DSinGIS
Doctoral Studies in GeoInformation Sciences

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TASHKENT INSTITUTE OF IRRIGATION AND AGRICULTURAL MECHANIZATION ENGINEERS

REPORT

on study online to Obuda University of Hungary in the frame of the Erasmus+ DSinGIS project

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Content

Introduction

Geographical Information Systems (GIS) and Remote Sensing (RS) techniques have emerged as efficient and powerful tools in different fields of science over the last two decades. The GIS has the ability to store, arrange, retrieve, classify, manipulate, analyze and present huge spatial data and information in a simple manner. The RS technique is used to collect detailed information in space and time even from inaccessible areas. Nowadays, both GIS and RS are regarded as essential tools for groundwater studies especially for extended and complex systems.

Today, importance of Geographic Information System (GIS) and Remote Sensing (RS) technologies in society are improving day by day. GIS and RS technologies are being looked as an important tool for key spheres and directions of Uzbekistan: water and land resources management, agriculture, cartography, geology, ecology and in other sciences, essential in decision making for sustainable development.

Geoinformation Science (GISc) is a new science, however, has its roots thousands of years. It integrates three traditional geosciences (firstly, geodesy as the science of precise spatial data acquisition; secondly, geography as the science of studying human and physical aspects; finally, cartography as the science of making maps. The integration of these sciences is based on the rapidly evolving computer science [1].

Numerous of young researchers and doctoral students of Uzbekistan have been thinking about applying of GIS and RS technologies in their research topics and field of studies. For implementation of those, mainly advanced knowledge of using software devices and computer technologies as well as theoretical and practical knowledge in the field of study are vital [2].

In this case, support of highly ranked foreign Higher Educational Institutions and qualification of their well-qualified teachers play crucial role. Erasmus+ “DSinGIS –Doctoral study in Geoinformatics” project has been giving good opportunity for doctoral students and young researchers of Uzbekistan in case of organizing 2 months scientific and practical training courses to improve their knowledge and skills in Geoinformatics [7].

So far, several researchers and doctoral students from partner HEIs of Uzbekistan have been improved their skills and qualification in their research topic and field of studies at European partner universities. Among them, I also had a chance to visit for two months as a researcher to Alba Regia Technical Faculty of Obuda University, Szekesfehervar, Hungary. However due to the COVID 19 pandemic situation, the trip, scheduled for 2 months, was made in an online view under supervision of Dr.Wojtaszek Malgorzata on the topic of “Applying GIS and RS technologies in precision agriculture”[2] .

Study Plan

Before the study visit to Obuda University of Hungary, Study plan had been applied with requested documents. Here, below study plan is given:

1. Introducing my Supervisor from Host Institute
2. Taking tasks and assignments from my Host Institute Supervisor;
3. Reviewing the scientific papers and articles, which are related to:
   a. Application of Remote Sensing and GIS in precision agriculture;
   b. GIS methods for land use optimization in irrigated agriculture area with ecological constraints.
4. Learning new applied remote sensing methods and GIS programs.
5. Going to library and learning new scientific books which are regarding to my field of study;
6. Learning how to write scientific papers in my research;
7. Participating to International scientific conferences or Workshops (if applicable)
8. Preparation of an article for an international conference together with the Supervisor

Activities and Outputs of the online study

During the two months online study at Obuda University, I have strengthened my scientific and practical knowledge on Remote Sensing and GIS especially QGIS and eCognition software's. Firstly, basic concept of remote sensing, pixel and segment based classification, basic algorithms of image processing were taught by Dr Wojtaszek Malgorzata.

Moreover, under supervision of Dr. Wojtaszek Malgorzata important Remote sensing methods and tasks such as: image geometric correlation, atmospheric correlation, assessing quality of the satellite images, classifying types of Agricultural crops through segments or training areas, monitoring of land cover changes by using supervised and unsupervised methods by using Sentinel 2 and Landsat 8 satellite images (Fig. 1).

