



Land Covers Change Assessment After Small Dam's Construction Based on the Satellite Data

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Abstract

The small dams were constructed in the study area for storing the rainwater. The present study was conducted to assess the impact of small dams on the LCC (Land Cover Change) in Nagarparkar, Pakistan based on the satellite data. The ENVI (Environment for Visualizing Images) software was used for classification of the four year's images and three classes viz. water, vegetation, and soil were taken for detection of LCC. The MLH (Maximum Likelihood) supervised method was used to classify the multispectral satellite images. The classified results of the classes were found different each year before and after dam construction. Average results of the two years before dam's construction revealed that water availability, vegetation cover and soil cover was 3.02%, 18.52%, and 32.30% respectively. However, after the dam construction, the water availability, vegetation cover and soil cover was 8.49%, 34.33%, and 17.15% respectively. Overall results revealed that water availability and vegetation cover were increased by 5.47 % and 15.18% respectively while soil cover decreased 15.15% after the construction of dams. Hence, based on the results, it is confirmed that the constructions of small dams have a direct and indirect positive impact on the land cover changes and it can play an important role in the resettlement of the communities of the arid areas.

Keywords: Land Cover Changes; Assessment; Before and After Dam Construction; Satellite Data; ENVI Software; Nagarparkar Area.

1. Introduction

Pakistan is an agricultural country and once was a water-surplus country; now a water shortage country [1]. It has two main water resources and five climatic zones; the water resources are classified into two main classes: primary and secondary. Primary resources consist of precipitation, glaciers, and snowmelt; secondary resources consist of surface and subsurface water. Climatic zones include arid, coastal, semiarid, and humid. Nagarparkar area comes under the arid zone, in the arid zone irregular and insufficient rainfall occurs having the annual rainfall is less than 250 mm.

In light of the above fact, the Government of Sindh launched the small dam projects in 2007. The main objectives of the small dams' project were to provide water in the arid areas to meet the demand of irrigation, domestic, livestock, potable water and serves for soil and water conservation measure to the remote areas in Sindh. The main water remote areas of Sindh are Kohistan region, Nagarparkar and Ubhan Shah Hills region in which the project was launched, and some small dams have been completed, and some are underway.

After the completion of a few dams in the Nagarparkara area, felt dire need to assess the impact of small dams on land cover change (LCC), hence selected the area for research study purpose. Before selecting the area, the researcher

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visited the area and consulted most of the stakeholders. After visiting and consulting, the area was selected in the surrounding of the dams. Before to start the work, a number of the research literature, booklets, district profiles, Government and non-Government agencies' - reports and web-pages were reviewed to understand the background of the issues.

Many of the world researchers have reported their views about the small dams in a different way, here quoted few reports of the researchers which revealed that large numbers of small dams/ reservoirs are constructed in remote areas / urban areas for multiple purposes, such as domestic use, livestock raising, agricultural, brick making and to increase the groundwater storage capacity [2-4]. Small dams enhance water availability, which improves the living standard and food security of inhabitants in direct and indirect ways [4]. Water harvesting structures are beneficial in water-scarce areas for sustaining the water supplies for domestic, agricultural and livestock back purposes [4]. These water harvesting structures help to reduce the shortfall in the water supply.

