

DESCRIPTION USGS AND CALCULATION OF NDVI IN QGIS

¹NURZHAMAL M. KASHKIMBAYEVA, ²MIRA ZH. KALDAROVA, ³JAMALBEK A. TUSUPOV, ⁴DMITRY V. LIKHACHEVSKY, ⁵ERMEKOV K. FARABI

¹Ph.D student, Department of “Information technology”, Faculty of information technologies, L.N.Gumilyov Eurasian National University, Kazakhstan

²Senior Lecturer, Department “Computer Engineering and Software”, Faculty of computer systems and professional education, Kazakh Agro Technical University S. Seifullina, Kazakhstan

³Doctor of Physical and Mathematical Sciences, Professor, Department “Information technology”, Faculty of information technologies, L.N.Gumilyov Eurasian National University, Kazakhstan

⁴Ph.D, candidate of technical sciences, Dean of the faculty “Computer design”, Belarusian State University of Informatics and Radioelectronics, Belarus

⁵Head of GIS Technology Center, Kazakh Agro Technical University S. Seifullina, Kazakhstan

E-mail: ¹knm25-1979@mail.ru, ²kmiraj82@mail.ru, ³tussupov@mail.ru, ⁴likhachevskyd@bsuir.by, ⁵f.yermekov@gmail.com

ABSTRACT

The present article gives an overview of the Kostanay region in terms of its vegetation state as it is one of the most significant agricultural produce suppliers. The study was carried out using the means of remote sensing as a source of data, which was consequently used to derive the NDVI figures with QGIS software that offers tools for handling raster calculations. Even though the period of study was as short as six months, beginning from May 2019 to October 2019 inclusive, the derived figures have shown that the arable land was efficiently used in summer months; however, the figures followed a descending trend from August to October 2019.

Keywords: *Remote sensing, satellite imagery, Normalized difference vegetation index, Quantum GIS, land monitoring, area coordinates, line graph.*

1. INTRODUCTION

The use of images in socio-economic research is not as widespread as in the study of natural resources. Most significant is their use for agricultural purposes. Agricultural industry plays one of the leading roles in the economies of both developed and developing countries. Food production concerns everyone, and efficient and profitable production is the goal of any state, regional governance structures and an individual producer. Accurate and timely information on the condition of crops and soil, an assessment of the quality and quantity of the future crop and, as a result of this, the forecast of prices for agricultural products have a significant impact on the economy of a particular region and the entire world trade.

The vast territories occupied by agricultural land are rather difficult to control due to the lack of accurate maps, an undeveloped network of operational monitoring points, ground stations, including meteorological, the lack of air support, due to the high cost of staffing, etc. In addition, due to various kinds of natural processes, there is a constant change in the boundaries of sown areas, soil characteristics and vegetation conditions in various fields and from site to site. All these factors impede the obtaining of objective, timely information necessary for stating the current situation, its assessment and forecasting. And without this, it is almost impossible to increase agricultural production, optimize land use, predict crop yields, reduce costs and increase profitability. Space imagery materials can help both for solving

complex tasks of managing agricultural territories, and in highly specialized areas [1].

Using satellite monitoring, it is possible to control the timing and quality of basic agricultural work and thereby optimize the management of agricultural production [2].

Remote sensing data are growing exponentially in variety, volume and velocity, due to more satellites being sent into orbit and more sophisticated sensors that provide higher resolution [3].

Ever since the Republic of Kazakhstan has gained independence, agriculture has played a significant role in the development of Kazakhstan and its economy, providing produce for domestic use and import and multiple workplaces. It is estimated that around eighteen million hectares are occupied by grain crops, and out of them, approximately twelve hectares are used for cultivating wheat whose gross harvest amounts to six hundred thousand tonnes a year. The wheat crop breeds cultivated in Kazakhstan are rich in gluten, and, as it has been stated above, a great deal of harvest is imported to the countries worldwide, making contributions to state income. [4], [5].

