DSinGIS
Doctoral Studies in GeoInformation Sciences

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TASHKENT INSTITUTE OF IRRIGATION AND AGRICULTURAL MECHANIZATION ENGINEERS

REPORT

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

(February 1– May 11, 2020)

PhD student: Mr. Ilhom Abdurahmanov

Mentor: Dr. Malgorzata Verőné Wojtaszek

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Content

Introduction

Natural and social science disciplines attach great importance to the domain of geoinformatics (GI). It is seen as a pivotal tool to support decision-making in various and numerouse fields such as natural resource management, spatial and landscape planning, disease mapping and monitoring, crime analysis, transport and distribution services planning, and emergency response [1; 2; 3]. Due to this, there is a growing demand for professionals with GI skills [4; 5; 1].

Especially, in developing countries such as Uzbekistan the number of experts and students in the GI domain is limited compared to the existing needs. This includes, for example, fields such as Geographic Information System/Science, Digital Cartography, Remote Sensing, and Photogrammetry [6, 1, 2; 7].

Now, to address the high and increasing demand on GI experts and, in consequence, on GI education in Uzbekistan, in particular E-learning has gained interest of the DSinGIS project (http://www.dsingis.eu/) which is a funded under the ERASMUS + Capacity Building in Higher Education programme (Key action 2). This project aims at developing a curriculum including E-learning courses to meet the need for teaching and learning content and material related to a doctoral studies programme on GI in Uzbekistan.

The wider aim of the project is to support Uzbekistan in sustainable development by GISc. The objectives envisaged with the project is to establish a missing puzzle from the Uzbek educational system after the MSc level has been completed and before the DSc is targeted [8]. The duration of the project is 42 months (10/2017 – 04/2021) financed by the European Union.

As a key pillar of DSinGIS, exchange scholarships are offered to prospective PhD candidates who are affiliated with one of the Uzbek higher education institutes (HEI) that participate in DSinGIS. These scholarships provide the opportunity for the Uzbek PhD students to embark on a two-month stay at one of the three European partner institutions where they further their research project under supervision of and in close collaboration with the selected mentors from the European institution.

The DSinGIS exchange scholarships aim to enable PhD students to improve their research capacities and advance their doctoral research, particularly through:

- studying state-of-the-art literature and research methodologies for processing and analysis of spatial datasets applicable to their scientific project;
- gaining visibility in the scientific community through support in publishing their research in appropriate, internationally recognized scientific journals and conferences;
- improving their scientific network with contacts at the European HEI, and;
- foster long-term cooperation between Uzbek and European HEIs to facilitate joint proposal development and eventual collaborative research projects.

Taking into account the one of the aim of the project, DSinGIS had a call for young researchers' mobility in short term period at partner universities. Me, Ilhom Abdurahmanov, a current PhD student of the Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, Uzbekistan successfully admitted and shortlisted from the second call of the mobility and had opportunity two-month research-visit to the Alba Regia Technical Faculty of the Obuda University, Szekesfehervar, Hungary. Actually my study visit was planned for the period February 1 – April 1, 2020. But because of the situation with Covid-19, it has been prolonged to May 11, 2020. During this period of stay I continued my PhD research under the supervision of Dr. Malgorzata Verone Wojtaszek in the sphere of remote sensing and GIS on the research topic "Time-series analysis of satellite imagery for monitoring grazing impact in a rangeland ecosystem".

During the 100 days stay I had a great chance to be familiarize with new Remote Sensing analysis such as Land classification, Land use mapping, supervised/unsupervised and segment based classifications and image tools. Moreover, during my visit I had several face-to-face meetings with the Project Coordinator Dr.Lorant Foldvary and Prof.Bela Markus in order to discuss the Project Management issues.

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:

- meet young researchers, professionals, scientists, experts, policy- and decision-makers, students, stakeholders, learn and get acquainted with their experiences, recently implemented projects, researches, applied methods, up-to-date technologies and innovations;
- to explore and learn new research methodologies and technologies and apply them in my research activities;
- develop new methods and researches which I am currently conducting;
- share knowledge, opinions and projects with scientists, experts, researchers, public and private sector representatives active in the field of geoinfomatics;
- participate in different workshops and exhibitions, investigate the latest products, machinery and technology, improve knowledge in geoinformatics, get new ideas and apply them in my research and job;
- learn challenges, opportunities, new trends and experiences in the field of geoinformatics;
- apply for more international educational and research projects/programs together with host partner higher education institution;
- share experiences gained with researchers and students;
- implement my research findings/results into practice here in Uzbekistan.

