Monitoring the dynamics of green spaces in Surkhandarya region based on remote sensing data of climate change

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Abstract. Smallholder farmers in Uzbekistan have been facing severe climate related hazards, in particular highly variable of drought. Climate change-induced rise in temperature is the main impetus for more reforms and adoption of modern technologies in the agricultural sector. This article analyzes the data of 2 weather stations, including Kamashi and Shakhrisabz, in 2017, 2018 and 2019 to study the effects of climate change in the Surkhandarya region and its border areas. These weather stations provide information on temperature, precipitation, relative humidity, and humidity deficit. In addition, Landsat 8 OLI images for the study area were used for land cover change analysis in 2010, 2015 and 2020. In addition, NDVI analysis for the studied area was also carried out. From these data, it can be concluded that intensive horticulture plantations implemented in the region serve as an effective tool to reduce the impact of climate change on the agro-economic sector.
Key words: Mountain and sub-mountain, GIS, degradation, pastures, monitoring.

1 Introduction

Different scenes of climate change including: changed rainfall, increased temperature and higher atmospheric carbon dioxide concentration have particular affection on plant production and crop yields. Cooperatively, these effects have been increasing or decreasing crop production. Rate of evapotranspiration and water stress of crops are also increasing consequences of the increasing temperature [1], [2]. Soil salinity is being studied world-wide using various techniques with satellite observations and remote sensing is the most significant of them for being cost effective, time saving and provides global coverage [3]. Diverse types of satellite data are being used in various kinds of soil salinity studies with similar approaches. RS and GIS related approaches have been adopted by numerous published works in attempts to study, map and model soil salinity in an effectively efficient way [4], [5].

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In Republic of Uzbekistan viticulture has been spreading since ancient times. And today, gardening issues are in the focus of the government. Today, the demand for raisins is not only responsible for the domestic market, but also for demand in the foreign market.

Name of regions	**Gross yield of intensive orchards, thousand ton**			**Average yield of intensive orchards, c / ha**		
	2016	**2018**	**2020**	**2016**	**2018**	**2020**
Karakalpakstan Republic	2.1	121	121	121	2.2	2.4
Andijon	39.4	161	161	161	41.1	44.4
Bukhara	22.4	149	149	149	23.4	25.2
Jizzak	42.5	172	172	172	44.3	47.7
Kashkadarya	15.1	133	133	133	15.8	17.0
Navoi	9.4	142	142	142	9.9	10.6
Namangan	17.3	151	151	151	18.0	19.5
Samarkand	158.0	191	191	191	165.4	178.0
Surkhandaria	18.4	159	159	159	19.16	20.7
Syrdarya	4.4	140	140	140	4.63	4.98
Tashkent	140.6	165	165	165	146.7	158.0
Fergana	5.6	166	166	166	5.86	6.32
Khorezm	12.4	126	126	126	13.0	14.0
In the Republic of Uzbekistan	**489.2**	**168**	**168**	**168**	**510.3**	**549.5**

Table 1: Dynamics of the yield of existing intensive orchards and the gross harvest in the Republic of Uzbekistan from 2016 -2020. [6]

Increasing gardening to a high level, creating and locating fruit trees and grape varieties suitable for soil climatic conditions, using new and modern agro technologies to increase their productivity, thereby expanding the range of fruit and vegetable products and increasing the demand for fruits and grape products. In particular, one of the urgent tasks today is to ensure effective use of existing irrigated lands, preserve, restore and improve soil fertility and ensure their targeted use. The decree of the First President of the Republic of Uzbekistan on April 13, 2013 No. PD-1958 “On measures to further improve the meliorative status of irrigated lands and rational reasonable of water resources for 2013–2017” and the implementation of this resolution on February 24, 2020 Cabinet of Ministers No. 39 concerning “On the territory Republic” of the State Committee for Land Resources, Geodesy of Irrigated Agricultural Land, a study is being conducted on soil maps [7]. Traditional soil salinity assessments have been doing by collecting soil samples and laboratory analysis of collected samples for determining TDS and electro conductivity [5]. However, traditional methods of soil salinity assessment are slow and expensive, because sampling requires long time activities [8] The time consummation of traditional methods has been stated by [9], [10], but GIS and Remote Sensing technologies provide more efficient, economic and rapid tools and techniques for soil salinity assessment and soil salinity mapping . As well as, in Uzbekistan the research institutes and projects, which are responsible for soil salinity assessment using GIS tools in high level. Currently, two main organisations are working on soil salinity assessment including: Meliorative expedition of Surkhandarya province and Cadastre Agency under the State Tax Committee are doing soil salinity assessment in the study area.Republican irrigated lands, geological and hydrogeological objects, orchards and vineyards in the hills and foothills, their biological needs, soil types, as well as resource-saving irrigation technologies, new, modern and innovative irrigation, irrigation methods (methods of unconventional irrigation of orchards and vineyards). For the irrigation season, water is the basis for ensuring water supply for water supply, crop yields, creating scientific foundations and using renewable technologies.

