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Assessment of Crop Changes in Southern Uzbekistan for Better Crop Allocation and Water Resource Management

Zafar Gafurov, Dilshod Nazaraliev, Farrukh Kattakulov

***Abstract:** Economy of Central Asian countries heavily rely on irrigated agriculture. The region is facing challenges with regard to water shortages to meet currently cultivated crop water requirement. Talking about water generally gives a view of food security, climate change and energy efficiency. Scarcity of water leads to better understand the role of water to the environment and its effect to the nature. As water is indispensable part of agriculture, there is always need for positive developments of sustainable water management system in agricultural fields. Improper crop allocation can influence for degradation of land, groundwater level change, as well as food security. Therefore, this study aims to learn crop pattern changes over time which can serve as a basis for better water management in the region. In addition to this, this study covered what is the major changes in irrigated agriculture in terms of crop allocation to understand the crop rotations over time. Freely available satellite data was used for mapping crop classification and their changes for this region. Widely used Normalized Difference Vegetation Index (NDVI) technique was applied to extract information from Landsat raw data. The study was carried out in Karshi Steppe in southern part of Uzbekistan and this region is one of the area that is experiencing challenges on water availability where water resources are mainly pumped from Amudarya River which is located in the lower altitude of the region. Therefore understanding currently cultivated crop types will help to further explore actual crop water requirements which may provide an information on how much water is actually needed and can be lifted with minimum financial costs. They are then can be used in further application to find out Evapotranspiration (ET) of individual crops and help decision makers making better decisions.*

***Keywords:** Karshi Steppe, Change analysis, NDVI, Classification, Landsat.*

I. INTRODUCTION

Water has always played an important role for human being, for the life and for our beautiful environment. Water resources in Central Asia are very much important for many sectors [1]. With the increase of Central Asian demography and potential to climate change, we as human being should more actively act to ensure the life for tomorrow's generation in this region. When we look back into the second decade of 20th century, we can observe huge developments of deserts into irrigated lands in order to increase crop production in this area. The Karshi steppe is one of the main examples to this point, which has already tripled the irrigated area in size as a result of massive developments of deserts during Soviet Union period. This region is facing with tremendous water management issues as today it includes irrigated land with about 330 thousand hectare and around 75 % of this area is irrigated by lift irrigation system, rest is irrigated from Kashkadarya river that flow naturally originated from Pamir mountains [2]. The karshi steppe was about 100 thousand hectare in size in 1970s but now it has turned into about 350 thousands of hectares. It has started to increase its size after the extension actions of cotton fields in Central Asia started during the Soviet time. After about 1980s, the scarcity of water and energy were clearly visible in the area, also influences to soil quality and ground water quality and quantity has changed by time. The main reason of soil quality decrease and increasing salts in the region was extending agricultural field with mismanagement crop rotation and irrigation system. Taking into account above mentioned problems we obviously should look back and understand how the changes over past periods has practiced in that area and learn crop change dynamics. The change dynamics illustrated in this paper will help us to better understand what the size of the study area was in fact in the past and how the dynamics developed with time. It is of advantage to have change dynamics analysis in order to make proper decisions that should mitigate possible changes of study area for the future if further irrigation extension/reduction is required. Considering all above mentioned issues, this study was carried out where the outcome can be useful information for several sectors dealing with similar cases in another part of Central Asian countries in order to protect the nature.

II. OBJECTIVE

The objective of this study in one hand focuses on temporal change analyses of crop pattern via pixel based classification method using freely available medium resolution remote sensing data and on the other hand make temporal change analyses of irrigated areas for proposed regions using NDVI method.

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* Correspondence Author
Zafar Gafurov*, National Researcher on GIS and Remote Sensing at International Water Management Institute, Central Asia, Tashkent, Uzbekistan.
Dilshod Nazaraliev Head of Hydrology and Hydrogeology Department of Tashkent Institute of Irrigation and Agricultural Mechanization Engineers
Farrukh Kattakulov Associate tenure of the Department of Hydrology and Hydrogeology of Tashkent Institute of Irrigation and Agricultural Mechanization Engineers.

III. STUDY AREA

Study area consists of six regions which are located in western part of Kashkadarya province. The irrigation of an area of interest is fed by Talimardjan reservoir which was built during Soviet Union period. Water is pumped up to the reservoir with special pumps through Karshi Magisterial canal and filled during winter time and used its water in summer. Mainly six regions (Karshi, Kasby, Nishan, Mirishkor, Muborak and Koson) are using the water of reservoir.