Land cover change (LCC) is a physical material on the face of the earth. It includes grass, asphalt, trees, bare land, water, etc [5] and plays an important role in sustainable development and global environmental changes. It also falls in major issues throughout the world [6-8]. The LCC affect the local, regional, and global climate processes and it would continue to affect the vulnerability from climate change. Traditional methods to estimate LCC are expensive and time-consuming to update, and difficult to understand and evaluate reliable information about the land cover change from past to present and to predict future changes [9-10]. The researchers have turned their attention towards GIS (Geographical Information System) and RS (Remote Sensing) techniques for monitoring, assessing and analyzing the impact of dams on land cover changes (LCC). The RS is an important, cheap, efficient and effective technology and it is a broad field of human knowledge [11]. It is a technology concerned with the facts and it held together by principles (rules) for obtaining accurate timely information for a significant variety of applications, including: the study of daily weather and long-term climate change; urban - and suburban LCC monitoring; ecosystem modeling of vegetation, water, snow/ ice; and many others. RS can provide fundamental new scientific data, and biophysical information, including Locations x, y, z elevation or depth, temperature and moisture content under controlled conditions (Digital image processing book, 4th addition, John R. Jensen). Also, GIS and RS technologies provide a flexible environment for collecting, storing, displaying and analyzing digital data necessary for LU/LCC change detection [12, 13]. Variation in land changes is happening with respect to the passage of time. The land conversions from one type to another occur due to various activities and changes. These activities and changes bring a positive and negative impact on the area and settled communities. These activities and changes are executed for resolving the current and futures issues as well as improving the economy for the betterment of the public. These efforts are launched based on the availability of resources to satisfy mankind's immediate demand. At the same time, these efforts also disturb the land surface, climatic, environmental and socio-economical conditions of the area. Due to disturbance livelihood resources, its type and pattern changed from traditional to newly market-oriented demand. Vaidya et al. [14] reported that peoples changed the cropping patterned and its varieties from traditional to market valuable crops. Land use and land cover change is a very important issue considering in many parts of the globe. Welda et al. [15] conducted a study on Tekeze Dam watershed; the aim was to estimate the potential impacts of the land use land cover (LULC) dynamics on hydrological response and reported significant changes were found in the land use land cover over the 22-year interval. Huge changing were found in cultivated land and bare land (increment occurred at 8.51% and 0.9%) respectively. The majority of the people were related to agriculture; hence more changing were occurred due to intensive use of the agricultural practice in the area which later causes a rapid reduction of shrub land and grassland by 5.62% and 3.33% respectively [15]. Extension of agriculture, urbanization, deforestation and the day to day activities of mankind community resulted to spatial and temporal variation in land use land cover have affected water flow path ways and water balance [16]. Venkateswaran et al. [17] conducted a study in the Vaniyar sub-basin of the Ponnaiyar River in South India. The aim of work was to identify the variation occurred in land use/cover changes by artificial recharge structures (ARS). He reported that the artificial recharge structures have the positive impact on the surrounding area and play a very important role to conserve natural resource like, water and soil, which is reducing day by day at an alarming rate. Furthermore reported that the area of evergreen forest land has been increased by about 4 % in and around artificial recharge structures due to the influence of the check dam [17].

2. Study Area

Nagarparkar, an ancient Hindu and Jain pilgrimage site, is located in Tharparkar District, Sindh, Pakistan. It is located 129 km from Mithi, in Sindh, Pakistan. The Nagarparkar is located between latitudes $24^{\circ} 14' N$ to $24^{\circ} 33' N$ and longitudes $70^{\circ} 36' E$ to $71^{\circ} 03' E$, and it covers an area of approximately 313.63 km^2 . The Nagarparkar area is connected by road with Karachi, Hyderabad, and Badin via Mithi and Islamkot. It is situated in the south-east corner of Sindh Province and is shown in Figure 1 [18]. General Information of Tharparkar District and its local Government setup are mentioned in Tables 1 and 2 respectively. The current growth rate of the Tharparkar and study area are shown in Figure 1, while the study area is shown in Figure 2.

Table 1. General Information of Tharparkar District

S#	Parameter	Description
1	Area	19638 Square Kilometer
2	Demographic information	7 Talukas, 64UC ,172 Deh, 26 Circle and 56Tapa
3	Current population	1649661 Tharparkar
5	Population growth rate	3.15% Tharparkar
6	Current Agri: growth rate	0.1 % Tharparkar
7	Livestock growth rate	2.2% Tharparkar
8	Current population	260170 Nangarparkar
9	Population growth rate	2.82% Nangarparkar
10	Population growth rate	2.82% study area
11	Current Agri: growth rate	1.8 % study area
12	Livestock growth rate	2.6 % study area
13	Livestock population	3656933 (TRDP)
14	Birth rate	38.8 Crude birth rate and 5.5 fertility rate
15	Mortality rate	87 Infant mortality rate/ 1000
16	Literacy rate	18.32 % for male and 6.91 % for female
17	Main livelihood sources	Agriculture and livestock
18	Health	1 CH, 3 THQHs,2, 2 RHCs, 30BHUs, and 40 Dispensaries
19	Climate	Tropical, deserted and consist of a barren tract of sand dunes
20	Minerals	Coal, Granite, China clay and salt mines

