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Impact Investigation of Kajaki Dam on Vegetation Coverage of the Surrounding Basin Using Landsat Satellite Image Processing Method: An Analytical Comparison between 2000 And 2021

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Abstract
The construction of dams for a long time has been considered to manage surface water by societies that are living in arid regions of the world. But today the construction of such structures in most countries has been moving very fast, especially in the last decades in Afghanistan the process of dam construction grown-up dramatically.
This study investigates the aspects of Kajaki dam construction via Landsat Satellite images and assesses the impacts of its construction on the vegetation of the areas around the Kajaki in 2000 and 2020. In preliminary processing, 10 vegetation indices including II, IR2, MND, MIRV1, NDVI, PD312, PD322, RAI, SAVI, VINR1 were applied to the Satellite Images. As result, the map of all indicators was extracted for both years i.e., 2000 and 2020, in addition, the parameters such as minimum, average, maximum, and standard deviation of all indicators were calculated to obtain the outcomes.
The min of parameters in 2000 was more compared to 2020, which indicates the increase of water in the reservoir rim or water on the upstream side of the dam in 2020, the amount of the other three parameters in 2020 was a significant increase compared to 2000, which indicates an increase in vegetation. The average increase in the indices was more than 27%.
This research exposed that the construction of the dam has had a significant impact on increasing agriculture in the region, and it is recommended to use different analyzes using remote sensing on different water resources engineering projects, including dams to get accurate marks.

Keywords: Dam, Vegetation, Remote Sensing, Landsat Satellite Images, Kajaki Dam

Introductions

The construction of dams is mostly thru to meet economic needs (Khlifi *et al*., 2010) [8]. Subsequently, dams have several effects, in a comprehensive study of 27 effects have been identified, which are generally categorized into three categories of biophysical, socio-economic, and geopolitics impacts. (Brown *et al*., 2009) [2]. With the construction of the dam, agricultural lands may be sufficiently irrigated using stored surface water, and cities may be developed in downstream areas to reduce the risk of flooding and increase the availability of crops and provide electrical energy. These systematic changes in land use and vegetation coverage can increase the availability of local moisture circulation at the microclimate scale (Niyogi *et al*., 2010) [10].
Nowadays, population growth and limited resources have been created many problems. Moreover, the market and the global economy are among the most important factors that have affected land uses. For example, the price of meat has been influenced more than the price of wheat in land-use changes in rangeland and agricultural land uses in the United States (Hadian *et al*., 2013) [6]. Dam construction has been proposed as one of the most strategic methods in most countries to manage water resources, prevent wastage of potable water, electricity generation, flood prevention, increasing cultivation and drinking water supply. After the harmful effects of these structures gradually became apparent among the scientific community, environmentalists, farmers, and rural people who were forced to migrate due to being in the areas of the reservoir of large dams, a sedentary movement was

formed (Billington *et al*., 2005) [1].

Dams also have important effects on canal morphology, sedimentation, and vegetation of the areas (Conesa and Garcìa, 2010; Zema *et al*., 2014; Zema *et al*., 2018) [3, 13, 14]. Remote sensing has emerged as a key technology that reflects both spatial and time-based patterns of vegetation (Kattenborn *et al*., 2021) [7]. Remote sensing technology can provide the extent and dynamics of terrestrial vegetation, which provides very useful insights for applications in environmental monitoring, biodiversity conservation, agriculture, forestry, urban green infrastructure, and more in relevant contexts (Xue & Su, 2017) [12].

Regarding the impact of the dam on the vegetation coverage of its surrounding basin, several studies have been conducted, including Yu-Xuan *et al*. (Yi *et al*., 2019) [18], Zema *et al*. (Zema *et al*., 2018) [14, 17], Zaimes *et al*. (Zaimes *et al*., 2019) [15] and Lucas-Borja (Lucas-Borja *et al*., 2018) [16].