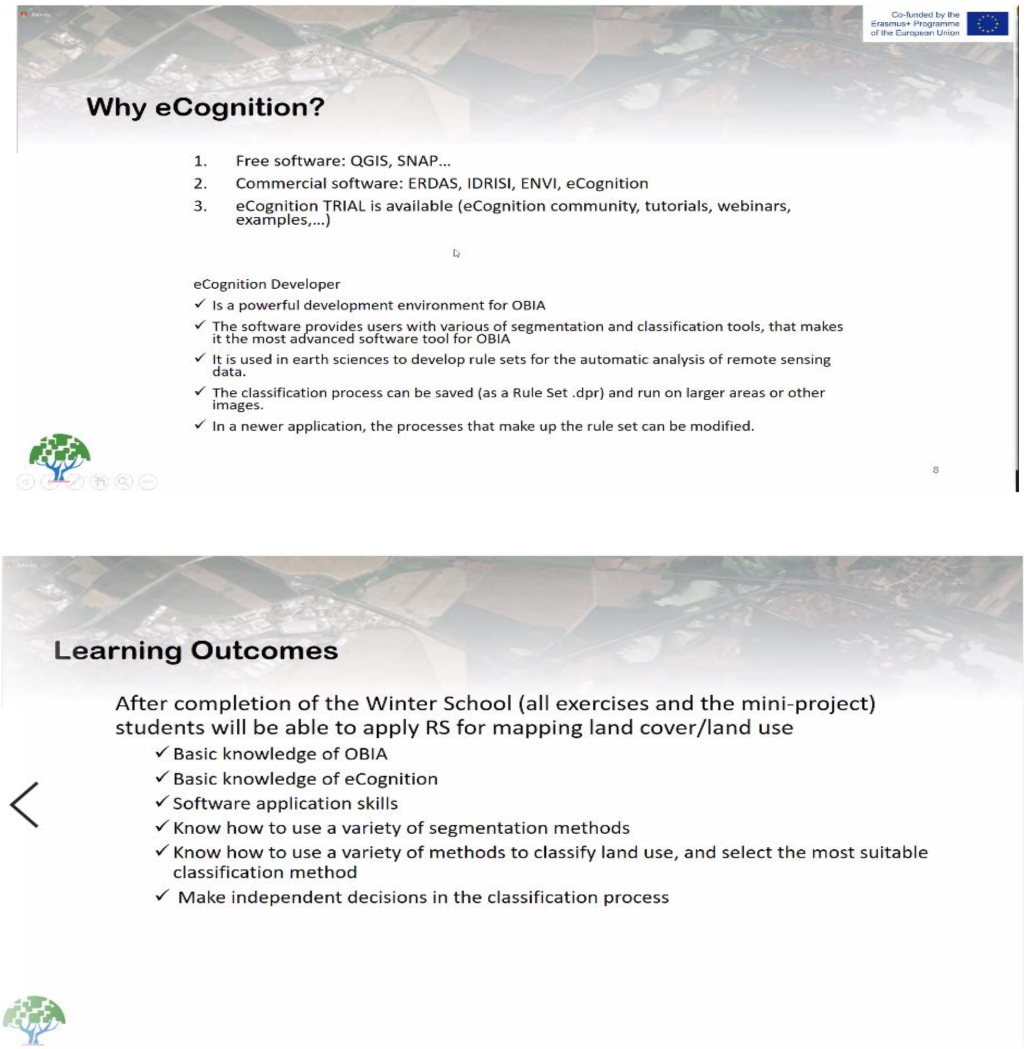


Fig. 1. Introduction to eCognition by Dr. Wojtaszek Malgorza

New software for implementing remote sensing tasks as eCognition Developer software opportunities have been learned and have done some analyses with them on classifying agricultural crop types (Fig. 2 and 3).