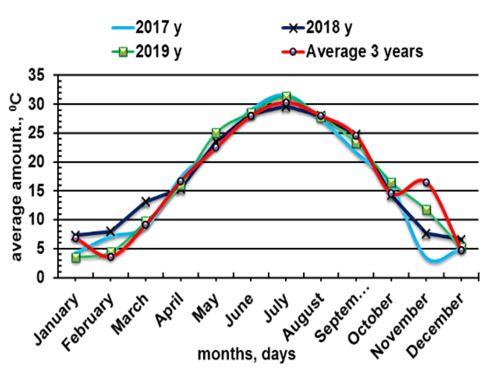
2 Study area

Uzbekistan is a country in Central Asia. It is one of the 12 landlocked countries of Asia. It is bordered by Turkmenistan, Afghanistan, Tajikistan, Kazakhstan, and Kyrgyzstan, all of which are, themselves, landlocked countries. The total territory of the republic is 44892400 km^2, in which just less than 4331700 km^2 is used for agricultural purposes. Large valleys and deserts, foothills and mountain regions characterize the landscape of Uzbekistan. Due to the geographical location of Uzbekistan, dry and continental weather can be observed at any time of the year and it is considered as a (semi-)arid zone [11]. Uzbekistan has a unique climate condition consisting of long, dry and very hot summers, cool and wet autumns and very cold winters with thaws [12].

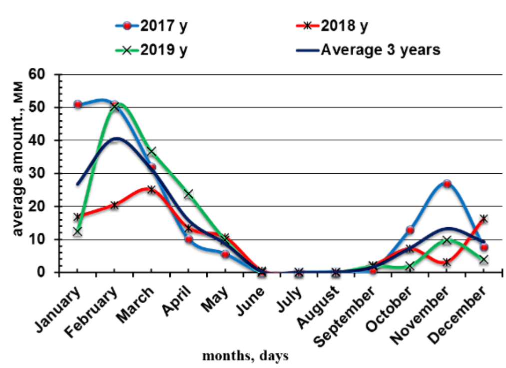
2.1 Climate

Since the massif is located in the south of Uzbekistan, the climate is typical for the southern regions of the republic, i.e. sharply continental. The average temperature during the peak summer time (July) is 28°C while the mean temperature is 1°C in the peak wintertime (January). The mean annual sum of the precipitation is 424 mm [12], [13]. Temperature fluctuations within 16,3-29, 5 ^{0}C for the nearest Kamashi station are shown in Table 2.1.2. The evaporation of water is about 1794 mm. The air temperature fluctuates between 18,9-19,6 ^{0}C, precipitation - within 250-350 mm, the average annual relative humidity of the air is 45-53%, the wind is weak, not higher than 5 m/s, but winds up to 15 m/s are still repeated 1-2 times a month. In a multi-year plan, summer wind invasions occur in July-August. These days, the air temperature rises to 350-450 C, drying up the leaves, which causes a massive dropping of ovaries and cotton flowers. The duration of hot days in the region is 215-245 days a year, and on some days, the temperature reaches 46 ^{o}C - 57 ^{o}C. (fig 1,2,3,4) [14]

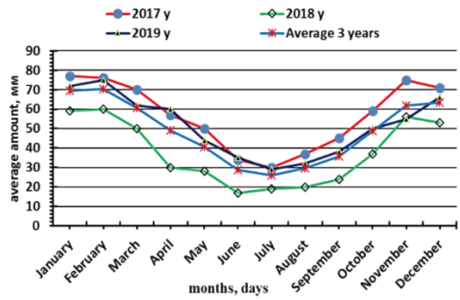
Figure 1. Data from Kamashi weather station.

