

maps of agriculture will be the basis for the creation of thematic maps for other regions of the Republic. The electronic map of agriculture, created on the basis of improved methods and technologies, serves as a basis for the creation of analytical maps that visualize the qualitative and quantitative indicators of sectors that require a small or separate study of agriculture.

Interactive and web agricultural maps of the republic, created on the basis of field surveys, geodetic measurements, data obtained from government agencies in the field, statistics and other additional, auxiliary sources, in the assessment and forecasting of economic indicators of agricultural sectors, as well as by foreign investors. the importance of web cards in making investments is enormous.

References

1. A. Lefebvre, C. Sannier, T. Corpetti, *Monitoring urban areas with Sentinel-2A data: Application to the update of the Copernicus High Resolution Layer Imperviousness Degree*, J. Remote Sens. **8**, 1-21 (2016)
2. R. K. Oymatov, Z. J. Mamatkulov, M.P. Reimov, R.I. Makhsudov, R.N. Jaksibaev, *Methodology development for creating agricultural interactive maps*, J. IOP Conf. Ser. Earth Environ. Sci., **868** (2021)
3. N. Teshaev, B. Mamadaliyev, A. Ibragimov, S. Khasanov, *The soil-adjusted vegetation index for soil salinity assessment in Uzbekistan*, Conference: GI support of sustainable development of territories: Proceedings of the International conference (2020)
4. T. Dong, J. Meng, J. Shang, J. Liu, B. Wu, *Evaluation of Chlorophyll-Related Vegetation Indices Using Simulated Sentinel-2 Data for Estimation of Crop Fraction of Absorbed Photosynthetically Active Radiation*, IEEE J. Sel. Top. Appl. Earth Obs. Remote Sens., **8**, 4049-59, (2015)
5. B.Y. Tam, W.A. Gough, T. Mohsin, *The impact of urbanization and the urban heat island effect on day to day temperature variation*, J. Urban Clim., **12**, 1-10 (2015)
6. K. Yu, V. L. Wiedemann, X. Chen, G. Bareth, *Estimating leaf chlorophyll of barley at different growth stages using spectral indices to reduce soil background and canopy structure effects*, ISPRS J. Photogramm. Remote Sens., **97**, 58-77 (2014)
7. S. Roy, S. Pandit, E. A. Eva, M.S. Bagmar, M.Papia, L. Banik, T. Dube, F. Rahman, M. Razi, *Examining the nexus between land surface temperature and urban growth in Chattogram Metropolitan Area of Bangladesh using long term Landsat series data*, J. Urban Clim., **32**, 100593 (2020)
8. R. Oymatov, S. Safayev, *Creation of a complex electronic map of agriculture and agro-geo databases using GIS techniques*, J. E3S Web of Conferences, **258** (2021)
9. D. Bazarov, S. Umarov, R. Oymatov, F. Uljaev, K. Rayimov, I. Raimova, *Hydraulic parameters in the area of the main dam intake structure of the river*, J. E3S Web of Conferences, **264** (2021)
10. N.T. Tam, H.T. Dat, P.M. Tam, V.T. Trinh, N.T. Hung, *Agricultural Land-Use Mapping with Remote Sensing Data*, **2**(020)
11. A.M. Youssef, M.A. Hegab, *Flood-Hazard Assessment Modeling Using Multicriteria Analysis and GIS* (Elsevier Inc., 2019)
12. J. Jiang, W. Cai, H. Zheng, T. Cheng, Y. Tian, Y. Zhu, R. Ehsani, Y. Hu, Q. Niu, L.Gui, X. Yao, *Using digital cameras on an unmanned aerial vehicle to derive optimum color vegetation indices for leaf nitrogen concentration monitoring in winter wheat*, J. Remote Sens., **11** (2019)