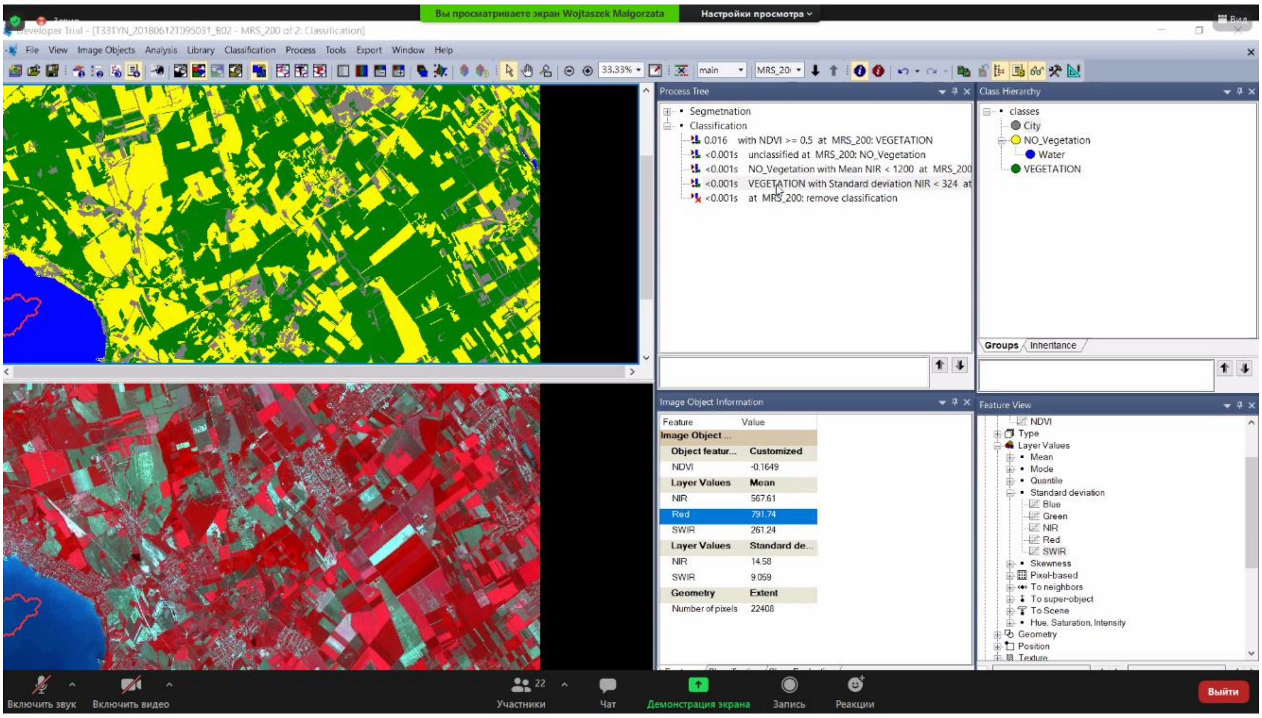


Fig. 2. Land use/land cover classification

Before classifying crop types, process starts with land use/land cover classification.

Land cover is fundamental, because in many existing classifications and legends it is confused with land use: Land cover is the observed (bio) physical cover on the earth's surface [3].

Land use is characterized by the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it. Definition of land use in this way establishes a direct link between land cover and the actions of people in their environment [3].

A classification describes the systematic framework with the names of the classes and the criteria used to distinguish them, and the relationship between classes.

Classification thus requires the definition of class boundaries, which should be clear, precise, possibly quantitative, and based upon objective criteria [3]