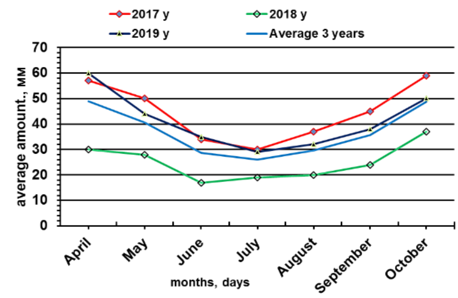


a-fig. Air temperature, ^{0}C



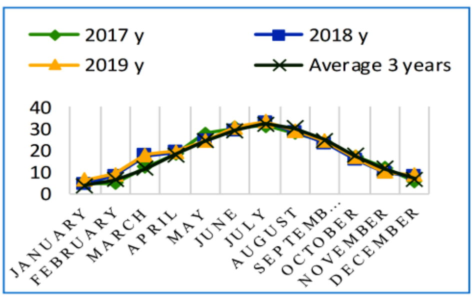
b-fig. Precipitation, mm



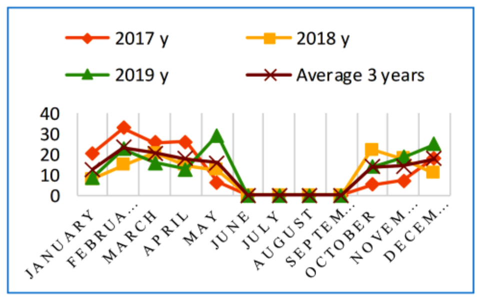


c-fig. Relative humidity,% **d-fig. Lack of moisture, mm**

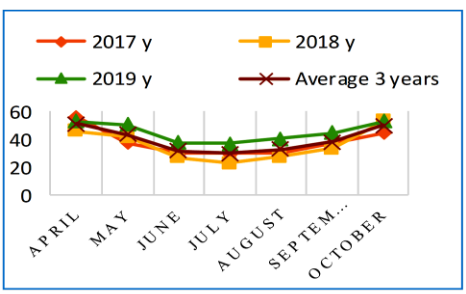
Figure 2: Data from Shakhrisabz weather station.



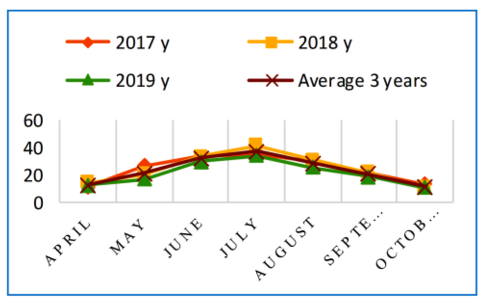
a-fig.Temperature, ^{0}C



b-fig. Precipitation, mm



c-fig. Relative humidity, %



d-fig. Lack of moisture,mm

To achieve additional increases of monitoring land cover changes, the grower deliberately applies approximately of the substance in certain areas of the area to test the correct application of remote sensing. This technology became possible to the development of Geo-informatics, data progress in the land cover of automation of machinery learning, the development of remote sensing data and measuring complexes for collecting information in the land use land cover changes , understanding how land use land cover changing analysis and assessing the effects of future land use change and monitoring [15].

2 Materials and methods

First of all, remotely sensed Landsat 8 OLI image was projected to the WGS 1984 UTM Zone 42N coordinate system and clipped to the extent of the study area. After that, we used an NDSI mask to extract the saline areas. Normalized Difference Soil Index

(NDSI) using equation formula can be used only for Landsat OLI 8 satellite sensor raster layers were calculated using the following formula (Equation 1):

$$NDSI = (Green - SWIR)/(Green + SWIR). \quad (1)$$

The range of NDSI values was divided into 5 classes (Table 2), linked to the soil salinity classification (no salinization, weak, moderate, severe, and very severe salinization) [16], [17]. For the analysing of soil type was used the Soil Adjusted Vegetation Index (SAVI) from a multiband raster Landsat 8 OLI object and returns a raster object with the index values. The Soil-Adjusted Vegetation Index (SAVI) is a vegetation index that attempts to minimize soil brightness influences using a soil-brightness correction factor. This is often used in arid and semi-arid regions where vegetative cover is low soil salinity soils high [18]:

$$SAVI = ((NIR - Red)/ (NIR + Red + L)) * (1 + L), \quad (2)$$

There: L- 0.5 (The amount of green vegetation cover).

Table 2. NDSI range on soil salinity classes.