Area of Study

Kajaki Dam is one of the two main hydroelectric dams in Helmand province of Afghanistan. This dam is built on the Helmand River and its function is to irrigate 1,800 square kilometers of dry land as well as generate electrical energy. The water catchment capacity of this dam is 2.8 billion cubic meters, which is one-third of the reserves of the Hamon River. The dam has 100 meters high, 2,290 meters wide, and has a discharge capacity of 1.2 million cubic meters. The water from this dam flows up to 500 km downstream in the agricultural canals of the region. During the past years, due to the drought in Afghanistan and the reduction of water inflow to Iran, disputes arose between the two countries. (Fig. 1 & 2)

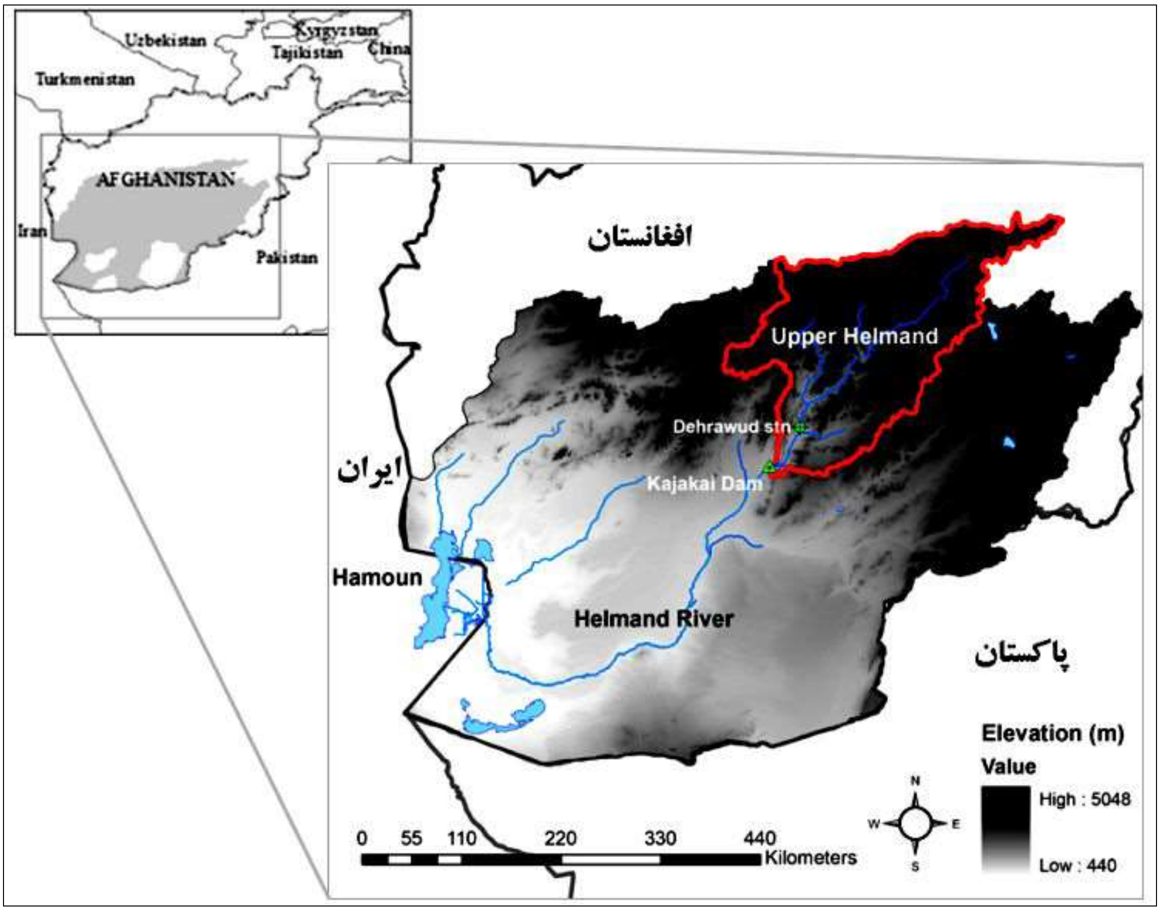

Fig 1: Location of Helmand Basin, and Kajaki Dam, Source: Authors

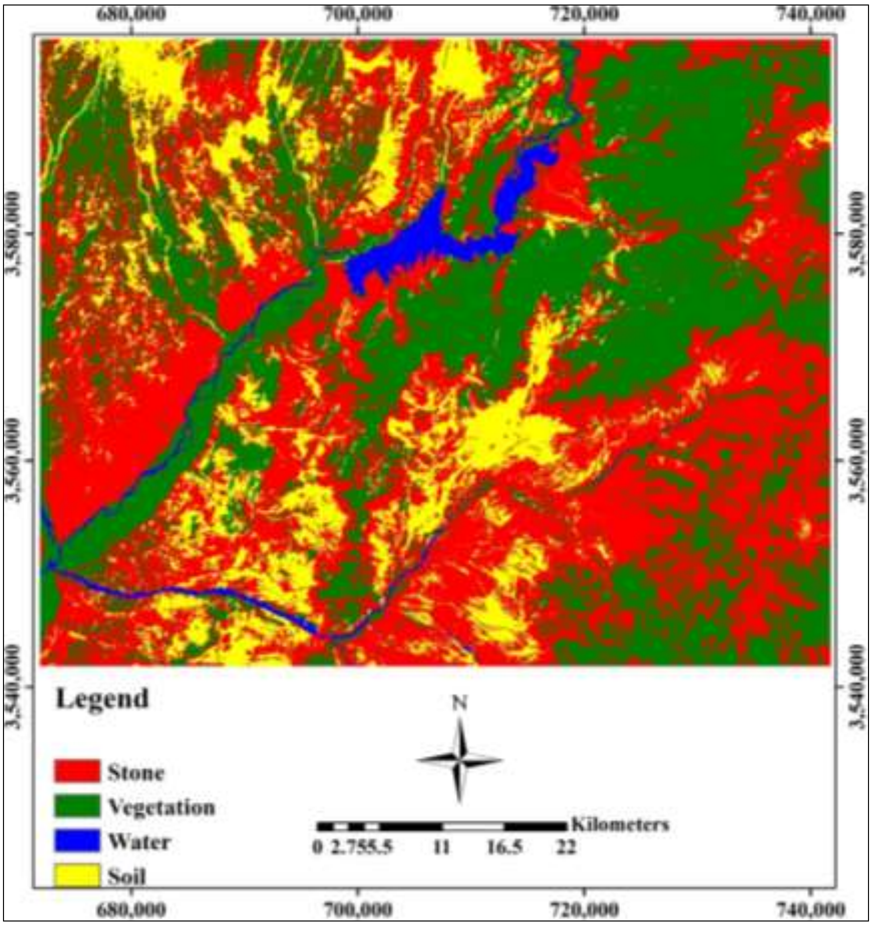

Fig 2: shows the location of the Kajaki Dam, Source: https://earthexplorer.usgs.gov

Methodology

In this research, the Landsat 7 and 8 Satellite Images were used to explore the effects of the Kajaki dam on changes in vegetation and plant in the neighboring areas. Satellite images were taken from the study area on 17 June 2000 and 16 June 2020 and a radius of 25 km was chosen for the study area. In order to process the images, some initial preprocessing must be applied, these preprocessing included geometric and atmospheric corrections. Formerly, to