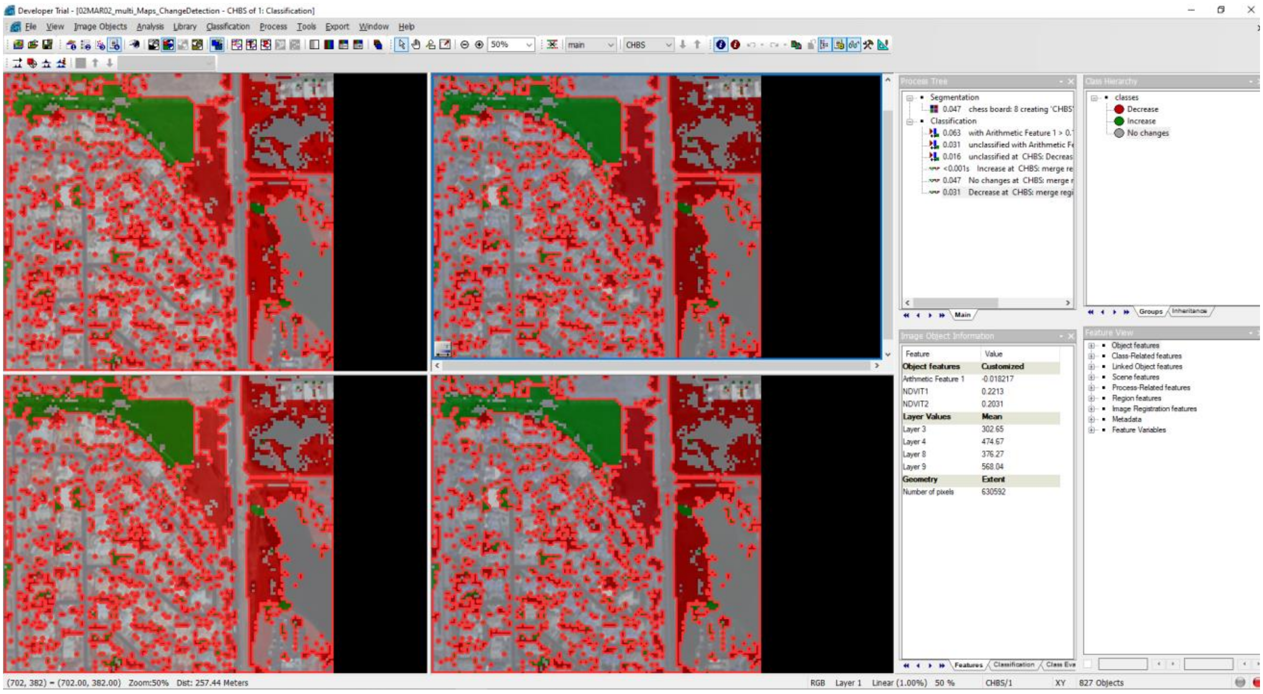


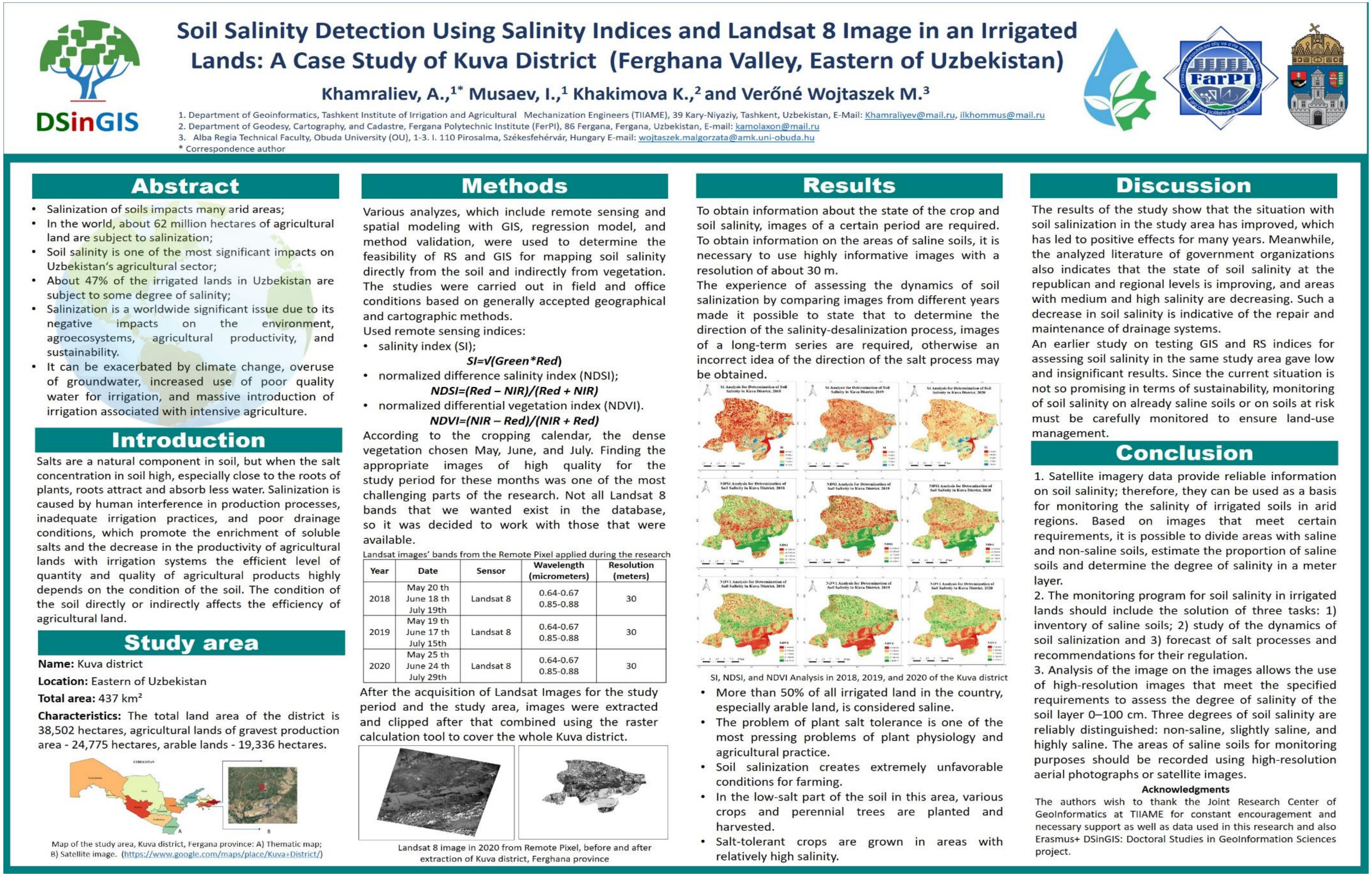
Fig.3. Creating land cover classification of small subset area

Land use/land cover (LULC) classification is one of the most important applications in remote sensing, but is a complex procedure, because different factors, such as the spatial resolution of the remotely sensed data, availability of different data sources (e.g., field survey data, digital elevation model data), a suitable LULC classification system, availability of classification software, and the analyst’s experience may affect the classification results [4].