13. R. K. Oymatov, Z.J. Mamatkulov, M.P. Reimov, R.I. Makhsudov, R.N. Jaksibaev, *Methodology development for creating agricultural interactive maps*, J. IOP Conf. Ser. Earth Environ. Sci., **868**, (2021)
14. S. Khidirov, R. Oymatov, B. Norkulov, F. Musulmanov, I. Rayimova, I. Raimova, *Exploration of the hydraulic structure of the water supply facilities operation mode and flow*, J. E3S Web Conf., **264**, 1-10 (2021).
15. R. Cioffi, M. Travagliani, G. Piscitelli, A. Petrillo, F.D. Felice, *Artificial intelligence and machine learning applications in smart production: Progress, trends, and directions*, J. Sustain., **12** (2020)
16. M. Wojtaszek, L. Ronczyk, Z. Mamatkulov, M. Reimov, *Object-Based Approach for Urban Land Cover Mapping Using High Spatial Resolution Data*, J. E3S Web Conf. **227**, (2021)
17. B. Saipova, Z. Mamatkulov, A. Altiev, M. Rajapbaev, B. Kabulov, *Importance of land use and land cover change analyze in land resource management*, J. AIP Conference Proceedings, **2432**(1), 040038 (2022).
18. Z. Mamatkulov, K. Abdivaitov, S. Hennig, E. Safarov, *Int. J. Geoinformatics*. **18**(1), (2022)
19. N. A. Mfondoum, S. Hakdaoui, R. Batcha, *Landsat 8Bands' 1 to 7 spectral vectors plus machine learning to improve land use/cover classification using Google Earth Engine*, J. Ann. GIS, **00**. 1-24 (2022)
20. M.V. Wojtaszek, I. Abdurahmanov, *Crop water condition mapping by optical remote sensing*, *Int. J. Geoinformatics*, **17**, 11-7 (2021)
21. Z. Mamatkulov, E. Safarov, R. Oymatov, I. Abdurahmanov, M. Rajapbaev, *Application of GIS and RS in real time crop monitoring and yield forecasting: A case study of cotton fields in low and high productive farmlands*, J. E3S Web Conf., **227**, (2021)
22. S. Khasanov, R. Oymatov, R. Kulmatov, *Canopy temperature: as an indicator of soil salinity (a casestudy in Syrdarya province, Uzbekistan)*, J. IOP Conf. Series: Earth and Environmental Science, **1142**, 012109 (2023)
23. S. Egamberdiev, M. Kholmurotov, E. Berdiev, T. Ochilov, R. Oymatov, Z. Abdurakhmonov, *Determination of substrate composition, light, and temperature for interior plant growth*, J. E3S Web of Conferences, **284**, 03015 (2021)

Improving the methods of Agricultural mapping using remote sensing data

R. Oymatov^{1*}, Z. Mamatkulov¹, R. Maksudov¹, M. Bakhriyev¹, G. Aminova¹, I. Menlimuratova¹ and A. Esirgapov²

¹“Tashkent Institute of Irrigation and Agricultural Mechanization Engineers” National Research University, Tashkent, Uzbekistan

²Tashkent State Transport University, Tashkent, Uzbekistan

Abstract. Based on remote sensing data, it is possible to create a real-time database of agricultural sectors of the study area, in particular, types of crops, fisheries, arable land, and other sectors of agriculture. Remote sensing techniques can also be used to help determine crop yields, parasite spread, increased damage, and soil conditions using satellite imagery and aerial photography. In agricultural mapping, a classification algorithm is required that ensures the reliability and accuracy of the data extracted from the remote sensing data. Research and experiments have shown that increasing the accuracy of classification results requires not only the selection of a perfect algorithm but also a high level of knowledge and skills in the field in which the research is conducted. The mapping of agricultural sectors, in particular the classification of crops, also requires close acquaintance with the existing types of crops in the region, their dependence on natural and climatic conditions, and their development trends.

Keywords: agricultural mapping, land monitoring, remote sensing, GIS, satellites.

1 Introduction

Nowadays, agricultural data is the most effective tool for specialization, analysis, and management – Geographic Information Systems (GIS). The operational source of geographic information systems is Earth’s Remote Sensing (RS) data (space images)[1]. Long-term world experience shows that satellite images from Earth satellites provide operational control over crop conditions and crop forecasting, improve the collection of agricultural statistics, and ensure uniformity, accuracy, and objectivity of observation [2–4]. Rural foreign research shows that agricultural research is conducted at the national, regional, and local levels and on individual farms.