Table 2. Local Government Setup of Tharparkar District

S. No	Taluka	MC	TCs	UCs	Circles	Tapa	Deh
1	Mithi	1	1	9	5	10	27
2	Islamkot	-	1	10	5	9	21
3	Diplo	-	1	5	2	4	26
4	Kaloi	-	-	7	2	6	18
5	Chachro	-	1	10	5	10	19
6	Dahli	-	1	11	3	7	23
7	Nagarparkar		1	13	4	10	38
8	Total	01	6	64	26	56	172

Where, MC is Municipal committee, TC = Town committee, UC = Union council

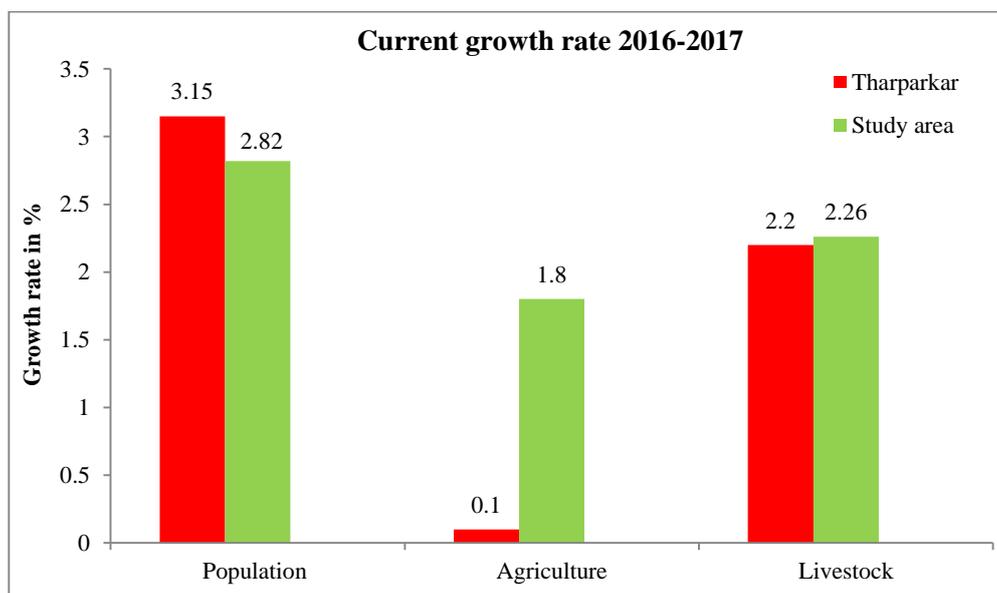


Figure1. The current growth rate of the Tharparkar and study area

2.1. General Field Conditions

Nagarparkar region is divided into two categories based on geomorphology. Area one is the Thar Desert, and an area two is the hilly Thar (Nagarparkar) region shown in Figure 2. The Thar Desert consists of an area of high sand dunes, composed of fine, coarse sand with silt. The drainage system of the Thar rainwater that comes from the sand dunes and accumulates into the low-lying areas. The hilly Thar (Nagarparkar) is mostly flat land. The drainage system of the hilly Thar area consists of fifteen streams and rivers, locally called Nai. These seasonal Nai drain the rainwater from the plain and Karonjhar hills to Ran Kutch. In that region, there is no functional irrigation system; the only available source of water is from underground sources. The rain is the only source for groundwater recharge, agriculture, and livestock, livelihood resources of the settled communities entirely rely on the rain. Even a short drought adversely affects the groundwater recharge and resources. The rainfall that occurs in that region is mostly irregular and undependable. Annual average rainfall in the region varies from 4 to 6 inches, whereas Nagarparkar receives 13 to 15 inches or more. The monthly status of the rainfall and evaporation for the year 2017 are shown in Figure 3. Small dams were constructed in hilly Nagarparkar for harvesting the rainwater; salient features of the dams are shown in Table 3.