Activities and Outputs of the stay

As I mentioned above my study visit lasted longer than planned because of Covid-19. During my study visit I could improve my scientific, programming and statistical skills. Under the supervision of Dr. Wojtaszek Malgorzata Verone important Remote sensing methods and options such as image geometric correlation, atmospheric correlation, assessing quality of the satellite images, classifying types of Agricultural lands through segments or training areas, monitoring of grazing land usage, biomass, degradation and cover changes with the help of supervised and unsupervised classification methods by using Sentinel 2 and Landsat satellite images (Figure 1).

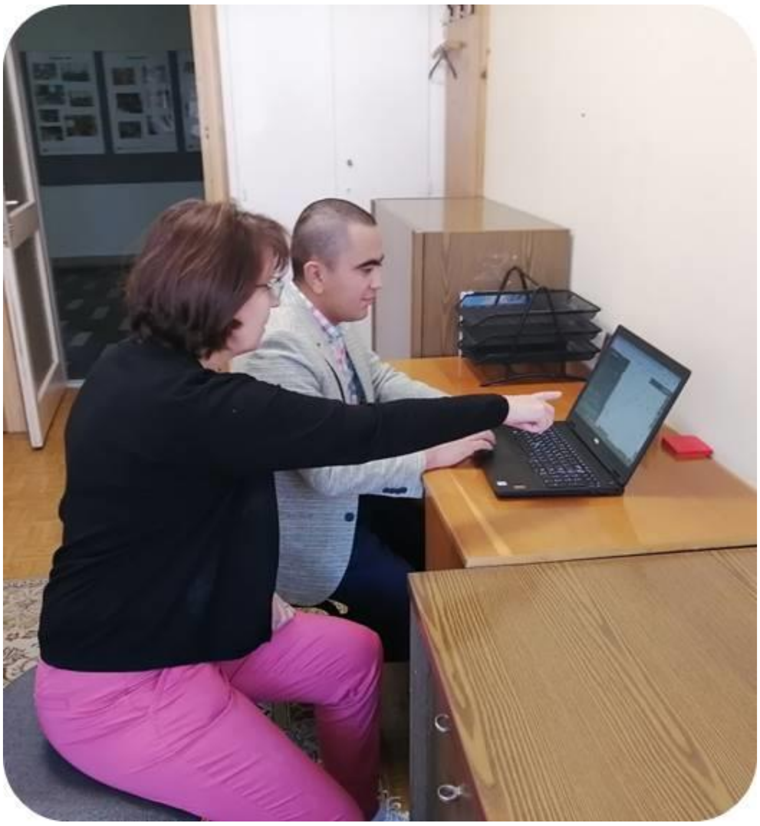

Fig. 1. The working process with Dr. Wojtaszek Malgorzata

Abstract of the research. This research aimed to assess vegetation status via remote sensing techniques using various vegetation indices in semi-desert and desert environments. The feasibility of applying such techniques is tested for assessing grazing impact in study area. The main objective of the research was creating a map shows the territory of rangeland degradation levels in study area for the three years of 2011, 2013 and 2015. Two common vegetation indices (NDVI, SAVI) were derived from Landsat Surface Reflectance (LSR) imagery. Vegetation Indices results were correlated to the field geobotanical monitoring results and appropriate values were defined for four degradation levels (weak, average, strong, very strong). Those values were applied for three years to define a degradation level in order to monitor grazing impact in the study area.

Introduction. Nowadays the total land area of Uzbekistan is 44896.9 thousand hectares, hayfields and pastures 21102.5 thousand hectares, which is 47.04 percent of the total land area [9].

The livestock sector is one of dynamically developing agricultural sectors of Uzbekistan, accounting for 46.8%1 of the gross national agricultural output [10]. The bulk of livestock output is produced by small household (dehkan) farms with an average size of 0.15 hectares (ha), which is the key specific feature of the sector. Livestock production in dehkan farms plays a significant social role, because it is the important source of income and food for rural families [11].

There are 12414.7 thousand cattle, 20680.5 thousand sheep and goats in Uzbekistan [10]. Based on this, we can see that 0.64 hectares of hayfields and pastures correspond to each livestock.