Working with the database in the GIS and using spatial analysis tools, it is possible to analyze data on the topography of the land for agriculture, soil properties, and the suitability of hydrological regimes [5–7].

The use of GIS and RS in the development of agricultural maps, on the one hand, serves to increase productivity through the implementation of agro-technical measures on the basis of operational and detailed information on the status of crops, on the other hand, to create electronic agricultural maps reflecting quantitative and qualitative characteristics accepted

* Corresponding author: rustam.oymatov@tiame.uz

as a basis. Use of remote sensing data. The role of remote sensing materials and GIS technologies, which are considered to be modern technologies in the creation of agricultural electronic maps, is invaluable[8].

At present, satellite imagery and aerial photography are used as the main tools for monitoring agricultural lands, as well as for classifying land user types, checking crop yields and their suitability[9].

The classification of agricultural sectors and land users through remote sensing of land serves as a very important piece of information in the conduct of agriculture today. Because today, accurate and reliable information on the users of agricultural lands in the regions and the lands they use is not reflected in any sources.

Objects, in particular plants, soil, water and other bodies, can be distinguished remotely by geophysical data explaining the properties of objects remotely due to their specific spectral reflections. It is much more convenient and cheaper to create an electronic map of agricultural networks through the same physical laws[10–12].

Many satellite images are available today. Because most satellites are used commercially, satellite images taken through them can be obtained for a fee. Examples of such satellites include images from IKONOS, GeoEye, QuickBird, Pleiades, and other satellites. The main reason for their commercial use is the high spatial capacity of the images and their ability to provide high-resolution data on agriculture and mapping. However, today there are also free satellite images that are allowed to be used by all, such as images from the Landsat (1-5, 7-8) and Sentinel (1-3) satellites.

In this dissertation, optical and multi-spectral images from the Sentinel 2 MSI satellite were used in the creation of the electronic map of agricultural networks of Bukhara region.

Sentinel 2 MSI multi-spectral images are made by two satellites in homogeneous bipolar, solar-synchronous orbits at 180 degrees relative to each other, carried out by the European Space Agency's The Copernicus Sentinel-2 mission. The main purpose of the satellite flight is to constantly monitor changes in the 560 southern and 840 northern latitudes, providing multi-spectral images at intervals of 290 km every 5 days, and 2-3 days in the cloudless mid-latitudes.

Typically, remote sensing data from a satellite or aircraft-mounted imaging sensor will have errors and omissions. Preparation for processing involves the preparation of data for analysis, such as the correction of systemic and random errors. Atmospheric correction of images during remote sensing (scattering and stops in the atmosphere affecting the numerical values of the surface of the object); solar lighting geometry; surface erosion; changes in satellite speed and altitude; Effect of rotation, height, errors in sensor operation (disorder in detector response, changes in mirror vibration); loss of the specified imaging line and other errors. But not all of these needs to be reworked by users, most of which are corrected before it reaches the user [10,21].

The most important technologies of preparation for data processing in the separation of information from remote sensing data are radiometric, geometric and atmospheric corrections. Radiometric correction. Radiometric correction of a remotely sensed image involves processing digital images to increase the accuracy of the brightness value. The main purpose of applying radiometric correction is to reduce the effect of errors and inconsistencies in the brightness value of the image. Because these errors can limit a person's ability to process, interpret, and analyse images. Recent scientific studies have argued that controlled classification algorithms show better results [13,20]. Controlled classification algorithms, in particular the Maximum Similarity Algorithm (MLC), Random Forest Algorithm (Random Forest), Base Vector Method (SVM), and Artificial Neural Networks (ANN) algorithms create unique classification capabilities[13]. The Random Forest random forest algorithm is important for its high accuracy and rapid computer analysis of data. Systematically analyses data for data classification based on this random

forest algorithm. Using data obtained from field experimental observations, the algorithm identifies groups by querying a large amount of data in each system. In other systems, classes are also determined by the spectral data voting method, and each pixel is classified based on its own objects [11].