The hilly Thar region also consists of mountains in which some granite matter is present. The Granite Mountains covers the central part of the hilly Nagarparkar, and they extend for approximately 80 square kilometers. The elevated peaks vary from 114 to 360 meters above a sea level, [18].

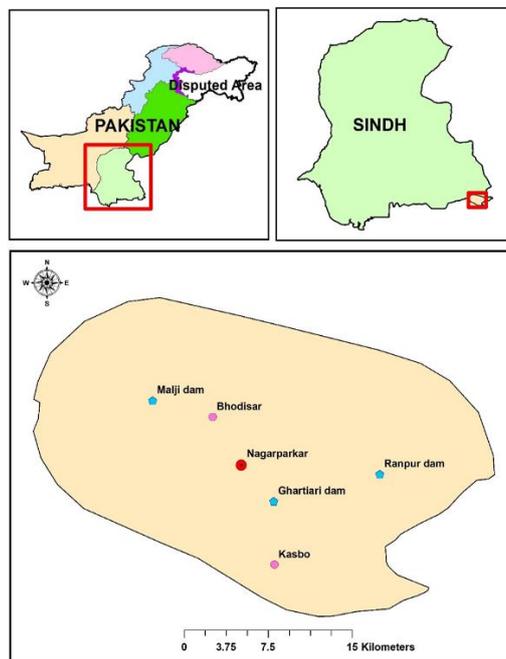


Figure 2. The Study Area [18]

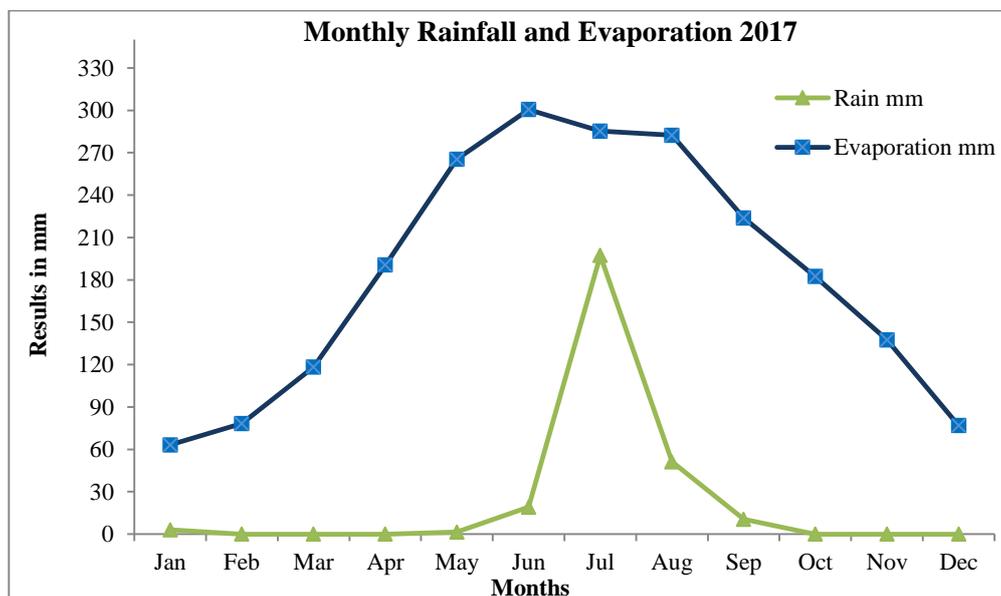


Figure 3. Monthly rainfall and evaporation of the year 2017

Table 3. Salient Features of the Selected Dams

S. No	Name	Type	Location	Cost (M)	Height (ft)	Spillway width (ft)	Capacity ft ³
1	Ranpur	Storage	Bhimara	115.312	10	150	3570
2	Bhodesar	Storage	M.jo w	53.831	7	111	763
3	Malji	Recharge	Khipora	119.711	8	270	7397
4	Ghartiari	Recharge	Ghartiari	167.690	11.5	115	753