According to statutory regulations, it is indicated that one livestock must be coincided with 1 ha of pasture in extensive technologies. The number of livestock increased, but the pasture lands decreased by 11.6 %, from 1990 till 2012 [12].

To stimulate grazing of flocks in remote rangelands rather than nearby villages it is suggested to establish a pasture fund to be supported from land leasing payments as well as income from environmental services such as carbon sequestration [13,14].

The vegetation changes of semi-desert and desert landscapes are temporally and spatially heterogeneous. Traditional field-based monitoring methods have failed to sample adequately in time and space in order to capture this heterogeneity and thus lack the spatial extent and the long-term continuous time-series of data necessary to detect anomalous dynamics in landscape behaviour [15].

Efficient use of pasture resources, reclamation and environmental problems should be solved by using advanced technology and efficient methods is one of the most important issues.

Fortunately, scientists around the world started long ago to look at the problem of land degradation and have developed assessment and monitoring methods. Therefore, assessment methods have been developed to determine the status of the land, extent and impact of land degradation and to help designing possible conservation activities. Accurate and relevant assessment methods of land degradation in drylands with a flexible scale combining socio-economic, institutional, and biophysical aspects and driving forces are needed to plan actions and investments to reverse land degradation, improve socio-economic livelihoods, and conserve dryland ecosystems and its unique biological diversity [16].

Remote sensing offers unique opportunities to monitor grazing landscape processes, reflected in a large number of studies on land use/land cover change [17,18]. Its techniques have long been applied for the quantitative and qualitative evaluation of vegetation in semiarid ecosystems. Visible and near-infrared (NIR) multispectral images are the most useful data to examine vegetation patterns and corresponding ecological processes at regional and global scales. Vegetation indices (VI) [19] derived from remotely sensed data have frequently been proposed as a method for predicting green biomass.

The use of remote sensing in assessing and monitoring of vegetation, erosion and land degradation under different environmental conditions is reported by many researchers. As can be seen from the above studies that use remote sensing, the methods can be quite beneficial. These examples show that integration of remote sensing with land degradation assessment gives useful results. A remote sensing tool has been available for more than 30 years [20]. Remote sensing is recommended by many users because of its broad areal coverage, repeatability, and cost and time effectiveness. It has the greatest comparative advantage when the scale is small because it can provide data for a large area at one time. Therefore, it is, in principle, an ideal methodology for regional or global degradation assessments [21].

In remote sensing applications VIs play a significant role for qualitatively and quantitatively evaluating vegetation cover by contrasting intense chlorophyll pigment absorption in the red against the high reflectivity of plant materials in the NIR [22]. Studies on the use of remote sensing for assessing the impact of livestock grazing on vegetation cover and land degradation in arid and semi-arid areas are numerous [23,24,25,26,27,28]. In our research we apply and evaluate well-used VIs from satellite data for detecting grazing impacts in a semi-desert and desert environment, and compare it with ground measurements of vegetation.

The main problem with the method is that the data should not be used as such alone but should be accompanied by adequate ground data in order to obtain reliable estimates. This is one of the reasons why remote sensing is most often used for degradation assessments of relatively small areas. Experienced and knowledgeable people are required to interpret the data and run the software [21].

Materials and methods. The research area (1480 km2) comprehends the territory of the shirkats “Bogdon”, “Orolov”, “Mustakillik”, “Narvon” the forest agency in Forish district. It consists of different ecosystems, including a plain with steppe and semi desert vegetation (about 20-30 kilometres broad), where four villages and about 30 shirkat farms are situated, the foothills of the mountains with mainly steppe vegetation, where about 25 villages are situated along the mountain streams and the Nuratau mountain range in the South, mostly under the administration of the forest agency [29].

In this research Landsat ETM+ Surface Reflectance imageries, which represent the wet season (May-June) of 2010 for correlating to the field monitoring results, and dry season (August–September) of the three years of 2011, 2013 and 2015 for applying correlation results, were used. The list of used Landsat images is given in Table 1 below.