The Maximum Similarity Algorithm (MLC) is one of the most widely used classification algorithms [14]. The algorithm is based on probability, and according to the statistics of field experimental data, each spectral index is assumed to be normally distributed across the class cross section. The SVM algorithm interconnects and classifies the relationships between the measured samples by optimizing the closest location of the field experimental samples and calculating the maximum distances between them [15,16].

The Artificial Neural Networks (ANN) algorithm is an algorithm that can provide appropriate solutions to detect sensor data that is typically nonlinear, complex, inaccurate, and prone to imperfection or error. Image classification using neural networks is performed by determining the tissue property and then applying a regression algorithm [17-19].

2 Materials and methods

Taking into account the unique climatic conditions of Bukhara region (Figure 1) which is the object of research, a technological system of mapping of agricultural lands as of 2020 has been developed. Among the software belonging to the GIS family, the ArcGIS program. In addition, the program has a set of tools for working with raster data, which allows you to process RS data (space images), and perform analytical work using analytical functions. The full capabilities of ArcGIS include the ability to convert spatial raster data from one projection to another, transform images and link coordinates, and export from raster format to vector format [20-21].

For agricultural research, a Sentinel 2 a synthesized spatial image consisting of natural colours in JPEG format connected to a multi-zone (archived images in TIFF format) and a coordinate network was selected. The spatial dimensions of these space images were 30 meters and were taken from the Earth System Data Explorer (ESDE) of the U.S. Geological Survey. This spatial image processing level is L1, and Landsat space images at this level provide their radiometric and geometric correction using a digital model of relief. Outgoing cartographic projection UTM and coordinate system WGS-84. The brightness level of the spatial image, which is widely used in the formation of synthesized images, was realized through the function "Attach channels". Depending on the purpose of the study, the sequence of channels may be different [22-23]. Multispectral spatial image processing is accomplished by modifying indexed images. Based on mathematical operations, raster images are created based on the brightness value matrix in channels with a clear sequence. The pixels in these raster images are called spectral indices. The next stages of the research are carried out using the created image. Vegetation indices are widely used in the study and evaluation of agricultural crop species. These indices are visible and near-infrared spectrum fragments of space images, based on various bright pixels. Currently, there are 160 species vegetation indices, which are classified on the basis of experiments, depending on the characteristics of plants and soils.