These days, it is common to utilise the means of remote sensing technology to track changes in vegetation dynamics, temperature and precipitation changes, urbanisation, mapping of ocean floors, etc. [6]. This way, remote sensing is able to facilitate in assessment of the vegetation areas, providing statistical information on many aspects, such as plant traits, soil state, crop yield forecasting, etc. Thanks to the development of the cutting-edge technology, there are various means of acquiring the information remotely, which includes aircrafts, drones, probes, satellites, etc. [7], [8].

Remote sensing is the acquisition of Physical data of an object without touch or contact. Remote sensing is the acquisition of Physical data of an object without touch or contact. With the advancements in sensor technology, earth imaging is now possible at an unprecedented level of detail. Imaging spectrometers and thermal multispectral systems acquire detailed spectroscopic information of physical properties of the earth's surface.

Most of the satellite remote sensing data immediately comes in digital form, which allows you to directly apply modern computer technologies for their processing, using which it becomes possible to assimilate and implement satellite information using automated data

processing systems. Such systems usually contain two groups of blocks that differ in technological purpose. The first group of blocks provides automation of solving technical problems, including the geographic location of the image. The second group allows you to automate the solution of meaningful tasks, that is, it provides information about the characteristics of the studied objects.

Methods of digital image processing play a significant role in space research, including the compilation of maps from satellite images. Digital image processing to obtain a geographical result is a sequence of standard procedures defined for each task.

The ground-based data processing system is designed to extract useful information from multispectral remote sensing data and transmit it to consumers. The processing system is an intermediate link between the remote sensing sensor and the user. Therefore, its characteristics largely depend both on the nature of the data and, to a large extent, on the requirements of consumers of remote sensing information [9].

Satellite imagery has become a valuable tool in tracking the state of vegetation in many countries, using the NDVI index, proposed by Tucker [10] as opposed to Jordan [11] who first suggested to implement Simple Ratio to describe and assess vegetation. NDVI, which stands for normalised difference vegetation index, is used for detecting whether a particular targeted area is covered by green vegetation [12].

The primary purpose of this paper is to determine and analyse the changes of NDVI of Kostanay region throughout the period from May 1, 2019 to October 31, 2019. Kostanay region has been chosen because of its significance as one of the main wheat-producing regions in the Republic of Kazakhstan (Figure 1).



Figure 1. Kostanay region overall area as marked on USGS source Earth Explorer

Kostanay region, as one of the main producers of agricultural products, is located in the north-western part of the country between the mountains of Ural on the west and the Kazakh hills on the east with Tobol and Urgan rivers close by. Out of 114 thousand square kilometres of its area, the total amount of land used for agriculture accounts for 18 thousand hectares which arable land reaching approximately 5.6 hectares overall. [13] Kostanay region's significance is also conditioned by its gross output of agricultural produce, making up about 91,882.4 million tenge, half of which comes from crop production [14].

It also should be noted that the Kostanay local authorities have paired up with software developers to provide local manufactures with a tool to track the state of crop fields by the means of satellite imagery and various methods of utilising this imagery to derive various figures as it has been stated above. The project itself is in the phase of development and deployment, and the demonstration does not yet satisfy the demands of obtaining quality quantitative information about areas of interest.

2. DATASETS AND METHODS

2.1. DATASETS

The presentation of the data largely depends on the nature of the applications and the processing procedure used. For the tasks of studying the spatial and temporal variability of hydrophysical characteristics, one of the most suitable methods is to present the data in the form of maps.

Visualization tools allow you to create visual representations for the results of the analysis of satellite images. The use of color for image rendering is due to several reasons. Firstly, the color facilitates the recognition and selection of an object in the image, and secondly, a person is able to distinguish between thousands of different shades of color and only about two dozen shades of gray. The second circumstance is especially important in the visual analysis of images.

The color in this color model is described by three color values ranging from 0 to 255. Each value corresponds to one of the base colors and indicates its content in this color. The values are written in the following order: red, green and blue components. Table 1 provides descriptions of a

number of colors, including basic ones, in the RGB color model.

Table 1. Descriptions of some colors in the RGB color model

Red	Green	Blue	Result
0	0	0	Black
255	0	0	Red
0	255	0	Green
0	0	255	Blue
0	255	255	Blue
255	0	255	Yellow
255	255	0	Purple
255	255	255	White

For the purpose of presenting data in the form of cartographic images, palettes are developed in accordance with the means of the software used.

