in the southern part of Shpakovskiy district, in Andropovskiy, Apanasenkovsky, Levokumsky, Neftekumskiy and Kurskiy regions, which is due to the presence of significant areas of land unsuitable for arable land.

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Table 2. Quality of arable land in the Stavropol Territory, ha

Year	Name	Agricultural grounds	Arable land	The deposit
2000	Eroded	913 866	519 570	1 117
	Deflated	754 178	404 670	1 098
	Joint manifestation of erosion	123 830	84 936	-
	Overmoistened	361 126	119 251	6 323
	Wetlands	46 865	7 539	348
	Stony	228 477	102 834	77
	Salted	1 367 250	566 560	8 192
	Solonetzic and solonetzic complexes	796 808	339 732	4 552
2018	Eroded	904 528	498 173	1 462
	Deflated	854 232	501 382	1 238
	Joint manifestation of erosion	201 234	116 396	97
	Overmoistened	249 873	85 456	6 787
	Wetlands	17 545	4 997	431
	Stony	190 081	70 339	91
	Salted	1 263 054	528 713	8 650
	Solonetzic and solonetzic complexes	803 741	393 086	4 912

The natural forage lands include hayfields and pastures.

The hayfields include land plots covered with perennial grassy vegetation and systematically used for haymaking, but they do not include deposits and areas sown with intermediate crops.

Pasture is an agricultural land covered with perennial grassy vegetation, systematically used for grazing, and such use is the main one.

When taking into account the quality of land, these types of land have many classification features, such as cultivation, contamination by harmful, uneaten and poisonous plants, fouling, kinkiness, watering, etc. We in our studies at this stage will dwell on these lands in general, without classification and their qualitative state. The area of natural fodder land in the province has grown since 2000 and currently stands at 1684353 hectares. Dynamics of areas of hayfields and pastures can be traced in table 3.

Analyzing the table, it can be noted that the area of hayfields and pastures in comparison with the two thousandth year has increased significantly, but the area of agricultural land also increases, so the share of natural forage lands in percentage terms has increased, but insignificantly. In 2016, the area of natural forage land in the region is 27.57%.

Over the analyzed period, the pasture area in the province increased by more than 53 thousand hectares, and the area of hayfields by more than 5 thousand hectares. However, since 2006, the area of these types of land is constantly decreasing, albeit not very significantly. This is due to the plowing of abandoned pasture areas, usually on sloping lands, where there is a great danger of the development of degradation processes.

As can be seen from the table, in 11 districts of the region (Arzgirskiy, Budennovskiy, Turkmenskiy, etc.), hayfields as a species of land are completely absent, and in two regions (Sovietskiy and Georgievskiy) their areas are very small. The area of pastures varies considerably by regions and gradually increases from west to east. In such eastern areas as Levokumskiy and Neftekumskiy, the pasture area exceeds 50%, and in the Kurskiy and Shpakovskiy regions it is more than 40%. Natural feeding grounds are intended to provide a certain (estimated) livestock population with green fodder.

The qualitative state of the lands of natural forage lands is of great importance and affects their use and the efficiency of agricultural production.

Table 3. Dynamics of the area of natural forage land in the Stavropol Territory

Name	2000		2006		2012		2018	
	ra	%	ra	%	ra	%	ra	%
Agricultural land, including	5561472	100	5659580	100	5657080	100	5657352	100
Hayfields	97 070	1.62	102 620	1.68	102 155	1.67	102 136	1.67
Pastures	1529201	25.52	1585109	25.95	1582867	25.91	1582217	25.9
Total land of natural fodder land	1626271	27.14	1687729	27.63	1685022	27.58	1684353	27.57

In 2016, monitoring of forested areas was carried out and updated data on their condition were obtained. One can safely state the fact of the development of negative processes and the deterioration of the ecological situation in the hayfields and pastures of the region. The characteristics of the economic and cultural conditions of hayfields and pastures of the Stavropol Territory are presented in table 4.

Based on the data presented in the table, it can be noted that the main areas of hayfields (73618 ha) and

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pastures (1349072 ha) are clean, improved or plowed. But it is also evident that large areas of fodder lands are overgrown with bushes and forests, are clogged with stones, poisonous and harmful plants. About 50% of the pastures are medium to large in quality, and in these areas it is necessary to immediately stop grazing of agricultural animals and implement measures aimed at improving and preserving the natural forage lands.

This situation is due to lack of control over grazing and non-compliance with pasture rotation rules. Pasture rotation is necessary to increase the productivity of pastures by alternating grazing, resting and mowing, as well as other care activities aimed at improving the grass stand and the cultural and technical state of the forage lands.