Classification algorithm should be used for a specific dataset in a study area remained to be answered, although many classification methods, from traditional parametric algorithms such as maximum likelihood classifier (MLC), to advanced nonparametric algorithms such as artificial neural network (ANN),decision tree, and support vector machine (SVM) are available. Another challenge is to select a proper dataset for LULC classification. However, different kinds of sensor data have various characteristics in spatial, spectral, radiometric, and temporal resolutions, as well as different angles and polarizations for radar data. It is important to effectively incorporate different data features into a classification procedure for improving LULC classification accuracies [4].

Another goal of the 2-month study was to prepare an article for an international conference with a research supervisor. Using the theoretical and practical knowledge gained during the online study, using QGIS software an article "**Soil Salinity Detection Using Salinity Indices and Landsat 8 Image in an Irrigated Lands: A Case Study of Kuva District (Ferghana Valley, Eastern of Uzbekistan)"** was prepared for the 2021 GIS-in-Central-Asia conference and prepared a poster for the conference (Fig. 4).

Abstract. Salinization of soils impacts many arid areas. In the world, about 62 million hectares of agricultural land are subject to salinization. At present, about 47% of the irrigated lands in Uzbekistan are subject to some degree of salinity. Soil salinization is a worldwide significant issue due to its negative impacts on the environment, agroecosystems, agricultural productivity, and sustainability. The soil salinity is one of the most significant impacts on Uzbekistan's agricultural sector. This can be exacerbated by climate change, overuse of groundwater, increased use of poor quality water for irrigation, and massive introduction of irrigation associated with intensive agriculture. This is one of the most common land desertification and land degradation processes, especially in irrigated lands including arid and semi-arid regions, characterized by severe climatic conditions, with high temperature and evaporation, and low precipitations. The aim of this study is the evaluate different soil salinity indices derived from Landsat 8 and to assess to potential and limits of remote sensing in detecting soil salinity in irrigated lands.



Soil Salinity Detection Using Salinity Indices and Landsat 8 Image in an Irrigated Lands: A Case Study of Kuva District (Ferghana Valley, Eastern of Uzbekistan)

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Abstract

- Salinization of soils impacts many arid areas;
- In the world, about 62 million hectares of agricultural land are subject to salinization;
- Soil salinity is one of the most significant impacts on Uzbekistan's agricultural sector;
- About 47% of the irrigated lands in Uzbekistan are subject to some degree of salinity;
- Salinization is a worldwide significant issue due to its negative impacts on the environment, agroecosystems, agricultural productivity, and sustainability.
- It can be exacerbated by climate change, overuse of groundwater, increased use of poor quality water for irrigation, and massive introduction of irrigation associated with intensive agriculture.

Introduction

Salts are a natural component in soil, but when the salt concentration in soil high, especially close to the roots of plants, roots attract and absorb less water. Salinization is caused by human interference in production processes, inadequate irrigation practices, and poor drainage conditions, which promote the enrichment of soluble salts and the decrease in the productivity of agricultural lands with irrigation systems the efficient level of quantity and quality of agricultural products highly depends on the condition of the soil. The condition of the soil directly or indirectly affects the efficiency of agricultural land.

Study area

Name: Kuva district

Location: Eastern of Uzbekistan

Total area: 437 km²

Characteristics: The total land area of the district is 38,502 hectares, agricultural lands of gravest production area - 24,775 hectares, arable lands - 19,336 hectares.

Map of the study area, Kuva district, Fergana province: A) Thematic map; B) Satellite image. (https://www.google.com/maps/place/Kuva+District/)

Methods

Various analyzes, which include remote sensing and spatial modeling with GIS, regression model, and method validation, were used to determine the feasibility of RS and GIS for mapping soil salinity directly from the soil and indirectly from vegetation. The studies were carried out in field and office conditions based on generally accepted geographical and cartographic methods.

