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GEOSPATIAL IMPACT EVALUATION OF WATER DISPERSAL STRUCTURES ON NARI RIVER AT DISTRICT KACHHI USING REMOTE SENSING AND GIS TECHNIQUES

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Abstract

This article describes an improved Change Detection approach based on the Normalized Difference Vegetation Index for satellite image analysis (NDVI). With the help of a few band combinations of remotely sensed data, NDVI uses the Multi-Spectral Remote Sensing data technique to determine the vegetation index, land cover classification, vegetation, water bodies, open areas, scrub areas, hilly areas, agricultural areas, thick forests, and thin forests. Such remote sensing technique is applied in the Kachhi district of Balochistan (Pakistan). The floodwater dispersal project was started in 2008 by the Irrigation and Power Department of the Government of Balochistan. After the completion of the Project in 2016 and later increase in vegetation cover is detected. The flood dispersal structures at six points on river Nari were installed to irrigate the vast agricultural land on both sides of River Nari. The results show the robust change in vegetation cover after the proper distribution of water available for cultivation. Vegetation cover increased from 61082.48 hectares to 138490.38 hectares respectively.

Keywords: Change Detection, Kachi, Vegetation, NDVI, Remote Sensing

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INTRODUCTION

To understand present changes in the Earth system, scientists need quantitative, spatially explicit data on how the land cover has changed owing to human usage over the past 300 years and how it will change over the next 50 to 100 years. (Lambing et al., 1999) Multi-Spectral Remote Sensing images are especially useful for studying the ecosystem of the earth. (Ahmadi & Nusrath 2012). Without physically interacting with these objects, it is the Science and Art of gathering information and extracting features in the form of Spectral, Spatial, and Temporal about specific objects, areas, or phenomena, such as vegetation, land cover classification, urban areas, agricultural land, and water resources. (Karaburun &Bhandari 2010). Satellite data that has undergone digital image processing provides tools for applying different mathematical indices and algorithms to the image. Reflectance attributes serve as the basis for features, and indices have been created to highlight the image's standout characteristics. (Deep & Saklani 2014).

There are numerous indices available for emphasising vegetation-bearing areas on a remote sensing scene. (Bhandri & Kumar 2012) An index that is frequently used is NDVI, the ratio of the difference between the measured canopy reflectance in the red and near-infrared bands, respectively, is used to calculate NDVI (Nageswara et al., 2012). Numerous researchers have reported using NDVI to monitor vegetation (Yang et al 2010: Lan et al 1997). Several researchers have also reported using NDVI to monitor vegetation by assessing the crop cover (El-Shikha et al., 2007).

In the geographical analysis, including physical geography research, environmental analysis, and spatial planning methodologies, land cover plays a significant role. It must be updated periodically since it is a dynamic variable that reflects the interaction between socioeconomic activities and regional environmental changes. (Mare & Mihai 2016)

It is practicable to detect and map the different types of land cover by using satellite remote sensing data. The geo-database was built using GIS tools, which also combined satellite image data with classes, from the currently accessible land cover models. GIS techniques are used to overlay, examine, and evaluate the data layers. . So that its impact on the terrestrial ecosystem can be determined and sustainable land use planning can be developed, it is essential to study the changes in land use or cover (Muttitanon & Tripathi, 2005). Typically, the comparison of two registered, aerial or satellite multi-spectral bands from the same geographic area acquired at two separate dates is how land uses and urban expansion are measured in remote sensing. Such a study looks for changes that have taken place in the same region between the two times under consideration (Radke et al., 2005). Satellite remote sensing is a potentially effective way of tracking land-use change with high temporal resolution and less expense than using conventional techniques. (El-Raey et al., 1995) Balochistan experience a dry climate with extreme variability (Ambreen et al., 2022). Therefore need such kind of steps to use water resources fruitfully. In this article, the multispectral image of Kachhi district (Balochistan) is used to detect the robust change in the vegetative land area after the instalment of six flood dispersal structures at River Nari. To check the validity of different governmental projects for agricultural developments such studies are very beneficial.