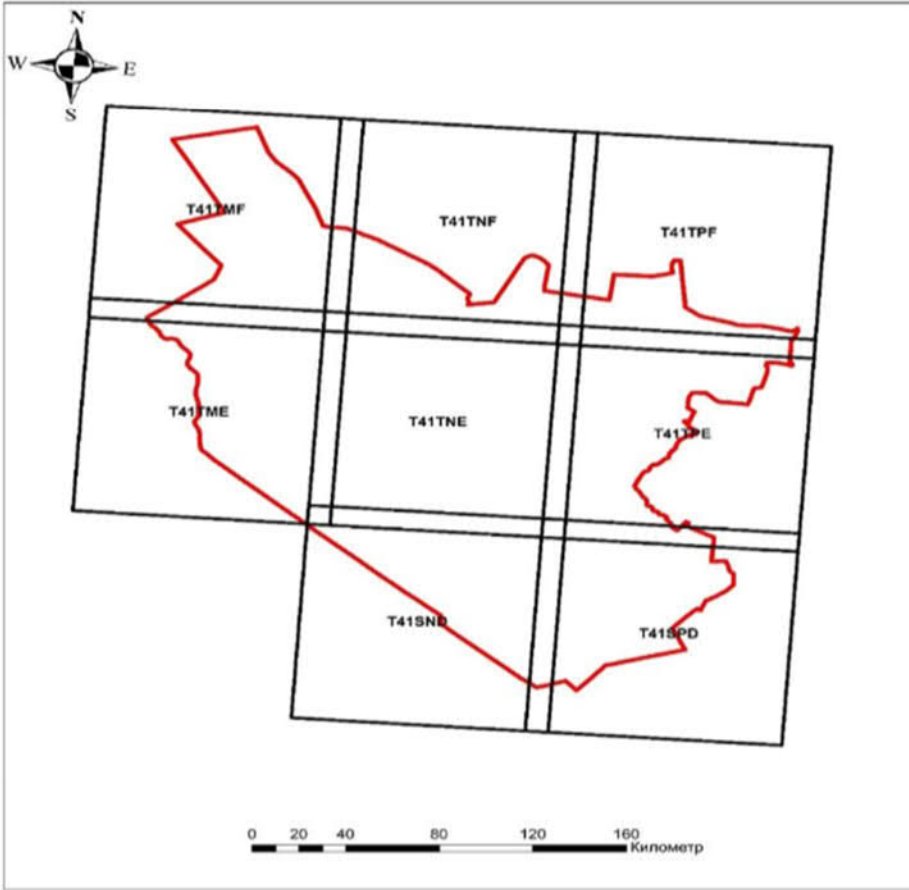


Fig 1. Study area. (Source www.gisgeography.com).

In our research, the study of the distribution and dynamics of change of NDVI vegetation indices consisted of determining the status (species) of agricultural crops using these indices. The NDVI button in the Image Processing window allows you to change the space images in the near-infrared-NIR and red-RED imaging zones and determine the vegetation index [9,22,23].

In ArcGIS 10.8 the NDVI vegetation index is determined by the following formula:

$$NDVI = (NIR-RED) / (NIR + RED) * 100 + 100 \quad (1)$$

In addition, this operation can be used to determine the NDVI vegetation index using the "Raster counter" function of the "Spatial Analyst" window of the program using the following formula:

$$NDVI = (float(NIR-RED)) / (float(NIR + RED)) \quad (2)$$

In the course of the study, the indicators of NDVI of agricultural crops in Bukhara region at different times were studied.

The NDVI value was calculated (Equations 1 and 2) using the Raster Counter in the Spatial Analyst section of the program. The difference between the index, the near-infrared rays, and the mapping value of the red regions of the spectrum is calculated by dividing

their total values. In this process, NDVI values range from -1 to 1. For green plants, it reflects well in the near-infrared region of the spectrum, and in the red range, the rays are well absorbed and the NDVI value is not less than 0. If the results consist of negative indicators, these are mainly in areas covered with clouds, water basins, salt or snow. If the NDVI values are very small (less than 0.1), the areas without vegetation cover, the values from 0.2 to 0.3 describe shrubs and meadows, and the values from 0.6 to 0.8 describe forests. Water bodies, residential areas, vegetation cover were identified using NDVI indicators obtained from the raster format belonging to the study area.

The collection, processing, registration and use of RS data is part of a larger system for agricultural research. The RS system enhances the ability to study the characteristics of agriculture through the proper organization, including the collection, selection, processing and transmission of data on Earth satellites, sensors, space image types.

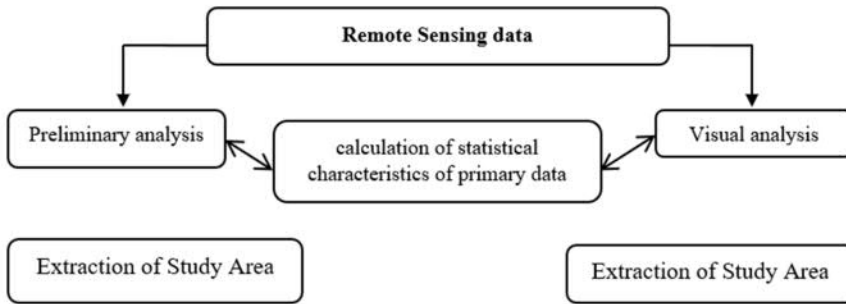


Fig 2. Technological system of agricultural mapping by remote sensing.

3 Results and discussion

Topical cartographic sources, topographic maps, agricultural maps, electronic maps, GPS, field research, remote sensing and statistical data are used as the main sources for creating agricultural maps based on geographic information systems and technologies. RS, topographic maps and statistics are the main sources of information on agricultural sectors, production volumes, natural and socio-economic conditions and infrastructure. Other sources are additional and auxiliary sources to establish the interrelationships of the events depicted on the map and to visualize the general characteristics of agriculture.