examine the changes in vegetation coverage in the study area, 10 vegetation coverage indicators were applied and the results of the above-mentioned two dates were compared. These indicators are embedded for Landsat images, which are based on the analysis of the amount of reflections between the bands. (Table 1).

Table 1: Equations of indicators applied in Satellite Images

Indicators	Equations	Sources
Normalized Deference Vegetation Index (NDVI)	(TM4 –TM3)/ (TM4 +TM3)	Guha & Govil, (2021) [5].
Soil Adjust Vegetation Index (SAVI)	(NIR-RED) *(1+L) / (NIR+RED+L) +L	Venancio *et al*., 2019 [11]
Contrast Reflectance in Visible and Near Infrared (VNIR1)	(TM4 –TM1)/ (TM4 +TM1)	Cordomí *et al*., 2015 [4]
PD322	(TM3 –TM2)/ (TM3 +TM2)	Cordomí *et al*., 2015 [4]
PD312	(TM3 –TM1)/ (TM3 +TM1)	Cordomí *et al*., 2015 [4]
Modified Normalized Difference (MND)	(TM4 – (1.2 * TM3)/ (TM4 +TM3)	Cordomí *et al*., 2015 [4]
IR2	(TM4 –TM7)/ (TM4 +TM7)	Maleki *et al*., 2018 [9]
Infrared Index (II)	(TM4 –TM5)/ (TM4 +TM5)	Maleki *et al*., 2018 [9]
Reflectance Absorption Index (RAI)	TM4 / (TM3 +TM5)	Maleki *et al*., 2018 [9]
Modified Infrared Vegetation Index (MIRV)	(TM4 –TM5)/ (TM4 +TM5)	Maleki *et al*., 2018 [9]

Note: The indicators used are based on TM images, which are convertible to Landsat 7 and 8 images. Moreover, in the SAVI index, the L factor indicates the soil and is equal to 0.5 (Venancio *et al*., 2019) [11].