Used remote sensing indices:

- salinity index (SI);

$$SI=\sqrt{Green*Red}$$

- normalized difference salinity index (NDSI);

$$NDSI=(Red-NIR)/(Red+NIR)$$

- normalized differential vegetation index (NDVI).

$$NDVI=(NIR-Red)/(NIR+Red)$$

According to the cropping calendar, the dense vegetation chosen May, June, and July. Finding the appropriate images of high quality for the study period for these months was one of the most challenging parts of the research. Not all Landsat 8 bands that we wanted exist in the database, so it was decided to work with those that were available.

Landsat images' bands from the Remote Pixel applied during the research

Year	Date	Sensor	Wavelength (micrometers)	Resolution (meters)
2018	May 20 th June 18 th July 19th	Landsat 8	0.64-0.67 0.85-0.88	30
2019	May 19 th June 17 th July 15th	Landsat 8	0.64-0.67 0.85-0.88	30
2020	May 25 th June 24 th July 29th	Landsat 8	0.64-0.67 0.85-0.88	30

After the acquisition of Landsat Images for the study period and the study area, images were extracted and clipped after that combined using the raster calculation tool to cover the whole Kuva district.

Landsat 8 image in 2020 from Remote Pixel, before and after extraction of Kuva district, Ferghana province

Results

To obtain information about the state of the crop and soil salinity, images of a certain period are required. To obtain information on the areas of saline soils, it is necessary to use highly informative images with a resolution of about 30 m.

The experience of assessing the dynamics of soil salinization by comparing images from different years made it possible to state that to determine the direction of the salinity-desalinization process, images of a long-term series are required, otherwise an incorrect idea of the direction of the salt process may be obtained.

SI, NDSI, and NDVI Analysis in 2018, 2019, and 2020 of the Kuva district

- More than 50% of all irrigated land in the country, especially arable land, is considered saline.
- The problem of plant salt tolerance is one of the most pressing problems of plant physiology and agricultural practice.
- Soil salinization creates extremely unfavorable conditions for farming.
- In the low-salt part of the soil in this area, various crops and perennial trees are planted and harvested.
- Salt-tolerant crops are grown in areas with relatively high salinity.

Discussion

The results of the study show that the situation with soil salinization in the study area has improved, which has led to positive effects for many years. Meanwhile, the analyzed literature of government organizations also indicates that the state of soil salinity at the republican and regional levels is improving, and areas with medium and high salinity are decreasing. Such a decrease in soil salinity is indicative of the repair and maintenance of drainage systems.

An earlier study on testing GIS and RS indices for assessing soil salinity in the same study area gave low and insignificant results. Since the current situation is not so promising in terms of sustainability, monitoring of soil salinity on already saline soils or on soils at risk must be carefully monitored to ensure land-use management.

Conclusion

1. Satellite imagery data provide reliable information on soil salinity; therefore, they can be used as a basis for monitoring the salinity of irrigated soils in arid regions. Based on images that meet certain requirements, it is possible to divide areas with saline and non-saline soils, estimate the proportion of saline soils and determine the degree of salinity in a meter layer.
2. The monitoring program for soil salinity in irrigated lands should include the solution of three tasks: 1) inventory of saline soils; 2) study of the dynamics of soil salinization and 3) forecast of salt processes and recommendations for their regulation.
3. Analysis of the image on the images allows the use of high-resolution images that meet the specified requirements to assess the degree of salinity of the soil layer 0–100 cm. Three degrees of soil salinity are reliably distinguished: non-saline, slightly saline, and highly saline. The areas of saline soils for monitoring purposes should be recorded using high-resolution aerial photographs or satellite images.

Acknowledgments

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Fig.4. Poster for the GISCA21 conference

Conclusions and future plans

Erasmus+ “DSinGIS –Doctoral study in Geoinformatics” project has been giving good opportunity for doctoral students and young researchers of Uzbekistan in case of organizing 2 months scientific and practical training courses to improve their knowledge and skills in Geoinformatics and RS.

RS and GIS technologies are well established tools and are routinely used in applied agriculture. Remote sensing and GIS are integrated to each other. The development of RS is of no use without the development of GIS. RS has the capability of providing large amount of data of the whole world and also very frequently. GIS has the capabilities of analyzing a large amount of data without no time. Likewise capability of GIS would have no use without the development of RS technology, which provides voluminous data. GIS and RS can be used as tools to enhance the monitoring and mapping community rangelands.

I had achieved very important and crucial knowledge on my dissertation topic during two months. In the future, I will more develop my knowledge on application of RS and GIS in agriculture.

Acknowledgements

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