3. Materials and Methods

The study was carried out for the Nangarparkar area (Tharparkar, Sindh), which is situated at the southeast corner of Sindh Province, having an elevation ranging from 114 to 360 m above mean sea level. The study area comes under the arid zones, annually rainfall occurs less than 250 mm. The different researchers have used different materials and methods for assessing the impact of the small dams on land cover changes. In this study, satellite data and ENVI software were used to assess the impact of a small dam in the targeted area. Landsat 5 and 8 were used for acquiring the satellite images and analyzed using ENVI software [18-23]. Total 04 year’s randomly selected cloud-free images were downloaded from the US Geological Survey (USGS) website for the years 2008, 2009 and 2015 and 2016. The selected images of Landsat 5 were used for ‘Before’ the year 2013 and Landsat 8 after 2013. The downloaded images were analyzed through ENVI software and classified based on the three classes such as (Water, Vegetation, and Soil). Training samples were taken for all the classes. Different colors were selected for identifying the classes. The samples were equally distributed and scattered over the study area. The maximum likelihood (MLH) supervised method was used to classify the multispectral images [24]. Before the classification, created a new subset of the images and training samples data were selected with the region of interest (ROI) to classify the land cover changes assessment.

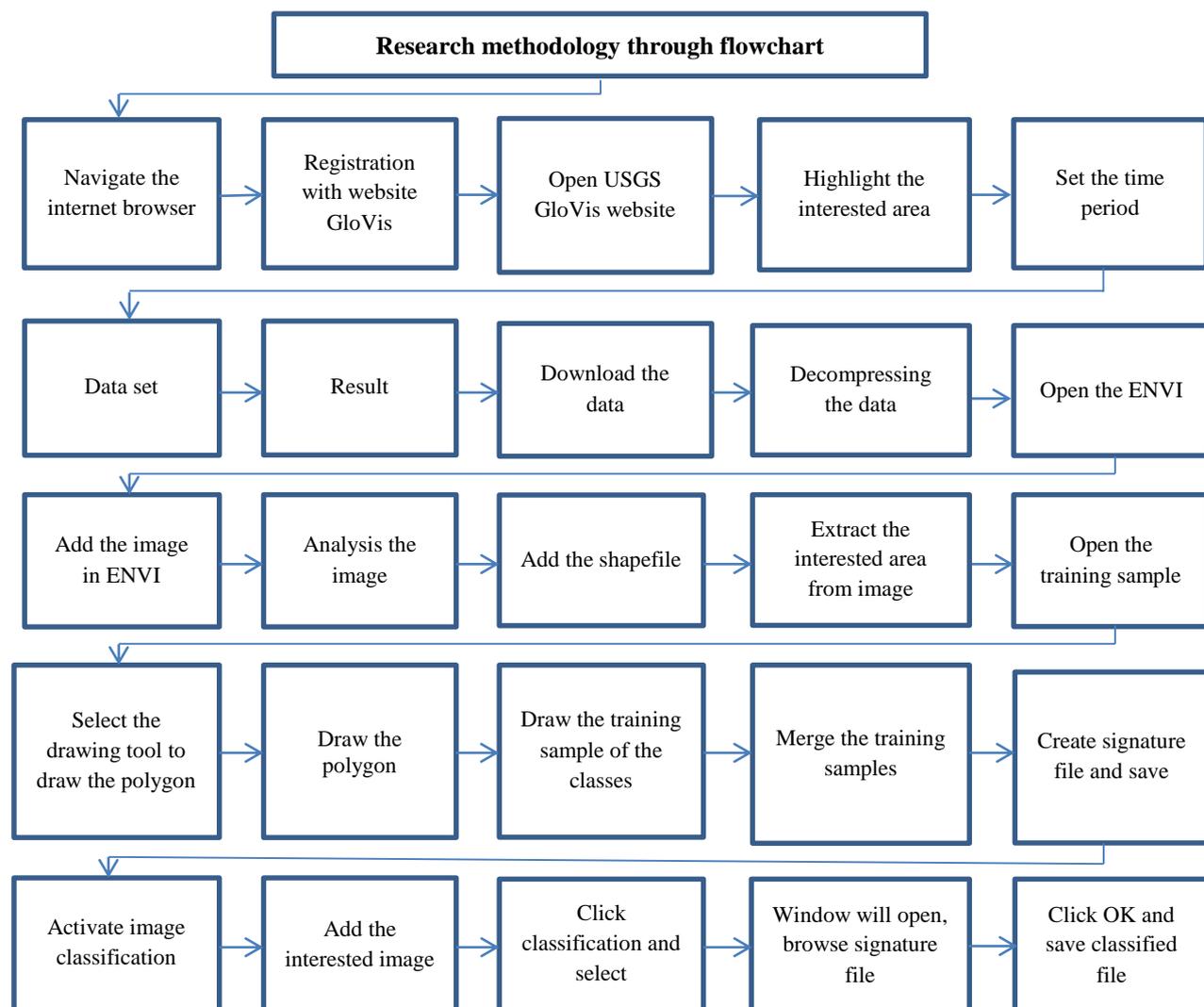


Figure 4. Flowchart of the Research methodology