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Study Area

Pakistan's Balochistan is a sparsely populated province with 35 districts and 6 divisions. According to the 2017 census, District Kachhi, which is in the Naseerabad division, has a 5682 sq. km. area and 309932 residents (Bureau of statistics). In south-eastern Balochistan, the Kachhi plain is arid, dry, and in a hot temperate zone (Ambreen et al., 2022). Seasonal floods, which take place throughout the monsoon season from July to August, are a key supply of irrigation and drinking water. The Main River of the Kachhi plain is River Nari. It is the primary source of water and fertile soil. Wheat, Sorghum, Mong, Chickpeas and Beans are grown here. The local population is very poor, depending on agriculture and livestock rearing for survival.

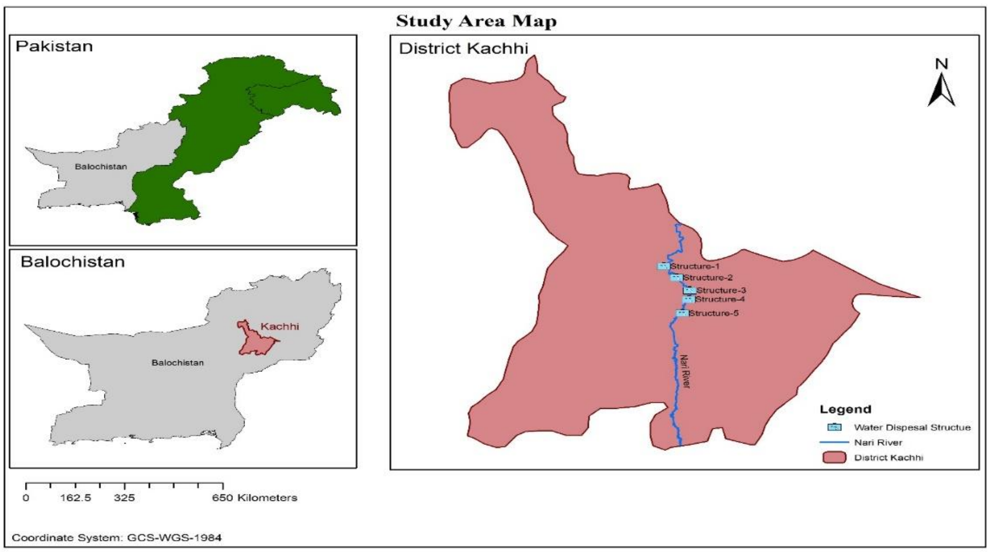

Figure 1: Map of Study Area

METHODOLOGY

Change Detection

The purpose of this research is to evaluate and quantify the impact of flood dispersal structures on the Nari River in district Kachhi. To determine changes in the study area and quantify the change in terms of vegetative land area in hectares, the methodology uses a remote sensing technique called the change detection module. ArcMap and Google Earth Engine are among the utilized applications.

Two images were required for the analysis to show the condition of the study area before and after the building of flood dispersal structures to capture the change. To extract Landsat 7 surface reflectance, the shape file of the study region was uploaded to Google Earth Engine. Before construction, image collections were extracted from 2008-01-01 to 2008-12-31, and following construction, from 2020-01-01 to 2020-12-31. A cloud cover threshold of less than 30% was then applied to Landsat image collections. The retrieved Landsat pictures were then bounds filtered and clipped to the study region.

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Both image collections were subjected to the normalized difference vegetation index (NDVI), a remote sensing environmental indices. Equation 1 was used to obtain the NDVI.

Equation 1: NDVI

$$\mathrm{NDVI} = (\mathrm{NIR} - \mathrm{R}) / (\mathrm{NIR} + \mathrm{R})$$

Where NIR (Near Infra-red) is SR_B4 (band 4), and R is SR_B3 (band 3)

The NDVI collections were reduced into a single output using the maximum value composite.

The NDVI's maximum value composite was reclassified to only include vegetated regions. The remaining NDVI values were classed as 0, whereas those that were above the given threshold were assigned 1 (vegetative areas).

Equation 2 was used to compute the difference between the study area before and after the irrigation structures' additional vegetative areas that the irrigation channels created.

Equation 2: Change Detection

$$\boldsymbol{DIFFERENCE = AFTER - BEFORE}$$

Where before is the 2008 imagery and after is the 2020 imagery. The images were exported to ArcMap, changed from raster to a dissolved vector polygon and their areas calculated.