Table 1. Landsat Images used in the research

№	Landsat Scene Identifier	Sensor	Spacecraft Identifier	Date acquired
1	LE71550322010148PFS00	ETM_SLC_OFF	LANDSAT_7	28-05-10
2	LE71550322011247PFS00	ETM_SLC_OFF	LANDSAT_7	04-09-11
3	LE71550322013252SG100	ETM_SLC_OFF	LANDSAT_7	09-09-13
4	LE71550322015258NPA01	ETM_SLC_OFF	LANDSAT_7	15-09-15

Surface reflectance is the fraction of incoming solar radiation that is reflected from Earth's surface. Retrieved from satellite images by correcting for atmospheric effects, surface reflectance images approximate what would be measured by a sensor held just above the Earth's surface, without any effects from the atmosphere or illumination and viewing geometry. Surface reflectance is the most basic remotely sensed surface parameter in the solar reflective wavelengths (i.e., visible and infrared), providing the primary input for essentially all higher-level surface geophysical parameters, including vegetation indices, land cover, and land cover change etc. Because removing atmospheric effects increases the comparability between images of Earth's surface taken at different times, surface reflectance is also used to detect and monitor changes on the Earth's surface [30].

Many different methods exist for reducing background influence on VIs. We selected and compared two VIs that characterise the vegetation cover.

Normalized Difference Vegetation Index (NDVI), where [31]:

$$NDVI = \frac{(NIR - R)}{(NIR + R)} \quad (1)$$

SAVI was specifically developed and is recommended for arid environments to reduce soil background effects on the vegetation signal and is calculated as:

$$SAVI = \frac{(NIR - RED)}{(NIR + RED + L)} * (1 + L) \quad (2)$$

The L is an adjustment factor which varies from 0-1 in accordance with soil background conditions. The recommended L factor of 0.5 was used for all images [32].

Figure 2. Geobotanical monitoring processes in the research area

We used field geobotanical monitoring (Figure 2) results which show 4 degradation levels (weak, average, strong and very strong) in 45 sample points within the study area for the year 2010. They were defined by using the traditional method of routing geobotanical research methods and laboratory deciphering the Landsat satellite images. For study of seasonal dynamics of forage on pasture reference sites laid transects 10 m^2 areas, which were carried out mowing and determined biomass of forage plants. Types of rangeland pastures were allocated according to the scheme of typology [33].

Weak – vegetation is characterized by full composition and structure, good life conditions and normal resumption most species, with weak signs of deterioration of the vegetation (the appearance of traces of weed species, a slight decrease in the abundance of fodder species).

Average (moderate) – noticeable adverse changes in the composition and structure of vegetation: growing an abundance of xerophytes, ephemeras and weedy species, they begin to play the role of subdominants; reduced abundance of food plants deteriorates their living condition and renewal; reduced projective cover.

Strong – the composition and structure of communities disrupted, changed set dominate and subdominants (dominated by ephemeral, uneaten, weed species). Status of fodder plants depression, renewed weakness. Pastures knocked out, grass is sparse, low productivity.

Very strong – pastures strongly stamped, indigenous communities were replaced by secondary phytocenosis with the dominance of weed species and ephemeral and very low productivity.

NDVI and SAVI methods were applied for the Landsat ETM+ SR image of 2010, and the mean value for the 5*5 neighbouring pixels was calculated for each pixel of the result image of those methods by using software Erdas Imagine 2014.

The ranges of values for 4 degradation levels were defined by correlating NDVI and SAVI values itself and mean values of them to field geobotanical monitoring results for exact points.

Results and discussion. First of all, we created subset and layer stack the required bands (1-5 and 7) for all satellite images to define and show only the territory of the study area by using AOI (area of interest) method. Then NDVI and SAVI were calculated within the unsupervised classification method for the image of 2010 year. The area was very homogeneous, so that the mean values of the pixels of the NDVI and SAVI result images were calculated as well. Appropriate values for the field monitoring sample point were derived from the images and those values correlated with degradation levels (Figure 3).

The results showed the correlation values were 0.259, 0.283, 0.261 and 0.263 for NDVI, NDVI mean, SAVI, SAVI mean methods respectively. So, we could decide that NDVI mean values were correlated with degradation levels better than other values. That's why we used those values for defining the ranges of values related to degradation levels (Table 2). Those ranges were used for the time series analysis of the Landsat images of the years of 2011, 2013 and 2015 in order to show the degradation level of study area which can help us to monitor grazing impact.