Table 4. Economic and cultural conditions of hayfields and pastures of the Stavropol Territory

Cultural and economic status	Area, hectares	
	Hayfields	Pastures
Total fodder land, incl.	102136	1582217
plowed	20340	162900
improved	7684	27050
clean	73618	1349072
overgrown with shrubs	958	38740
overgrown with wood	-	940
littered with stones	-	6398
From the total area of fodder land:		
medium-earth	3904	399870
severely defeated	608	354480
Clogged with plants:		
poisonous	409	213778
harmful	2727	250716

Natural fodder lands are subject to a large anthropogenic load and, accordingly, to a considerable extent, to the influence of various negative natural factors. Natural fodder lands belong to important agricultural lands, but in the territory of the Stavropol Territory, agro-landscape and ecological zoning has not been carried out, there is no typological map of fodder land and a map for the development of degradation processes, and measures have not been developed to organize and manage natural fodder land.

One of the conditions for the rational use and durability of pastures is the grazing of livestock in the pasture rotation system, the introduction of which will facilitate the provision of grazing cattle with green fodder. Effective use of pasture period is a real opportunity to produce products of low cost.

Practically all recommendations can be translated when developing projects for the organization of territory and working projects. Therefore, this work and the scheme for identifying degraded lands can be the main document for working out the methodology and developing working projects to eliminate local causes of degradation of natural forage lands.

References

Land resources of the Stavropol region: a training manual / V. I. Trukhachev, P. V. Klyushin, and A. S. Tsygankov, V. N. Chernyshev. Stavropol, 2001. 158 p.

CLARK, A.F., J. C. WOODS AND O. OECHSLE, A Low-Cost Airborne Platform FOR Ecological Monitoring, *International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*, Vol. XXXVIII, Part 5, Commission V Symposium, Newcastle upon Tyne, UK.; 2010. C. 167–172.

EISENBEISS, H. 2008. The Autonomous Mini Helicopter: A powerful Platform for Mobile Mapping. ISPRS Congress, Beijing, China, *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*. XXXVII. Part B1: 977-983; C. 977–983.

GRENZDÖRFFER, G. J., A. ENGELB, B. TEICHERTC. The Photogrammetric Potential Of Low-Cost Uavs In Forestry And Agriculture, The *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*. Vol. XXXVII. Part B1. Beijing 2008. C. 1207–1213.

Improving Model of Territorial Organization of Agricultural Land Tenure / E. V. Pismennaya, A. V. Loshakov, S. V. Odinsov, V. A. Stukalo. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*. 2016. № 7(6). C. 1783–1787.

KOSINSKY, V. V., KLYUSHIN, P. V., SAVINOV, S. V., LOSHAKOV, A. V. Monitoring and rational use of arable land in Stavropol region // Land management, cadastre and monitoring of lands. - 2017. -No. 9. – P. 47-56.

NIETHAMMER, U., S. ROTHMUND, M. R. JAMES, J. TRAVELLETTI, M. JOSWIG, 2010. Uav-Based Remote Sensing OF Landslides, *International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*, Vol. XXXVIII, Part 5, Commission V

Proceedings
ISBN 978-609-449-148-1 (on-line)

Symposium, Newcastle upon Tyne, UK; 2010. C. 496–501.

The Impact of Melt– And Rainwater on Soil Erosion by Water in The North Western Part of Stavropol Upland / D. A. Shevchenko, Y. V. Pelikhovich, L. V. Kipa, D. I. Ivannikov. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*. 2016. № 7(6). P. 2446–2450.

PISMENNAYA, E. V., KIPA, L. V., SHOPSKAYA, N. B. Production potential of agricultural zones of Stavropol krai. *The scientific heritage*. Budapest, Hungary. 2016. N 4 (4). P. 10–13.

ROKHMANA, C. A Some Notes on Using Balloon Photography For Modeling The Landslide Area, *Proceeding Map Asia 2008*, Kuala Lumpur, 2008. C. 1–7.

TSKHOVREBOV, V. S., FAIZOVA, V. I., NIKIFOROVA, A. M., NOVIKOV, A. A., MARIN, A. N. Soil fertility problems in Central Ciscaucasia. *Research Journal of Pharmaceutical, Biological and Chemical Sciences.* 2017. T. 8. № 6. C. 574–580.

WHELAN , B. and JAMES T. 2010. An introduction to Precision Agriculture for Australian grains, Australian Centre for Precision Agriculture, University of Sydney for the Grains Research and Development Corporation.; C. 15–22.

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