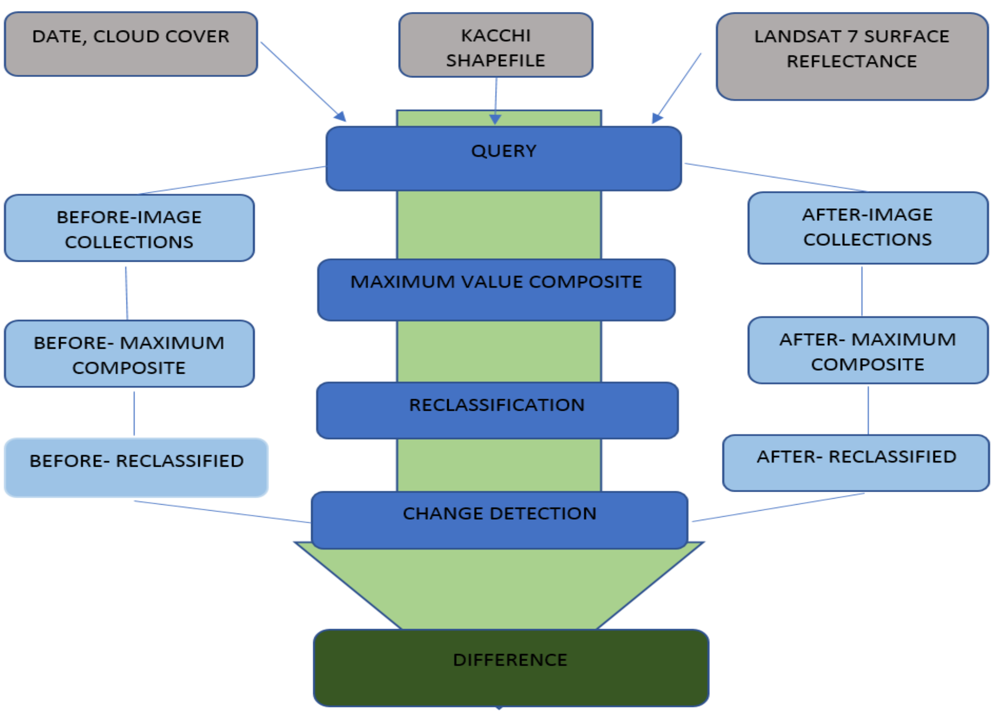

Figure 2: METHODOLOGY FLOW CHART

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Validation

Land cover data were retrieved from World Resource Institute (Brown et al., 2022) to validate the accuracy of the detected change (difference). Using the '.and' function in the earth engine, the intersection between the land cover and the different images was determined. The intersection image was exported to ArcMap and the area was calculated in hectares. Equation 3 was utilized to determine the validation accuracy.

Equation 3: Accuracy Check

$$\frac{INTERSECTION}{DIFFERENCE}\ X\ 100$$

RESULTS AND DISCUSSION

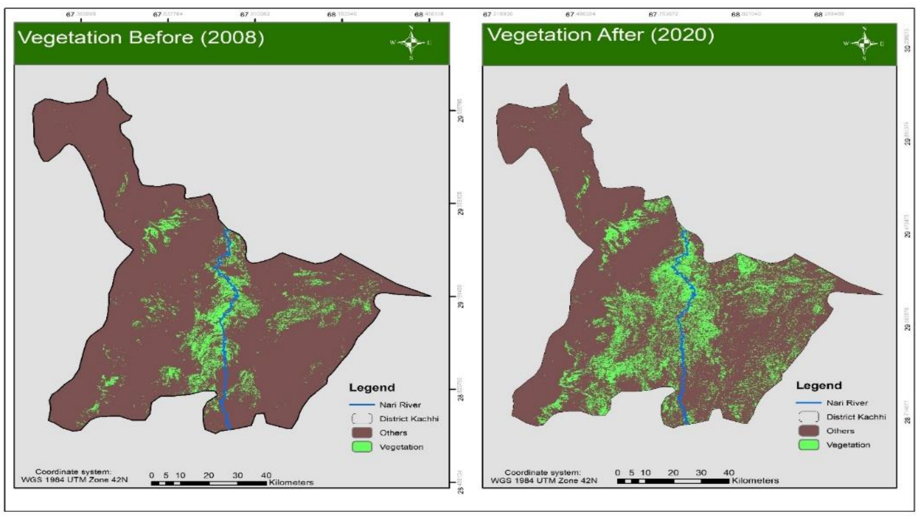

Figure 3: Map of vegetation in the study area before and after the installation of flood dispersal structures