Table 2. NDVI mean values corresponding to degradation levels

NDVI mean value	Degradation level	NDVI mean value	Degradation level
0.10-0.13	very strong	**0.20-0.25**	weak
0.13-0.16	strong	**0.25-1.00**	no degradation
0.16-0.20	average		

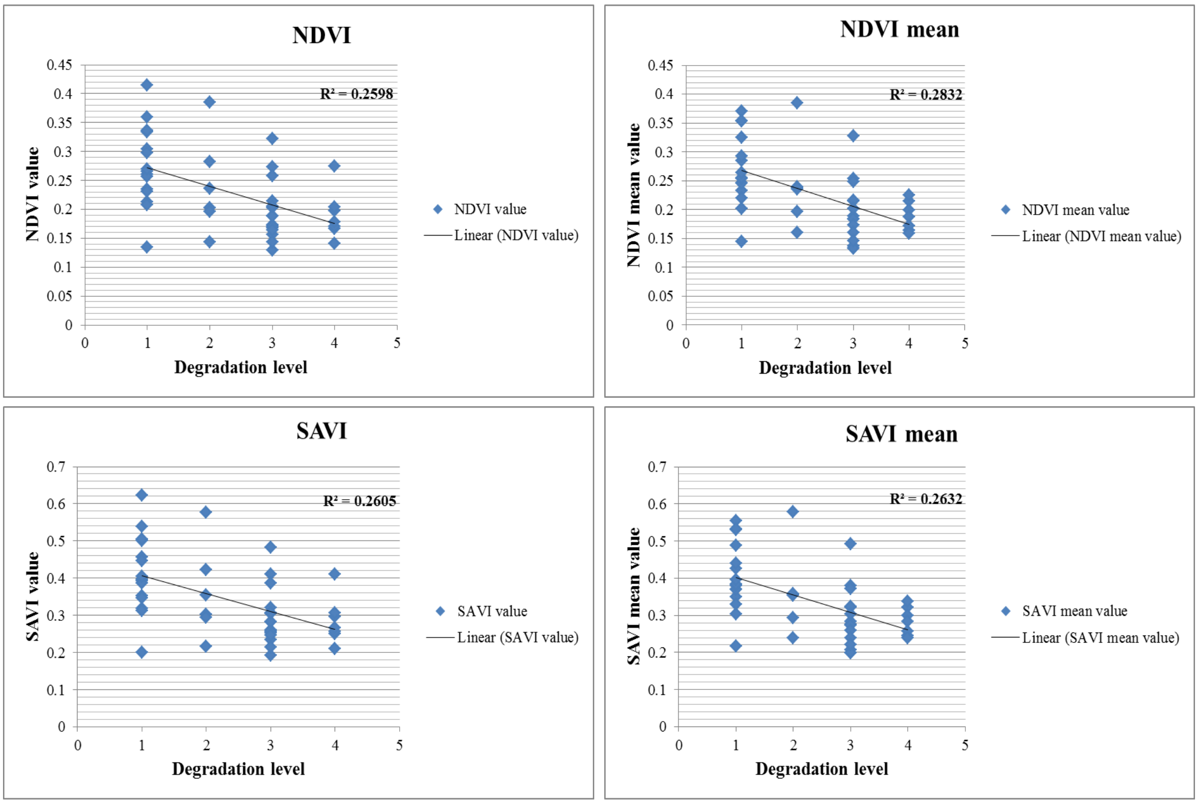

Figure 3. Comparison of NDVI, NDVI mean, SAVI and SAVI mean using degradation levels