Although the processing of remote sensing data includes standard steps, the specific implementation of these steps depends largely on the software used. Today, workstations and personal computers with high-speed processors and high-capacity drives have become the standard in remote sensing data processing systems, which makes corresponding requirements for data processing procedures [15].

For the purposes of this study, 20 samples of satellite imagery from USGS was used; in particular, the imagery obtained from Sentinel-2, the Earth observation mission designed to obtain high spatial resolution optical imagery of land and coastal areas.

It aims at monitoring variability in land surface conditions, and its wide swath width (290 km) and high revisit time (10 days at the equator with one satellite, and 5 days with 2 satellites under cloud-free conditions which results in 2-3 days at mid-latitudes) will support monitoring of Earth's surface changes. With its frequent and systematic coverage, SENTINEL-2 will make a significant contribution to land monitoring services by providing input data for both land cover and land cover change mapping, and support the assessment of biogeophysical parameters such as Leaf Area Index (LAI), Leaf Chlorophyll Content (LCC) and Leaf Cover (LC) [16].

The properties included a custom-derived shape of Kostanay region and additional properties in a form of omission of imagery with cloud cover above 10% as high cloud cover is known to distort the true NDVI figures [17]. Apart from skipping cloud-covered imagery, it was decided against using incomplete imagery with black distortions; this way, only complete and whole imagery was used. As it has been stated above, Kostanay region covers a vast share of land, so the areas provided by Sentinel-2 consisted of square-shaped portions much inferior to the overall area (Figure 2). The main point of the virtual raster is that on-the-fly QGIS mixes (composites) the necessary satellite imagery channels in the RGB model, creating a small (several kilobytes) metafile that stores information about the combination of channels. In addition, each month of the 6-month period was divided into approximately three parts, meaning imagery dated the beginning, middle and the end of each month. No additional parameters have been used.

As a rule, a specialist works only with a narrow area from the whole huge space image, therefore it is advisable to cut the desired fragment and put it in the project folder as part of creating a completely autonomous project. In this case, you will not have to look in the future where the original space image was put.

If super-high resolution images are used (2m, 1m, 0.5m), it is advisable to use pyramids (the method of creating small copies of images of different levels) to achieve high speed [16].

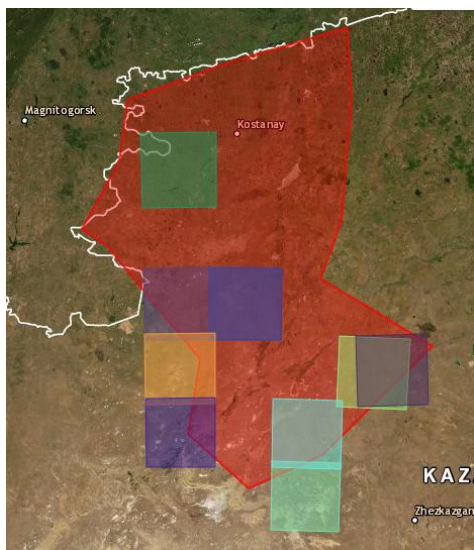


Figure 2. Sentinel-2 square-shaped imagery

It is advisable to adjust the image after cutting (clipping) a fragment of a space image. The newly formed raster image requires adjustment and will most likely look visually rather unsightly - too dark or non-contrast.

2.2. METHODS

QGIS software provides some of the tools required to manipulate and analyze remote sensed imagery in Processing Toolbox external algorithms (GRASS, SAGA or OTB).

For obtaining the figures of NDVI, a QGIS software was used which allowed the calculation of NDVI and its pseudocolouring according to the NDVI scale, where red stands for -1, yellow – for 0, and green – for 1. NDVI is derived according to the following formula:

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

Where NIR stands for near-infrared regions, RED stands for spectral reflectance measurements acquired in the red.