The technology of mapping was developed by analysing the cartographic sources used in the creation of agricultural maps. This technology involves 9 steps, including the complete process of creating electronic agricultural maps. At the map-making stage of the process, the main focus is on developing thematic elements of the agricultural map and agro-database.

As a result of the analysis of cartographic sources that serve to reveal the characteristics of agriculture, an agro-geological database based on geo-information systems and technologies was developed. This agro-database can be used for effective management of agricultural activities in the study area, monitoring and evaluation of socio-economic indicators.

A method of identification and mapping of agricultural lands was developed by studying the RS system used for agricultural purposes, space images, methods of their processing and analysis. Using this method, it is possible to classify the types of agricultural crops, assess their condition, determine plant diseases, soil properties and make general monitoring of agricultural activities, as well as thematic mapping.

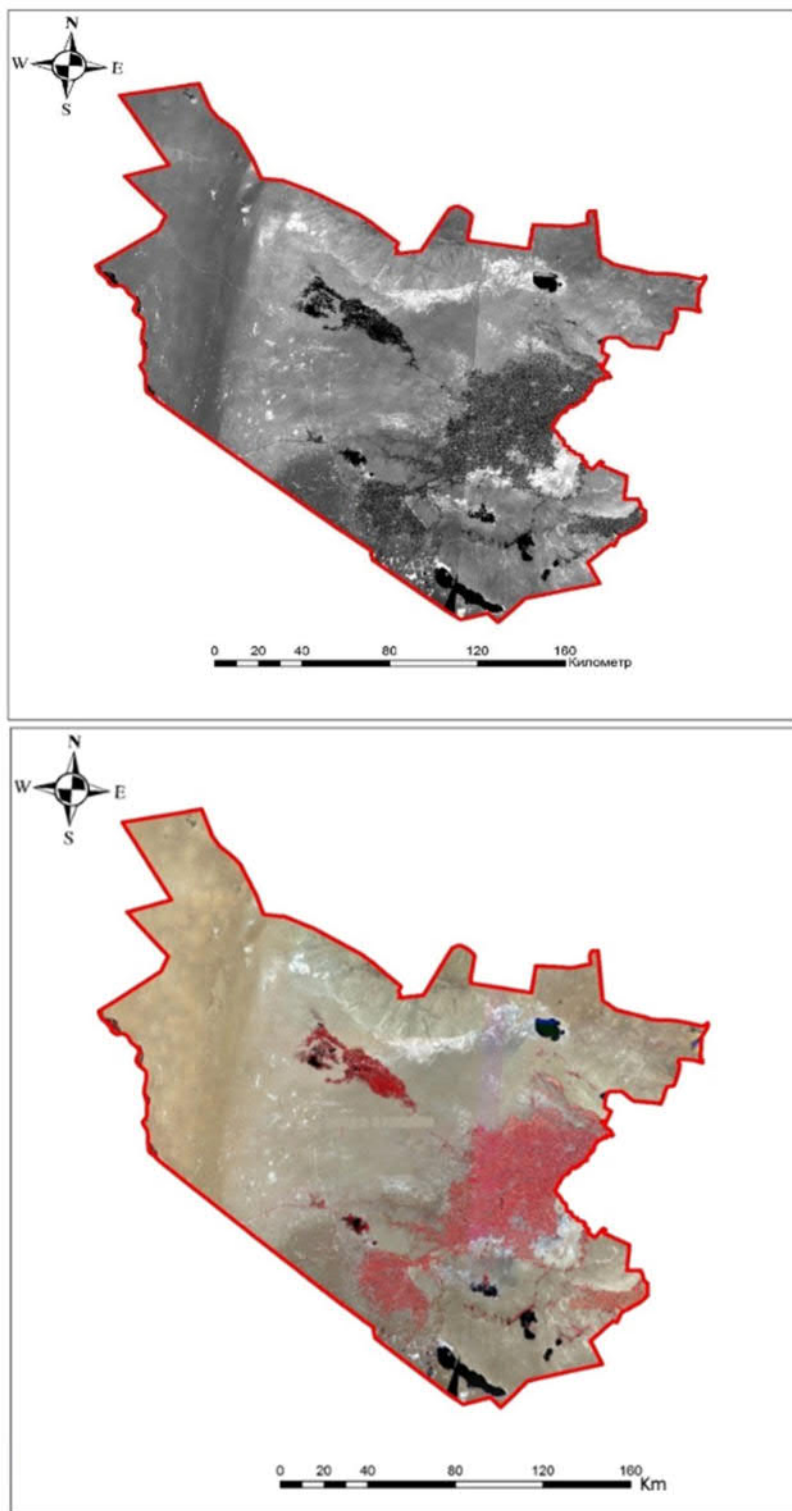


Fig. 3. Sentinel 2 images (band 8- NIR and false colour) of the Bukhara province, Uzbekistan.

Longitudinal and transverse overlays (mosaics) with downloaded and processed Sentinel 2 satellite images, multi-spectral space photoplan of Bukhara region were created with the help of ArcGIS program, and space-photoplan parts outside the province were removed (Figure 3).