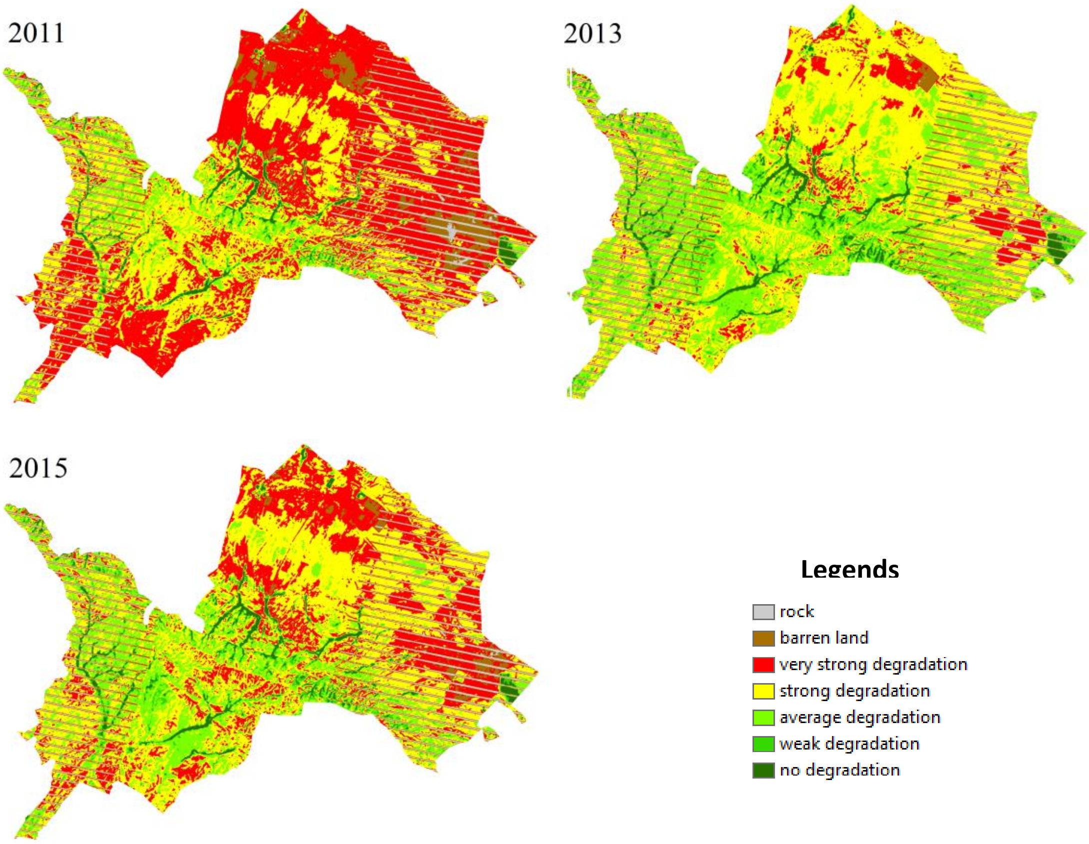

Figure 4. The dry season time series of NDVI images of the research area (Forish district)

We obtained 3 new raster layers for NDVI from Landsat images and other 3 new raster layers for NDVI mean from NDVI images for the years of 2011, 2013 and 2015 respectively. Those NDVI mean raster layers were used to classify and show the degradation level of vegetation. In total 3 images were created for showing grazing land degradation status which can help us to monitor the grazing impact in study area (Figure 4).

The fig.4 shows that the 2013 have particularly pronounced numbers of higher NDVI values (green) than other years and the most of territory were strongly degraded (red) in 2011. Actually, a dry season time series of scenes were used because wet season scenes tend to capture the dynamics of the more ephemeral components of plant communities such as annuals. Dry season scenes are appropriate for this analysis because they are constrained to the more permanent ground cover.

Conclusion. This research shows that Landsat ETM+ can be used to delineate vegetation change in ecosystems threatened by grazing land degradation in semi-desert and desert environments such as Forish district (Figure 5).

Vegetation indices derived from remotely sensed data are capable of estimating vegetation degradation levels on semi-desert and desert rangelands.

The methodology used in this research shows quantitatively that at 30 m spatial resolution both SAVI and NDVI have comparable performance to detect vegetation cover in the study area. Nevertheless, while correlation between the vegetation indices values and degradation levels, the NDVI values were better correlated than SAVI values during our research. SAVI is still correlated to degradation level of vegetation but with a lower accuracy than NDVI.

Hence, it is recommended to use NDVI index to produce vegetation maps for Forish district. Finally, this research confirmed the adequacy of more popular NDVI vegetation index over the SAVI in desert and semi-desert zones.

Figure 5. Rangeland ecosystem of Forish district

During my study visit I visited my former host university which is the University of Sopron, and met my teachers Dr.Kornel Czimber, Dr.Kiraly Geza, Dr.Brolly Gabor, and Dr.Tamas Bacso, and Erasmus+ Coordinator Ms.Marta Sandor. I discussed with them future possible cooperation issues (Figure 6).

Figure 6. Visit to University of Sopron, and meeting with Dr.Cornel Czimber and Dr.Kiraly Geza

In addition, during the quarantine period I have learned a new software SuperMap for implementing GIS tasks. (Figure 7).

SuperMap focuses on providing innovative GIS platform software and solutions for various industries, such as smart city, land management, real estate, urban planning, pipeline management, public service, etc. This software is developed by SuperMap Software Co., Ltd. It is a complete package of GIS platform software, including Desktop GIS, Service GIS, Component GIS and Mobile GIS platforms and spatial data production, processing and management tools.