Results

In order to determine the spatial changes of vegetation coverage in the above-mentioned two periods, maps of spatial changes of vegetation coverage that have been gotten after applying the indicators can be seen as follows in (Fig. 3 & 4):

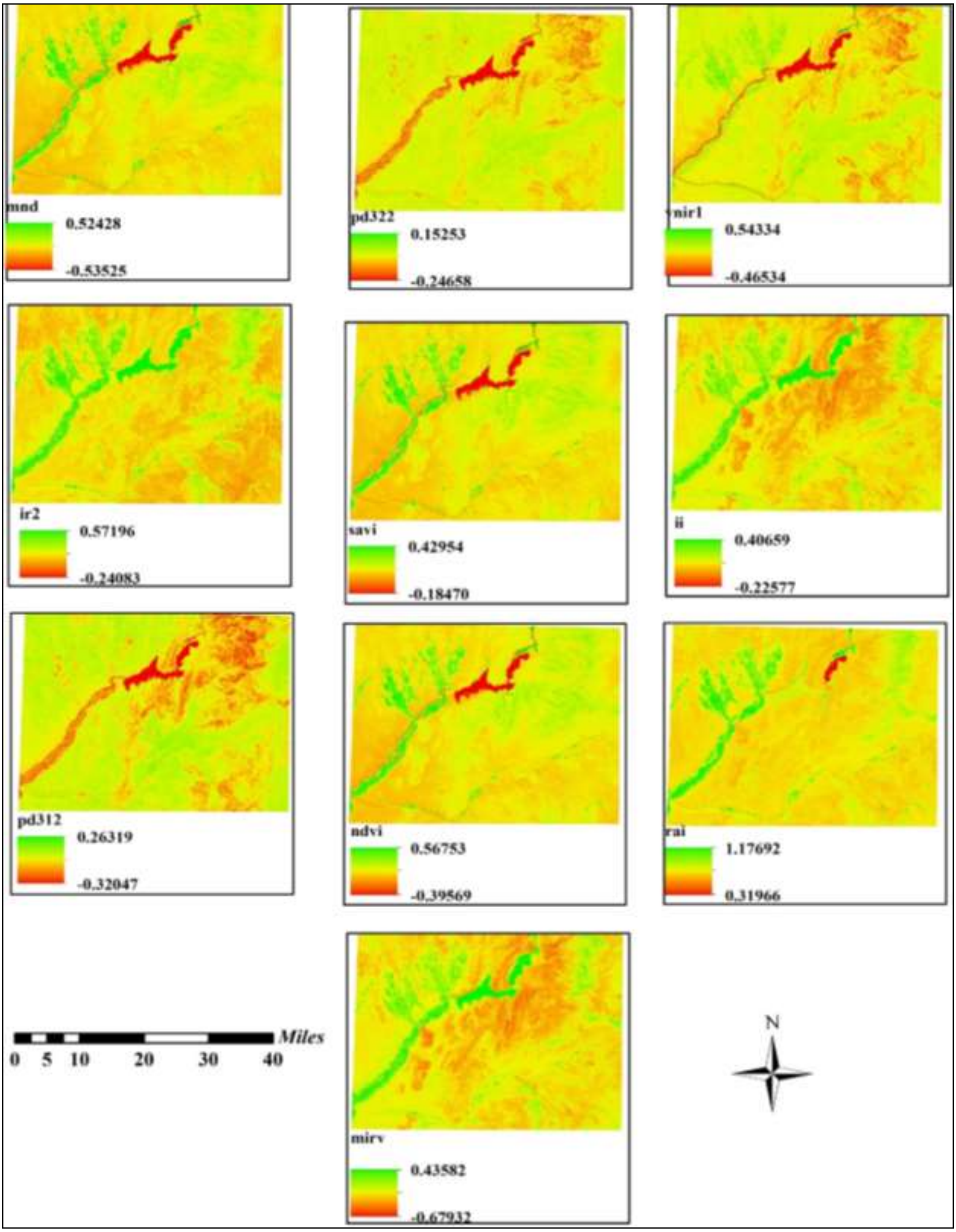

Fig 3: The results in spatial upshots after applying 10 indicators in the year 2000;
II ‘IR2 ‘MND ‘MIRV1 ‘NDVI ‘PD312 ‘PD322‘ RAI ‘SAVI ‘VINR1 (As of left to right and top-down)