The relevance of using NDVI to assess the past and current state of cultivated fields lies in the fact that the indices presented clearly outline whether cultivations are weak and thinned or well-developed since the figures for both of these states are different. Moreover, not only does it show the state and the agricultural works taking place in the target area but also weeds because their indices also differ from that of healthy crops. The calculation relies on two stable sections of spectral reflection curve of vascular plants. The red region of spectrum (0.6 – 0.7 μm) denotes the maximum absorption of solar radiation by chlorophyll contained in higher plants, while the infrared region (0.7 – 1.0 μm) shows the maximum reflection of leaf cell structures. This way, high photosynthetic activity which typically indicates luxuriant vegetation causes less reflection in the red region and constitutes to an increase in the infrared region figures. NDVI can be calculated on the basis of any high, medium or low-resolution images with spectral channels in red (0.55-0.75 μm) and infrared (0.75-1.0 μm) ranges.

The spectral reflectance figures are displayed on standardized continuous gradient scale and only range between -1.0 and +1.0. For example, dense vegetation would account for around 0.7, thinned one – 0.5, while empty soil would only constitute close to 0.025. Interestingly, the negative figures would be shown by snow and

ice (-0.05), water (-0.25) or artificial cover materials, such as concrete, asphalt, etc. (-0.5) [18].

For the purposes of this study, the only bands used were 4, which is the RED, and 8 – NIR out of 12 available [19], so the modified equation looks the following way:

$$NDVI = \frac{Band\ 8 - Band\ 4}{Band\ 8 + Band\ 4}$$

3. RESULTS AND DISCUSSION

3.1. OVERALL TRENDS

As it can be seen from Table 2, NDVI indexes have increased from May to August and then followed a downward trend. Minimum figures

remained relatively consistent throughout the period, ranging from roughly -0.5 to -0.3, which denotes the inhabited area of the region with urban features, such as concrete, asphalt, and weather conditions; in addition, negative results can denote water coverage. As opposed to the minimum indicators, it is clear that maximum values were prevalent in summer months with June having averaged at nearly 0.7, which is a demonstration of dense vegetation, while the lowest figures were recorded in the end of October. A visual representation of the figure changes can be observed on the Figure 3. In addition, a pseudocoloured map of the region is presented on Figure 4 (a, b, c, d, e, f): red stands for -1, yellow – for 0, and green – for 1.