Geographical location of Kashkadarya Province

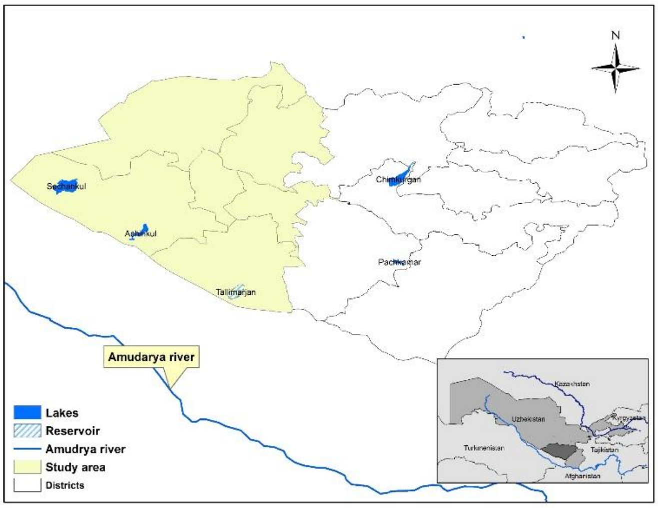

Fig 1 Study Area

IV. MATERIALS AND METHODS

The Landsat data was obtained from United States Geological Survey (USGS)[4] webpage. A good amount of data can be downloaded without any cost merely for the purpose of research. The temporal resolution of Landsat data is 16 days and the spatial resolution is 30 meters. Number of images for 1987 and 2017 was obtained for each year in order to classify based on phonological development of each crop types. Each images was preprocessed and are of interest was extracted in order to make analysis in study are which is inside a Landsat scene, please refer to below figure

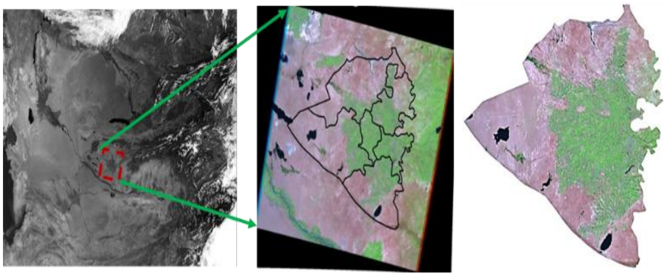

Fig 2 Landsat images

QGIS open sources software was used to build phonological curve of different crops. Main focus was to classify major crops (cotton and wheat) but also included bare soils, water bodies, grass lands, orchards and alfalfa. In most cases human eyes automatically recognize the type of land belongs to which class, but in order to recognize these patterns in computer system it is necessary to train software to differentiate the spectral response of pixels in a meaningful way. Normalized Difference Vegetation Index (NDVI) was introduced by Rouse et al. (1974)[3], since then it has been used in numerous studies.

$$NDVI = \frac{NIR - Red}{NIR + Red} \quad [3]$$

Where: NIR – Near InfraRed band

Red – Red band of Landsat image

NDVI is developed based on the variation in reflectance of vegetation in NIR and red channels. Vegetation reflectance in NIR is higher whereas in red band reflectance is comparatively low. NDVI gives values ranging from -1 to 1. Most of the vegetation ranges from 0.1 to 0.8. Values close to 1 indicate the most vigorous vegetation. NDVI helps to compensate changing illumination conditions, viewing aspects, atmospheric conditions and slope variations. It has been used in many studies to discriminate vegetation from non-vegetated areas. The NDVI technique used here for 30 meter Landsat spectral data in the visible channel 3 (0.63-0.69 micrometer) and near infrared channel 4 (0.76-0.90 micrometer) regions of electromagnetic spectrum.

Table 1 Decision criteria for different crops

Classes	Early irrigation period	Mid irrigation period	Late irrigation period
Water	NDVI < 0	NDVI < 0	NDVI < 0
Bare soil	0 <= NDVI < 0.2	0 <= NDVI < 0.2	0 <= NDVI < 0.2
Grasses	0.2 <= NDVI < 0.3	0.2 <= NDVI < 0.3	0.2 <= NDVI < 0.3
Wheat	0.3 <= NDVI	0.2 <= NDVI < 0.3	0.2 <= NDVI < 0.3
Cotton	0 <= NDVI < 0.2	0.3 <= NDVI < 0.4	0.4 <= NDVI
Orchards	0.3 <= NDVI	0.3 <= NDVI	0.3 <= NDVI
Alfalfa	0.5 <= NDVI	0.3 <= NDVI < 0.4	0.5 <= NDVI

This Methodology is a framework that allows humans knowledge to progress [5]. Therefore methodology implemented in this research was done based on the phonological development shown in (figure 3).