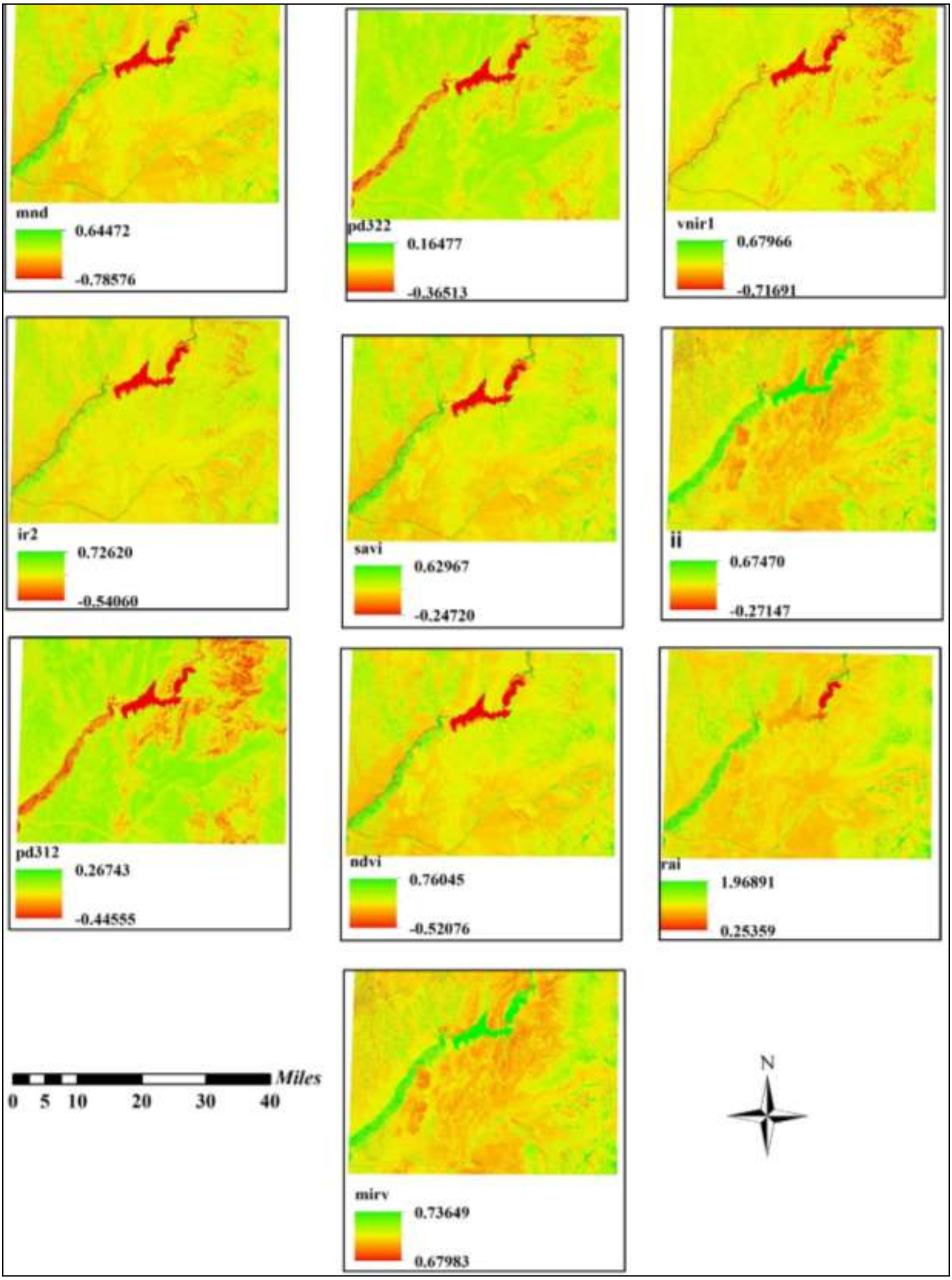

Fig 4: The results in spatial upshots after applying 10 indicators in the year 2020
II ‘IR2 ‘MND ‘MIRV1 ‘NDVI ‘PD312 ‘PD322‘ RAI ‘SAVI ‘VINR1 (As of left to right and top-down)

In the above indexes of vegetation coverage, the waterbody areas or reservoir (such as impoundment) have low values (usually negative), uncovered soil is about zero, and the denser and healthier the vegetation, the value of the index becomes more and bigger. Hence, the results of all indicators except II and IR2 are reliable.