NDSI range	Soil salinity level
0.17-0.28	Very high salinization
0.30-0.40	High salinization
0.41-0.55	Medium salinization
0.56-0.70	Low salinization
0.71-1.00	Very low salinization

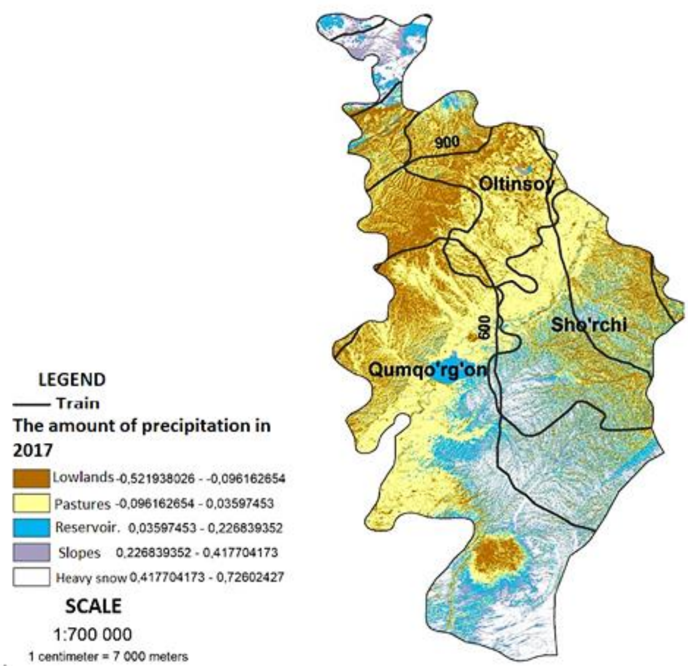


Fig3. The amount of precipitation in 2017

3 Results and discussion

Results of study land use/land cover index for transforming remote sensing data was proposed and evaluated for mapping forest area and bare land/open areas. The index was able to study of changing forest and bare land/open areas with a Maximum likelihood classification. The classification indices could perfectly differentiate between forest and bare land/open land because both of these land types show significantly spectral responses in all Landsat 5 TM+ bands, Landsat8 OLI. The 2010–2020 land cover change map indicates a mix of forest and bare land /open land change classes. Although some of the study area has undergone noteworthy land cove change over the 10-year interval from 2010 to 2020, extensive areas of forest and bare lands were not converted to some other land use. Some of the apparent land cover change during the observation period appeared to be of an agricultural area. Fig.4. In addition, the land cover change map included areas with deforestation, which help to illustrate the dynamic anthropogenic factors of land cover changes in the region during the observed 10-year time frame. The relief map of the study area is taken from the DEM file from the resource earthdata.nasa.gov. The relief map of the studied area identifies the elevation zones of that area, and in the surface classification, it is possible to determine at what altitudes the classification has changed. The results of the analysis show that between 2010 to 2020, forests in the study area, mainly in the area of 1000 m up to 2500 m, decreased and became open lands. (Fig.4)