Gradual Increase

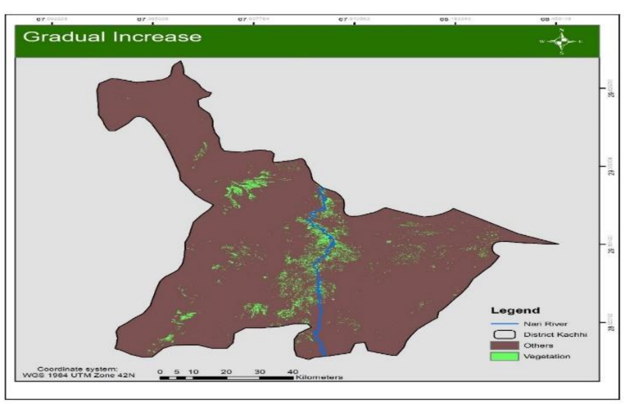

Figure 4: Map of Vegetation Change

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Table showing area of vegetation and non-vegetation (Others) of the following years and gradual increase. (All in hectares)

Table 1: Area of vegetation and non-vegetative areas

Class	2008	2020	Gradual Increase
Vegetation	63011	141421	108133
Non-Vegetation	691842	613432	646720

Obtaining information about changes to the ground object, in this example vegetation, by comparing and analyzing two or more remote sensing images collected at various periods in the same location is known as "change detection," and it is an essential application of remote sensing image interpretation (Théau, 2008). Due to its simple access to preprocessed datasets, the Google Earth engine was used. The methodology used Landsat's 30m resolution instead of Sentinel's 10m resolution since Landsat provides images that correlate to the time before irrigation systems were developed. Surface reflectance imagery was used instead of Top of Atmosphere reflectance because it enables a better comparison of different photos obtained over the same area by accounting for atmospheric characteristics such as aerosol scattering and thin clouds. (Bilal et al., 2019). Surface reflectance reveals the precise reflected radiation of features on the earth's surface. NDVI was utilized since it showed the best correlation with vegetation cover even though EVI is widely known for correcting NDVI's errors (Li et al., 2010). The Maximum Value Composite approach lowers the effects of cloud contamination, directional reflectance, and off-nadir viewing, as well as the effects of sun angle, shadow, aerosol, and water vapour (Diwakar et al., 1989)**.**

Reclassification was utilized to distinguish vegetation from various types of land cover because the NDVI yields values between -1 and +1. The vegetation threshold was 0.18 (Akbar et al., 2019). Due to the uncertainties in the earth engine environment, the area of the images was determined in the ArcMap environment. It was discovered that the total area for before, after, and the difference was 63011ha, 141421ha, and 108133ha, respectively. The Kachi District's vegetation increased by 171.6% when irrigational structures were built.

Validation

The difference found from the change detection was overlaid on the land cover because the study required validation from actual vegetation on the ground. The intersect imagery's total area was determined to be 98419.78ha. The project accuracy was very high with a total accuracy of 91% across all imagery.

CONCLUSION

In this study, we compare two satellite images from 2008 and 2020 before and after the flood dispersal structure fully operated. An effective method of describing the changes seen in each land use category is the Change Detection analysis. With a rise in agricultural land over more than a decade, there were significant fluctuations in vegetation cover. The overall accuracy of the image interpretation classes has been achieved

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through the cross-verification of supervised classification of Landsat pictures and ground truth traverse. The classification of land use would be properly enhanced by high-resolution satellite data. The government of Balochistan took the serious initiative to uplift the socioeconomic condition of the people of district Kachhi. They installed six flood dispersal structures at the main River Nari (CERBM 2022). The main objective was to irrigate the vast plains on both sides of River Nari. This brought a change in people's life not only the agriculture production increased but livestock also increased.

Results clearly show that after proper management of water, the vegetation area increased from 8.3% to 14.3% of the total area. District kachhi has a dry and highly variable climate such kind of steps taken by the government enhance the food security of the poor population. Almost the whole Balochistan province has the same climatic conditions except a few pockets, so it is highly recommended for rest of the Balochistan that where water is available should be managed smartly.

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