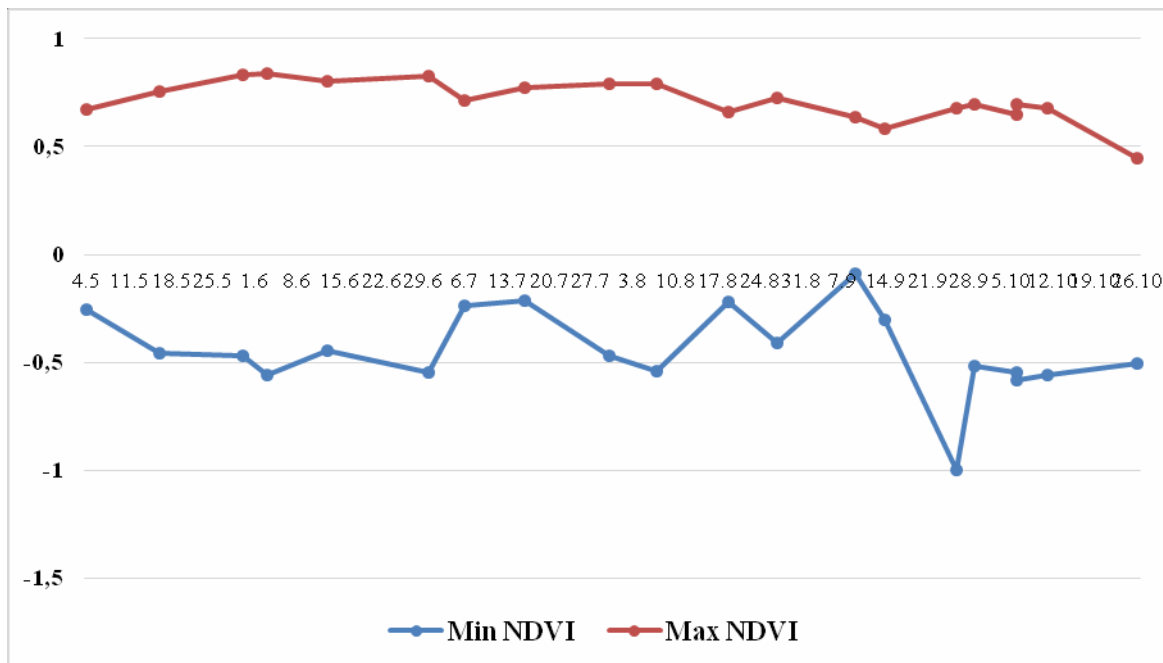


Figure 3. NDVI max and min line graph

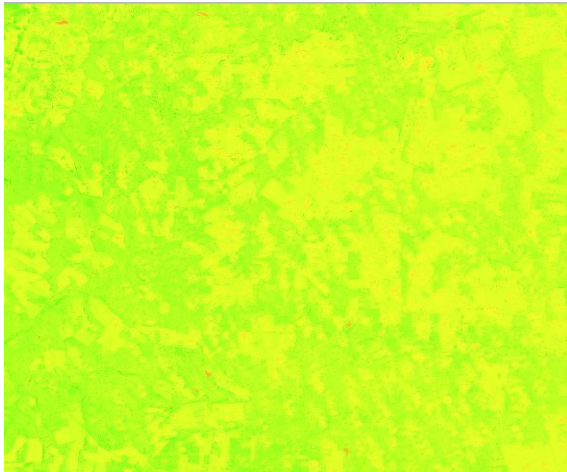


Figure 4(a). May, 2019

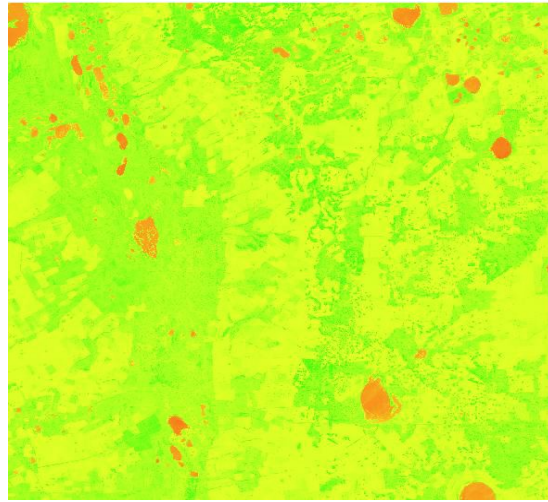


Figure 4(d). August, 2019

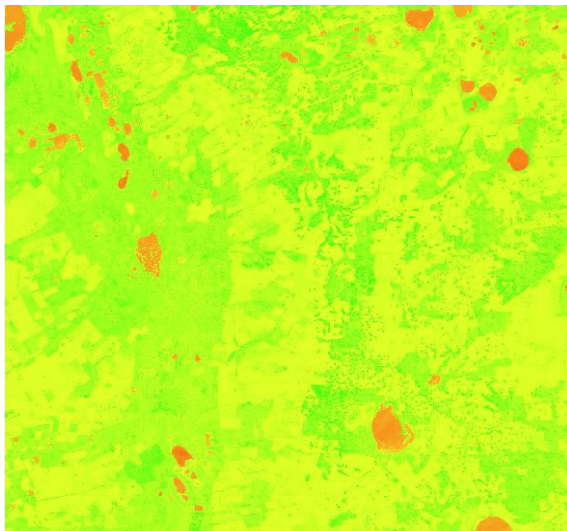


Figure 4(b). June, 2019

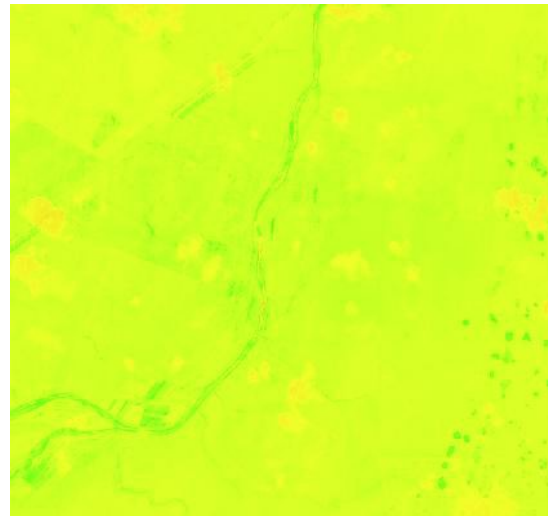


Figure 4(e). September, 2019

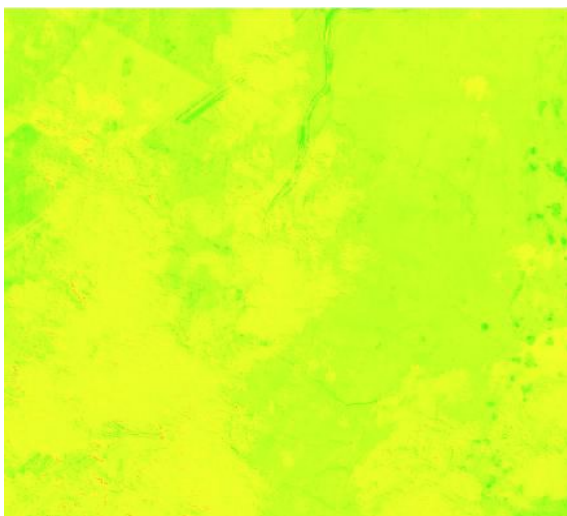


Figure 4(c). July, 2019

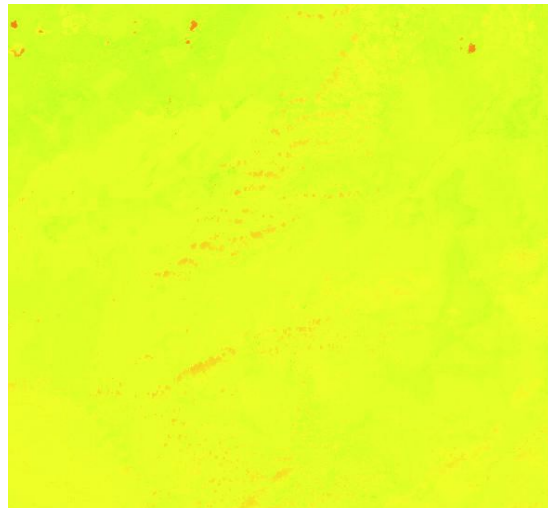


Figure 4(f). October, 2019

Table 2. Minimum, maximum, and average NDVI figures by area

No	Imagery ID	Area coordinates	Date	Max	Min
1	2	3	4	5	6
1	L1C_T41UNS	A - 51°27'08''N/063°03'41''E B - 50°28'23''N/063°00'03''E C - 51°26'18''N/064°33'40''E D - 50°27'33''N/064°32'40''E	OCT, 26	0.448406	-0.506039
2	L1C_T41UNT	A - 52°21'07''N/062°59'44''E B - 51°22'06''N/062°59'44''E C - 52°20'43''N/064°35'58''E D - 51°21'41''N/064°33'20''E	OCT, 11	0.675862	-0.558655