Consequently, the statistics of all indices are given in Table 2 to further examine the results of vegetation changes, these statistics include minimum, maximum, mean, and standard deviation.

Table 2: Statistics of indicators used in both mentioned-periods

(2000)					(2020)				
INDICATORS	**MIN**	**MAX**	**MEAN**	**STDEV**	**INDICATORS**	**MIN**	**MAX**	**MEAN**	**STDEV**
VNIR1_00	-0.46534	0.54334	0.22814	0.08647	VNIR1_20	-0.71691	0.67966	0.28970	0.10706
SAVI_00	-0.18470	0.42954	0.05610	0.02985	SAVI_20	-0.24720	0.62967	0.11023	0.4429
RAI_00	0.31966	1.17692	0.47093	0.03275	RAI_20	0.25359	1.96891	0.52012	0.54324
PD322_00	-0.24658	0.15253	0.09142	0.03776	PD322_20	-0.36513	0.16477	0.09578	0.4594
PD312_00	-0.32047	0.26319	0.16115	0.06152	PD312_20	-0.44555	0.26743	0.16140	0.06573
NDVI_00	-0.39569	0.56753	0.06888	0.04621	NDVI_20	-0.52076	0.76045	0.13429	0.06936
MRIV_00	-0.67932	0.43582	0.07653	0.07002	MRIV_20	0.67983	0.73649	0.07472	0.07663
MND_00	-0.53525	0.52428	-0.02423	0.05083	MND_20	-0.78576	0.64472	0.10243	0.085
IR2_00	-0.24083	0.57196	-0.00936	0.05389	IR2_20	-0.54060	0.72620	-0.0301	0.0556
II_00	-0.22577	0.40659	-0.11102	0.04531	II_20	-0.27147	0.67470	-0.07115	0.04607

According to the results, the minimum rate (MIN) in all 10 indicators for the year 2000 is more than 2020; Nonetheless, in the year 2020 other parameters (MAX, MEAN, STDEV) are more than the year 2000. The fact that the (MIN) parameter in the year 2020 is lower than in 2000 indicates the amount of more water held back by the dam (upstream side of the dam) in the year 2020, which means that more land was waterlogged from 2000 to 2020, and that is why the (MIN) parameter in all indicators is negative for both years.

On the other hand, the (MAX) parameter in all 10 indicators, which is higher in the year 2020, indicates the growth of vegetation in this year. therefore, according to the above-extracted maps, this vegetation growth is happening along the river and in the suburbs.

The (MEAN) parameter for all 10 indicators has grown up in the year 2020; This escalation indicates a significant increase in vegetation coverage in the region, given in mind that (MIN) parameter has increased (due to the increase in the water of reservoir) in the year 2020.

Lastly, the increase of the standard deviation parameter (STDEV) in the year 2020 is due to the fact that this year, on the one hand, with the rise of water level, the (MIN) has increased, and on the other hand, this rises in water, growths the vegetation coverage and increases the difference between (MIN) and (MAX) parameters.

Conclusion

Dams have many positive and negative effects on their surrounding areas; Having that in mind, the construction of dams are in some ways unimaginable, and on the other hand, every act in the ecosystem has a variety of positive and negative effects, it is necessary to maximize the increase of positive aspects to minimize the negative effects. Unfortunately, there are very few surveys based on remote sensing technology, in our country, Afghanistan, and such surveys in the country are vital. In this article, Remote Sensing Indicators based on Landsat Satellite Images, which is a valuable long-term and free resource, were used to investigate vegetation coverage (agricultural land uses) changes.

from processing satellite images on dams and their effects Various outcomes can be obtained, including changes in the amount of impoundment water in different periods, changes in the quality of water, changes in land use after construction of the dam, changes in vegetation coverage in different periods, etc. In this study, vegetation coverage indicators of remote sensing techniques are used to show the changes in vegetation in the two periods of 2000 and 2020 and discussed. The results of this study show the positive effect of the Kajaki dam on vegetation coverage and agricultural land in the surroundings.

The share of Remote Sensing Research in our country is very small, meanwhile remote sensing research is much cheaper and faster than survey research and provides noteworthy results, it is appropriate to suggest that such research should be done in different aspects for other dams of our country. One of these newly established dams is the Kamal Khan Dam, which in coming years can be studied the effects of this dam on the surrounding areas.

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