Moreover, I have participated with the paper and presentation about Erasmus+ DSinGIS project at the 6th International Conference on Research, Technology and Education of Space, Budapest University of Technology and Economics on February 27, 2020, Budapest, Hungary.

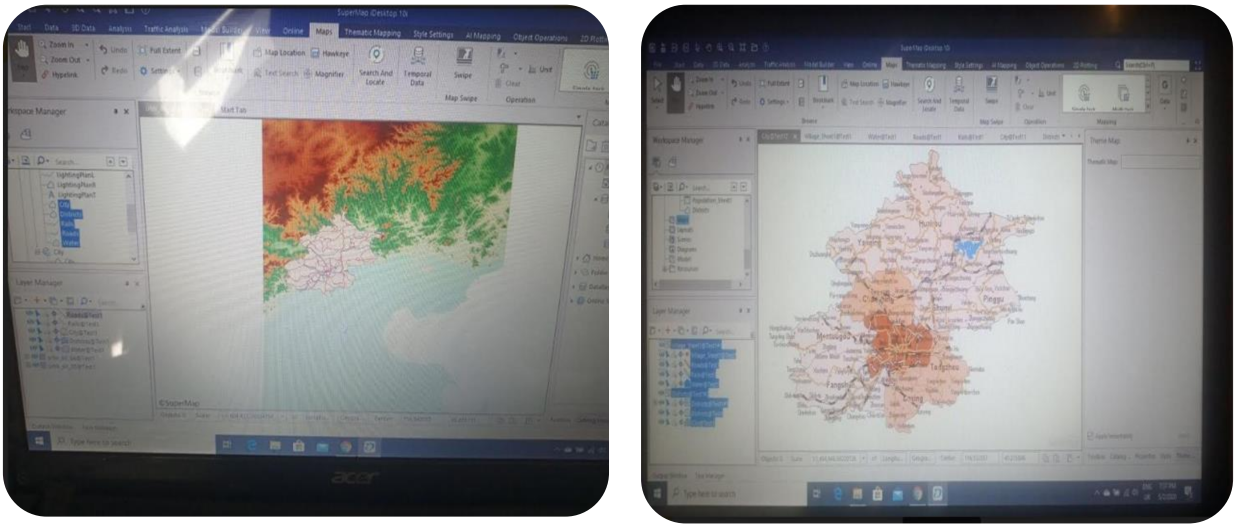

Figure 7. Photos taken during the training

During the quarantine period of Covid-19 I have participated in several webinars, read many sphere based literatures and analyzed lots of article sources related to my dissertation topic at the apartment in Szekesfehervar (Figure 8).

Figure 8. Certificates of participation in the Webinars during the quarantine period

Conclusions and future plans

International scientific exchange, such as DSinGIS and other projects funded by the Erasmus+ program of the EU are of utmost importance for fostering scientific dialogue across national boundaries, exchanging research ideas and methods, and learning about thematic aspects of different ecoregions. International exchange of scientific scholars hence underpins the necessary increase of the knowledge base and is crucial to help solving the grand sustainability problems that humanity faces over the 21st century. International exchange may particularly benefit developing and emerging countries in the development of their research capacities, infrastructures and human resources.

I believe that the collaborative meetings and activities conducted in the frame of the DSinGIS project are excellent tools to strengthen bonds between European and Central Asian institutions, to help develop common ideas about scientific research, and allow to build the strong and long-lasting networks that are needed to continue collaboration towards larger integrated research projects that advance science while at the same time provide solutions for simultaneously improving livelihoods and the environment.

I believe the DSinGIS project has substantially contributed to scientific development of both Uzbek and European scientists, as suggested by the scientific output that has been generated. All involved partners have made new colleagues and even friends in the frame of the numerous visits that have taken place until the COVID-19 pandemic prohibited additional exchange visits.

Erasmus+ project “DSinGIS: Doctoral studies in Geoinformation Sciences” has given me many opportunities to strengthen my knowledge and widen my contacts.

I think I have gained a lot of knowledge and experience on my research during 100 days stay in Hungary. In the future, I will work harder on myself, gain experience and gain in-depth knowledge of GIS.

I really like Hungary as it is my second home country, because I lived there during 2014-2016 years during my MSc study in Geography (Geoinformatics) at the University of West Hungary within the Erasmus Mundus gSmart project. People are really friendly and helpful.

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