3	L1C_T41UNQ	A - 49°39'02''N/063°00'03''E B - 48°40'05''N/063°00'13''E C - 49°38'36''N/064°30'42''E D - 48°39'33''N/064°29'03''E	OCT, 6	0.699101	-0.583825
4	L1C_T41UNR	A - 50°32'47''N/063°00'23''E B - 49°33'45''N/063°00'03''E C - 50°32'22''N/064°33'00''E D - 49°33'58''N/064°30'42''E	OCT, 6	0.646049	-0.543951
5	L1C_T42UQR	A - 50°30'16''N/065°49'48''E B - 49°32'28''N/065°45'51''E C - 50°27'45''N/067°21'45''E D - 49°29'41''N/067°16'09''E	SEPT, 29	0.698039	-0.516908
6	LC1_T41UPR	A - 50°32'25''N/064°24'46''E B - 49°33'19''N/064°23'07''E C - 50°30'42''N/065°57'03''E D - 49°32'15''N/065°53'25''E	SEPT, 26	0.680754	-1
7	LC1_T41UNV	A - 54°08'52''N/063°00'23''E B - 53°09'53''N/063°00'03''E C - 54°08'17''N/064°40'35''E D - 53°09'41''N/064°37'37''E	SEPT, 14	0.583191	-0.3
8	LC1_T41UMU	A - 53°14'14''N/061°30'44''E B - 52°16'11''N/061°32'23''E C - 53°14'49''N/063°08'18''E D - 52°15'47''N/063°08'38''E	SEPT, 9	0.637049	-0.0889621
9	L1C_T41UNS	A - 51°26'22''N/063°00'53''E	AUG, 27	0.726396	-0.407282

