Digitalization for remote monitoring to sustainable development of agrarian areas at V.I. Vernadsky Crimean Federal University

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Abstract. The article presents the experience of using nano-technologies for remote monitoring of agricultural areas in order to ensure sustainable development of territories. The survey resulted in the content of scientific and technical tasks. Technical testing on the territory of the Republic of Crimea showed how the digitalization can be used in educational process. In the research we identified the most cost-effective methods, sustainable development technologies, unmanned aerial vehicle and remote sensing exploitation algorithms, GIS across the Republic of Crimea. The indications provided by this research include data from integrated monitoring of agricultural lands with a total area of 15,000 hectares in different agro-climatic zones of Crimea (The South Coast of Crimea, Crimean Foothill, The Steppe Crimea, Prisivashye). The full project implementation provided criteria and requirements to promote an educational system in agro-technological digitalization sector.

1. Introduction
Testing the agricultural land remote monitoring technologies in the context of the intensive development of digitalization is an important practical task. Agricultural branch compliance with the regional and world level was indispensable to ensure an appropriate level of staff training. Present-day realities show that the Russian Federation regions as well as CIS countries are in the process of intensive development of remote technologies at the agricultural branch [1-9].

Agricultural field is a fundamental block in the Republic of Crimea economy so the tendency of fast advances in distance monitoring is the most visible.

The training of specialists in context of sustained development inside the Crimea plays an important role for the ideas of noospheric thinking [10-11]. V.I. Vernadsky Crimean Federal University uses the modern approaches in scientific and educational process as a leading part of staff training. [12-14].

Modernization in the Crimean agrarian branch points out a clear request for introducing remote sensing technologies. It causes an urgent need to retrain the specialists from the leading Republic universities.

Currently the introduction of modern technologies is missing in the Crimea. Over a period of 5-15 years we should make a research to find out the perspectives, potential output of total adoption and reproduction of modern technologies and further professionalization of the staff.
In the Republic of Crimea there is a lack of specialized staff because purposefully it has never been done. So, the issue of personnel reorganization takes an important place in the agrarian field modernization system.

A promising task is to form specialized professional degrees, M.Sc. studies, and additional educational system which is based on staff retraining from relevant authorities and specialized organizations.

2. Problem statement
The main task is:
1. to test the agricultural land remote sensing technologies in order to create at educational path due to circumstances available in the Republic of Crimea;
2. training subject-matter experts in context of technological development;
3. the need to ensure the staff training compliance to regional and world level in the educational branch.

The complex result, relevance and novelty of research is to carry out the research to identify the most cost-effective; appropriate methods and algorithms remote sensing technologies, unmanned aerial vehicles, GIS, autonomous weather stations to form the most available technologies for sustainable development in the Republic of Crimea.

3. Methodology and methods
Research Centre for Cyberagronomy was established to integrate science and technology policies in developing university system. The research is carried out by a development programme. Methodologies and ways of agricultural relating sensing remote technologies include the following elements:

1. The University owns an agrarian and industrial complex with the square of 4206 hectare in different Crimean agro-climatic zones (The South Coast of Crimea, Crimean Foothill, The Steppe Crimea, Prisivashye). It is used to collect accurate statistics.
2. The use of space monitoring data, meteorology and vegetation index.

This research area is based on ScanEX - space monitoring station. It served as hardware and software system for remote sensing data reception, processing, dissemination from Low Earth-Orbit. Station allows real-time data processing within 2.5 thousand kilometers from both Russian (Meteor-M, Kanopus V, Resurs-P) and foreign (Terra, Aqua, Suomi NPP, FengYun-3, SPOT 6/7, EROS B, Landsat-8, Sentinel-1A, KOMPSAT-3, RADARSAT-2, TerraSAR-X, COSMO SkyMed etc.) spacecrafts. Also, such devices collect data from all valid meteorological stations (Aqua, Terra, NOAA-18/19, NOAA-20, Metop-A/B, FY-3A/B/C).