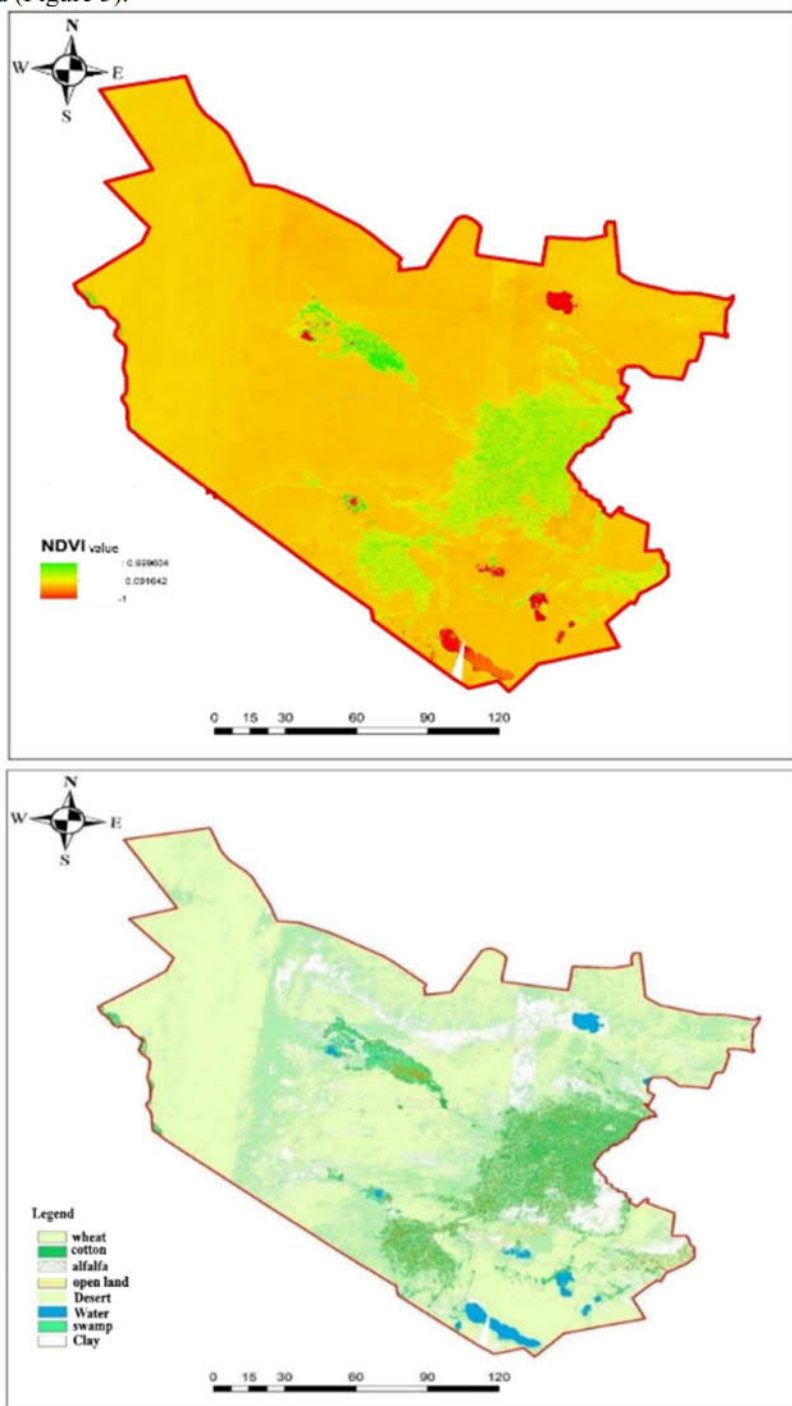


Fig 4. The NDVI maps of the Bukhara province, Uzbekistan.

The composition of the prepared multi-spectral photo plans is created by the command "Composite Bands" located on the toolbar of ArcGIS, the composition of near-infrared-red-green spectra is created using the function "False Color" - "Landscape typological map of the region" were used to separate the cultural landscape types of the area. As a result, the objects in the territory of the region, in particular, allowed to distinguish the specific features of the flora, soil and water bodies.

According to the multi-spectral space-plans of Bukhara region, we will analyse the region's NDVI (Normalize Difference Vegetation Index), i.e., the rate of normal growth of plants, in the separation of types of crops and other sectors. Based on this analysis, we obtain NDVI data on the available flora and biodiversity in the region (Figure 4)

One of the controlled classification types was selected to classify images using the Maximum Likelihood Classification, i.e., to create maps of agricultural networks (land users and land cover). Each controlled classification algorithm, in particular the maximum similarity algorithm, also requires samples on the spectral reflectivity of all objects in the area (plant, building, water, soil, road, etc.) before mapping agricultural sectors. Samples can be obtained as a result of visual and field studies. In this study, the samples also used electronic field (shapefile) data related to agriculture of Bukhara region, developed by field research and organizations under the Committee of the Republic of Uzbekistan "Davergeodezkadastr" with the help of ArcGIS. These data include crop types, settlements, roads and water bodies of the region. Sampling for each object is carried out using the command "Classification" - "Training Simple Manager" - "Sampling Management" in the toolbar of the program ArcGIS.