1	2	3	4	5	6
		B - 50°28'08''N/063°00'13''E C - 51°25'45''N/064°34'00''E D - 50°27'42''N/064°31'51''E			
10	L1C_T41UPQ	A - 49°37'10''N/064°24'26''E B - 48°39'36''N/064°21'08''E C - 49°35'53''N/065°53'25''E D - 48°37'12''N/065°49'28''E	AUG, 19	0.661565	-0.217784
11	L1C_T41UNQ	A - 49°38'30''N/063°00'43''E B - 48°38'52''N/063°00'33''E C - 49°37'39''N/064°30'12''E D - 48°39'00''N/064°28'33''E	AUG, 7	0.79195	-0.538342
12	L1C_T41UQR	A - 50°29'39''N/065°50'47''E B - 49°31'11''N/065°46'30''E C - 50°26'43''N/067°21'45''E D - 49°30'07''N/067°15'49''E	JUL, 30	0.789656	-0.471572
13	L1C_T41UMT	A - 52°19'12''N/061°33'42''E B - 51°20'45''N/061°34'02''E C - 52°19'36''N/063°06'39''E	JUL, 16	0.772973	-0.213213
14	L1C_T41UMT	A - 52°19'12''N/061°33'42''E B - 51°20'45''N/061°34'02''E C - 52°19'36''N/063°06'39''E D - 51°21'35''N/063°06'59''E	JUL, 16	0.772973	-0.213213
15	L1C_T41UQR	A - 50°24'11''N/065°10'15''E B - 49°32'02''N/064°47'09''E C - 50°27'20''N/067°20'46''E D - 49°30'33''N/067°15'10''E	JUN, 30	0.82601	-0.548154
16	L1C_T41UPS	A - 51°25'29''N/064°27'24''E B - 50°27'08''N/064°26'25''E C - 51°23'26''N/065°58'42''E D - 50°25'52''N/065°55'44''E	JUN, 13	0.800855	-0.445967
17	L1C_T41UPV	A - 54°06'53''N/064°33'40''E B - 53°09'18''N/064°30'22''E C - 54°05'12''N/066°11'33''E D - 53°07'07''N/066°07'55''E	JUN, 3	0.836094	-0.558242

18	L1C_T41ULT	A - 52°17'48''N/060°06'22''E B - 51°18'54''N/060°09'20''E C - 52°19'24''N/061°39'19''E D - 51°21'47''N/061°41'37''E	MAY, 30	0.830832	-0.4675
19	L1C_T41UPR	A - 50°31'44''N/064°26'05''E B - 49°33'19''N/064°24'26''E C - 50°29'51''N/065°55'24''E D - 49°32'41''N/065°52'26''E	MAY, 16	0.755479	-0.458921
20	L1C_T41UPS	A - 51°26'06''N/064°28'04''E B - 50°27'33''N/064°25'45''E C - 51°24'28''N/066°01'40''E D - 50°26'05''N/065°55'44''E	MAY, 4	0.669856	-0.258065

3.3 CONCLUSIONS AND IMPLICATIONS

In conclusion, thanks to the means of remote sensing technology and specifically-designed software, it was possible to get an overview of the state of vegetation of the Kostanay region, and according to the data presented above, figures followed an expected trend with NDVI rising in summer months and falling in autumn. Over the course of this study, it was established that the local and regional farmers should be trained to use the technology of remote sensing as a routine practice to monitor and assess the state of their crop fields as NDVI figures can indicate whether vegetation is in good condition, thinned or absent at all.

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