Along with this we use database in a form of satellite imagery from Landsat-8 and Sentinel-1A, Sentinel-2 and Sentinel-3. All the information is fully transparent by USGS (https://www.usgs.gov/) and Copernicus (https://www.copernicus.eu/en) projects. It stands with world-level standards in this segment of studies.

3. Using heavy, medium and small unmanned aerial vehicles for integrated monitoring of agricultural landscapes.

For these purposes, the university has an air fleet of unmanned aerial vehicles:
- 2 aircraft type heavy class unmanned aerial vehicles with a set of equipment (UAS ZALA 421-16E2 with unified quick-detachable TsN Z-16AGRO1 / FOTO-multispectral camera and photo camera, UAS ZALA 421-16E2 with unified quick-detachable TsN Z-16F3NIR);
- 1 middle class helicopter type unmanned aerial vehicle (Quadrocopter Geoscan 401 "video" with a set of attachments);
- 1 small class helicopter type unmanned aerial vehicle (Quadrocopter DJI Phantom 4 PRO plus V2.0).
4. The system of meteorological complexes (13 autonomous agrometeorological stations Sokol-M connected into a single information complex) to cover agricultural lands of V.I. Vernadsky Crimean Federal University.

The following meteorological parameters are recorded: air temperature, soil temperature, relative air humidity, air flow speed and direction, atmospheric pressure, amount and intensity of precipitation; indication of hydrometeorological parameters: soil and leaf moisture, ultraviolet solar radiation; photographic recording of weather phenomena.

5. Database compilation with a specific agricultural operation; comparison database and terms with the materials from satellite and unmanned remote sensing.

The basis of this block is the Geoserver which integrates all the project information. Visualization is presented by a Geoportal. It is available for PC and mobile devices.

The main functions of the Geoportal are:
- geoinformation support for making managerial decisions in the conduct of agricultural production;
- agricultural land monitoring using geoinformation technologies and remote sensing technologies;
- providing relevant information about the meteorological components environmental and agricultural lands;
- multiple services delivery to optimize the territorial planning of agricultural enterprises using cyber-agronomy technologies.

4. The main part

Conceptual study design is shown in Figure 1. The basic structuring of the blocks:

1. Using space monitoring data for meteorological parameters and vegetation index.

There was no systematic data collection on regional specific agricultural enterprises for the entire vegetational season based on all the available satellite imagery platforms provided in Crimea.

Cloud condition analysis and database during November 2019 - March 2020 from satellites Sentinel-2, Landsat-8 shows inability of daily or decade-long monitoring.

Satellite orbits make it possible provide one territory photo of the Crimea per day.

Practice shows the small number of images suitable for determining vegetation index by operational monitoring:

a. Simferopol region territory (Agrotechnological Academy lands) - 4 pictures in 120 days (November 13, November 23, December 28, February 16)

b. Malenkoe village college land - 3 pictures in 120 days (November 13, November 23, February 16)

c. Saki district territory (Pribrezhnoye college land) - 6 images in 120 days (November 16, November 23, January 15, February 1, February 4, February 16)

d. Dzhankoy region territory (Agrotechnological Academy land) - 4 pictures in 120 days (December 18, January 27, January 15, February 1, February 16)

e. Yalta territory (Agrotechnological Academy – Foros land) - 3 pictures in 120 days (December 18, January 15, February 1)

f. Sudak territory (Agrotechnological Academy - Novy Svet land) - 3 pictures in 120 days (December 18, January 15, February 1)

The Crimean region spatial can’t cover satellite monitoring during vegetation season to adopt agrarian operations.

Productivity index on V.I. Vernadsky Crimean Federal University agricultural land changed in the range from 0.25 to 0.8. It is a crops active vegetation period. In this period, it is necessary to carry out agricultural operations, for example, fertilization, pest control.
Figure 1. Structurally logical and functional diagram of the project.