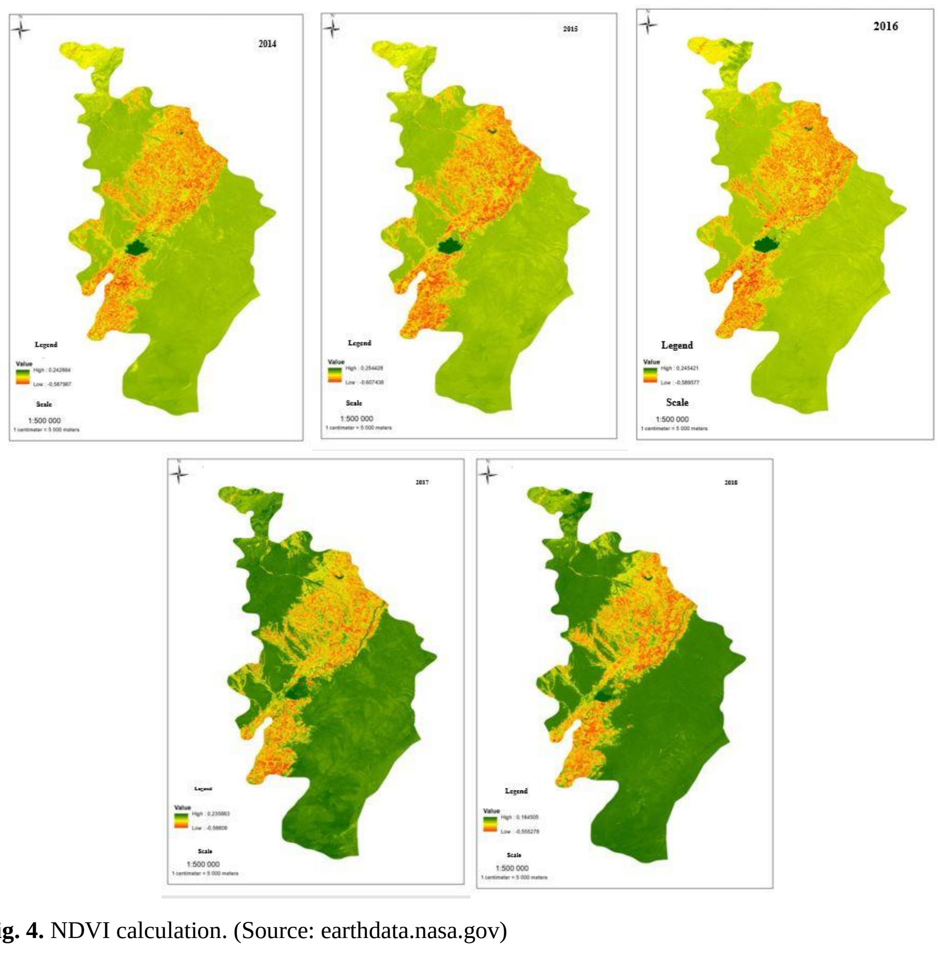
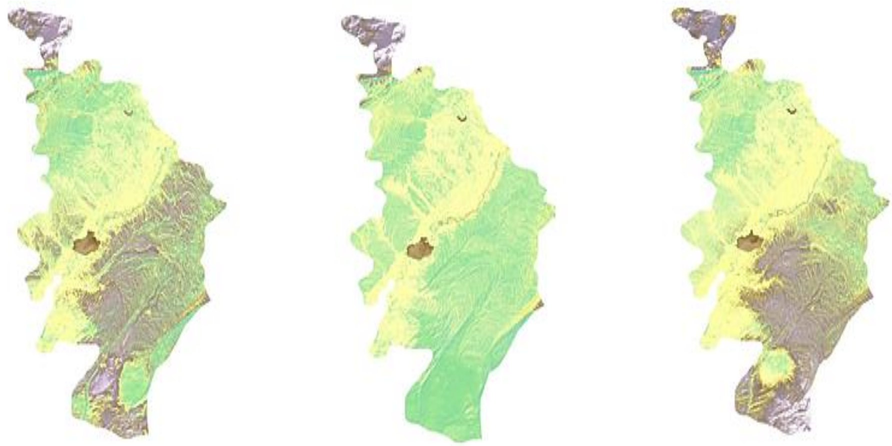


Fig. 4. NDVI calculation. (Source: earthdata.nasa.gov)

The Land cover changes index is rather a hint at what is currently happening on the land. Maximum likelihood algorithms usage for land analysis: at the beginning, in the middle, and at end of the growing season (summer). Growing of the season, the Maximum likelihood algorithms index helps to understand how the plant and trees has changes over the time (Fig. 5).



2010 y **2015 y** **2020 y**

Fig. 5. Land cover changing map.

Nevertheless, it should be kept in mind that high Maximum likelihood algorithms identification land cover classes needed to check using google earth pro this area. Land cover categories confirmed variation in the univariate statistical values of radiation heat flux parameters (Fig. 5. Spatial parameters characterized by gradational change in the values of each parameter. Fig maps shows the range of each parameter under study with their average and standard deviation values gave the best results in terms of land cover classification accuracy. Fig.4 shows the comparison of classes and accuracy for every land cover classes for classifications.

4 Conclusions

Remote sensing methods with accurate Landsat data and monitoring results can support assessing the further behaviour of land cover monitoring. The achieved results show that within 10 years the land cover changes of the mountains and highlands of Surkhandarya significantly. As a result of 10 years of inefficient use of pastures in the mountainous and foothill areas of Surkhandarya, these areas have become open lands. The study area exhibits different land cover changes and that land changes can causes soil erosion, floods, and landslides in future – all of which can turn into hazards once elements are at risk. Kamashi and Shakhrisabz, in 2017, 2018 and 2019 to study the effects of climate change in the Surkhandarya region and its border areas. These weather stations provide information on temperature, precipitation, relative humidity, and humidity deficit. In addition, Landsat 8 OLI images for the study area were used for land cover change analysis in 2010, 2015 and 2020. In addition, NDVI analysis for the studied area was also carried out. From these data, it can be concluded that intensive horticulture plantations implemented in the region serve as an effective tool to reduce the impact of climate change on the agro-economic sector.

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