Based on the available electronic data and research results during the sampling process, the objects are marked as separate fields and stored on a computer. The samples were divided into 10 main classes (grain, cotton, water bodies, alfalfa, pastures, vacant lands, saline lands, fodder crops, mixed crops, horticulture) based on the natural and economic situation of the region. Classification is performed by clicking on the command "Classification" - "Maximum Likelihood Classification" on the toolbar of the program ArcGIS, and the image is classified. This classification method was used for all 6 periods. The error matrix the results of the accuracy assessment study showed that the mapping of agricultural crop species using satellite images taken on 19 June showed 82% of the field-based accuracy and 94% of the application-based accuracy. For cotton, both accuracies showed above 90%, i.e., 97 and 91 percent, respectively. The highest clear results were shown by reeds, fodder crops, water and saline soils. These showed results of almost 100% on both levels of accuracy. The lowest result was shown by mixed crops with 70 indicators. The main reason for the low results of mixed crops is that the lands of residential areas are also considered to be "generalized" within this type of classification. The overall accuracy of the classification was 92% of the result.

The results of the study show that April-August is the main growing season in Bukhara region, and the period from June 2 to July 1 is considered the most favourable period in the classification of branches. This is because it was found in the research process that the vegetation period of agricultural crops is best developed during this period.

4 Conclusions

The natural conditions of Bukhara region, the existing agricultural sectors and infrastructure facilities almost cover the characteristics of agriculture in other regions of the country and can be used as a standard for agricultural research and mapping of regions. As a result of agricultural research and the use of RS data in its mapping, it will be possible to effectively organize the creation of electronic maps of agriculture in a short time. The methods and technologies developed for the creation of electronic, interactive and web