During this period, for example, there is an active growing season and increase vegetation winter crops index. Growing season is up to 0.5-0.8 units.

Space monitoring data allows carrying out a certain analysis changes in crop productivity based on existing images. It doesn’t provide a stable opportunity for business managers and agronomists to base agricultural operations on spatial data from a satellite. Dependence on cloudiness leads to lack of stability and consistency to receive information. Retrospective analysis based on received photographs is possible. Daily and a three-day monitoring can’t be done.

Resolving of this issue is the unmanned aerial vehicles of various types, designs and composition of research equipment.

The main task is to develop a methodology for using unmanned aerial vehicles of various calibers: to determine growing index; land monitoring with increased detail; management decisions.

During the growing season 2021-2022 Crimean Federal University is studying this issue.

2. Actual weather data in active monitoring for the main Crimean agrolandscape zones.

Meteorological complex system will allow the more detailed meteorological data collection from ground layer. So, it is possible to study local hydrometeorological features formation of territory. The main result of this research area is the organization of microregional agrometeorological monitoring and forecasting system in 4 regions of Crimea (Prisivashye Central Crimean Part, Saki and Simferopol areas, Simferopol city) It consists of 13 autonomous agrometeorological stations, which allow measuring, recording and forecasting 35 agroclimatic indicators, recording, storage and processing of these indicators on the appropriate server with a fixation interval in 3 minutes within a radius of 15 km.

It is interesting to compare data provided by modern meteorological services - GisMeteo, rp5 and reveal the effectiveness of their use in practical agriculture.

3. Scientific and scientific-technical problems were formed, and we proposed the solution based on the research results.

a. Testing and experimental field research for the best available remote sensing and monitoring technologies of agricultural lands as part of space monitoring systems, unmanned aerial vehicles, geographic information systems, autonomous meteorological monitoring systems;
b. Methodology development to form an educational trajectory for the specialists training and re-training to use innovative remote monitoring technologies of agricultural land in different landscape zones in the Republic of Crimea;

c. Reasoning the structure and characteristics available for remote monitoring technologies in agricultural land. Staff should be able to use innovations in the most effective way. It is settled directly in the Crimea and particular regions for the potential usage, economic efficiency, informativity and relevance;

d. Remote monitoring technologies in practical usage is made for different type of agricultural land according to environmental conditions and region specificity;

It is used for plowed field, permanent crops, vacant lands, urban wastelands, woodland conservancy ameliorative effect, water conservation zones, unauthorized landfill monitoring.

It allows forming an empirical basis for clarification of the practical aspects to form an educational trajectory.

e. Clarifying the qualification level, competencies and criteria structure that staff should follow to work with remote monitoring technologies in the Crimea.

f. Measuring quantification, demand, the need in such specialists to develop the agricultural industry of the Republic of Crimea in the future 5-15 years.

g. Establishing criteria for relevant training initiatives for future specialists and further vocational education. These programs should be structured with the aim of long-term staffing.

h. Develop proposals to train specialized staff in the Republic of Crimea with the aim of usage remote monitoring technologies in agricultural field.

5. Conclusions
1. We formed a scientific, methodological, educational and practical base to train qualified specialists for developing the agricultural sector. Database was formed to correspond Russian and world-level standards in remote monitoring technologies implementation.

2. Methodological framework was formed to integrate unmanned aircraft and nanotechnologies into educational system of agricultural branch.

3. Database was collected with a help of unmanned, automatic agrometeostations and remote sensing technologies as an experimental basis to observe it in different branches in Crimea.

4. Platform for data approbation is V.I. Vernadsky Crimean Federal University structural units, platform for competencies – the Republic of Crimea agricultural lands.

5. Level of region preparedness to compliance nanotechnology, staff qualification level and work experience was the main goal at this research stage.

6. The product of result is scientific-practical research in using remote sensing monitoring of agricultural land in the context of sustainable development of territories.

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