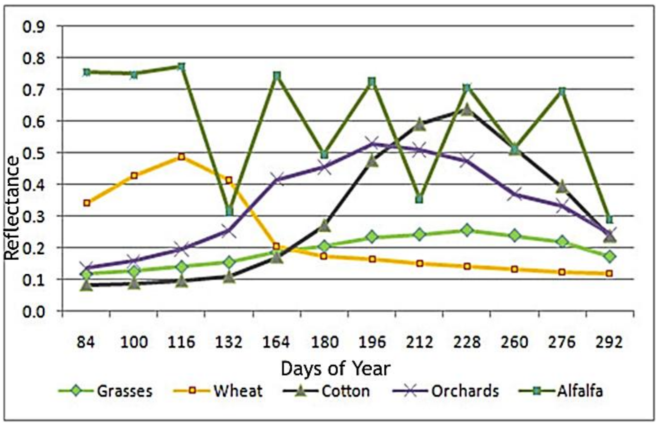

Fig 3 Phenological development curve of different crop types

As it is shown in the image above it is a necessary to use series of images for a certain year to develop phonological curve, for following NDVI classification an author used 12 images for 2017 and 9 images for 1987 to determine crop types.

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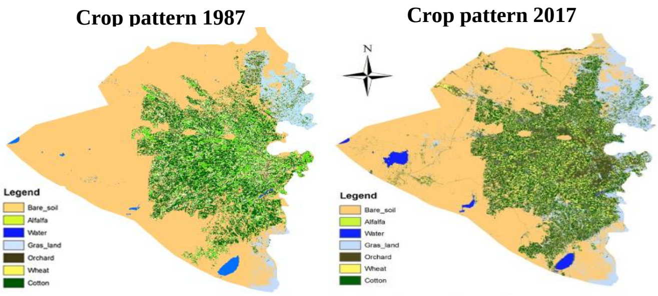
V. RESULTS AND DISCUSSION

The results show how the changes took place over time in terms of crop types changes. Mainly for the years of 1987 and 2017, last 30 years of period.



After classification it was possible to quantify the changes in area wise.

Table 2 Crop areas changes in quantified manner

Class Names	1987		2017	
	Area (ha)	Percentage (%)	Area (ha)	Percentage (%)
Irrigated area			Irrigated area	
Wheat	41.745	3.5	91.486.4	7.64
Cotton	222.876.2	18.6	136.687	11.41
Orchard	23.140	1.9	19.325	1.61
Alfalfa	79.292	6.6	19.829.1	1.66
Settlement	58.651	4.9	65.171.43	5.44
Total irrigated	425.704.2	35.5	332.498.9	27.76
No irrigated			No irrigated	
Water area	8.213	0.7	15.385	1.28
Bare soil	595.197.7	49.7	690.043	57.60
Grass lands	169.045	14.1	160.036	13.36
Total no irrigated	772.455.7	64.5	865.464	72.24
Total irrigated, no irrigated	1.197.963	100	1.197.963	100

From the table above one can understand that there is huge changes in mainly cotton and wheat crops. In fact cotton cultivated areas decreased while wheat crop cultivated area increased. This is mainly due to the fact to increase crop production in order to secure food security in the region.

VI. CONCLUSION

The aim of this study was to classify crop types of Karshi steppe for different time spans using publicly available Landsat Data. The results gave crop cover values for different years. This provides helpful information to generally observe the history of the study area in terms of crop types changes. Through this study it was possible to demonstrate changes in crop type over time in irrigated agricultural fields of the study area which clearly shows a dramatic changes mainly cotton and wheat crop cultivation . Outputs of this study can be very important in demonstrating the Karshi steppe issues in different sectors and at different level. Achieved results can play a great role on further understanding of actual crop water requirements of different crop types, which is crucial for this study area to learn and further development of long term water and land management strategy. The results can be used in decision making for designing and planning of crop cultivation and rational use of water resources and demnostrate proper irrigation scheduling to improve water productivity.

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AUTHORS PROFILE

Dr. Zafar Gafruov is a specialist on remote sensing and GIS, climate change and resource management in Central Asia. He has a PhD in Geographical sciences and MSc in Photogrammetry and Geoinformatics from University of Stuttgart in Germany. His research interests are connected to analysis of remote sensing datasets, spatial mapping, natural resources management and climate change adaptation strategies for sustainable management of land and water resources in Central Asia.

Dr. Dilshod Nazaraliev has an academic background with Tashkent Institute of Irrigation and Agricultural Mechanization Engineers He has 29 years of teaching experience. He has participated and presented in several different international and national conferences on Hydrology and hydrogeology with focus of understating surface and groundwater resources.

Mr. Farrukh Kattakulov has an academic background with Tashkent Institute of Irrigation and Agricultural Mechanization Engineers He has 14 years of teaching experience. He studied his postgraduate classes from Indian and European academic institutions. He has participated and presented in several different international and national conferences on water resource management in the region.