3.1. Graphical Methodology

Figure 5 (a-e) shows step by step methodology graphically, that was employed for assessing the impact of small dams on land cover changes. Figure 5(a-b) represents two images, Figure 5(a) shows the whole unclassified satellite image downloaded from the US geological survey (USGS) earth explorer website. The images of Landsats were used for acquiring pertinent spatial information of different year's. The detail of the data sources is described in Table 4. The subset of the interested area is executed and extracted from the image using different processes application. Figure 5(b) is also an unclassified image in which interested area is shown with red color represents the subset of the image. Figure 5(c) represents the shapefile of the study area extracted from the image in which executed locations of the selected dams are shown and its salient features are also described in Table 1. While Figure 5(d) also represents the shapefile of the study area in which training samples are shown in different colors which represent the classes. Figure 5(e) represents the classified image in which classes are shown which clearly indicates the classified quantity of each class. The results detail of each class is shown in Table 5.

Table 4. The detail of the data sources and Landsat

S.NO	Date, Month and Year of the Images	Landsat No.
Before dam construction		
1	19-11-2008	5
2	16-12-2009	5
After dam construction		
3	3-12-2015	8
4	22-12-2016	8

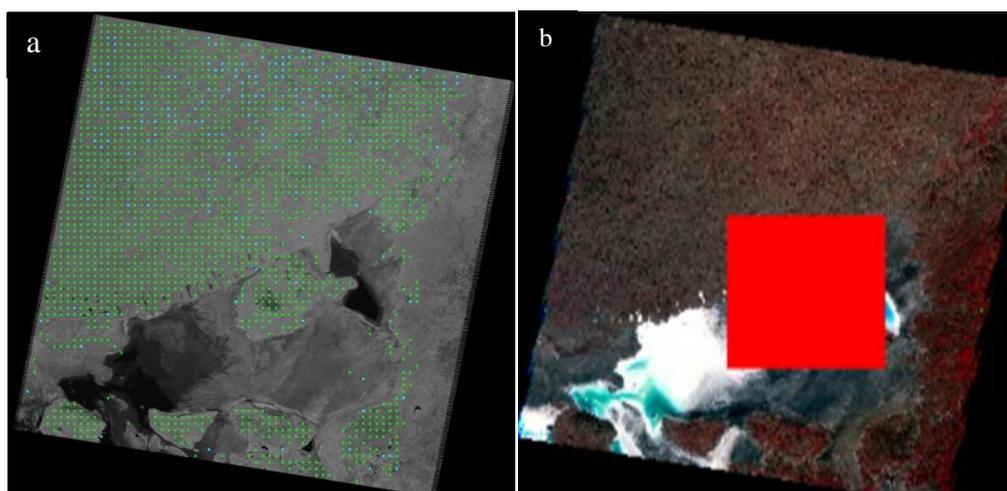


Figure 5(a-b). Represent the whole image and subset from the image

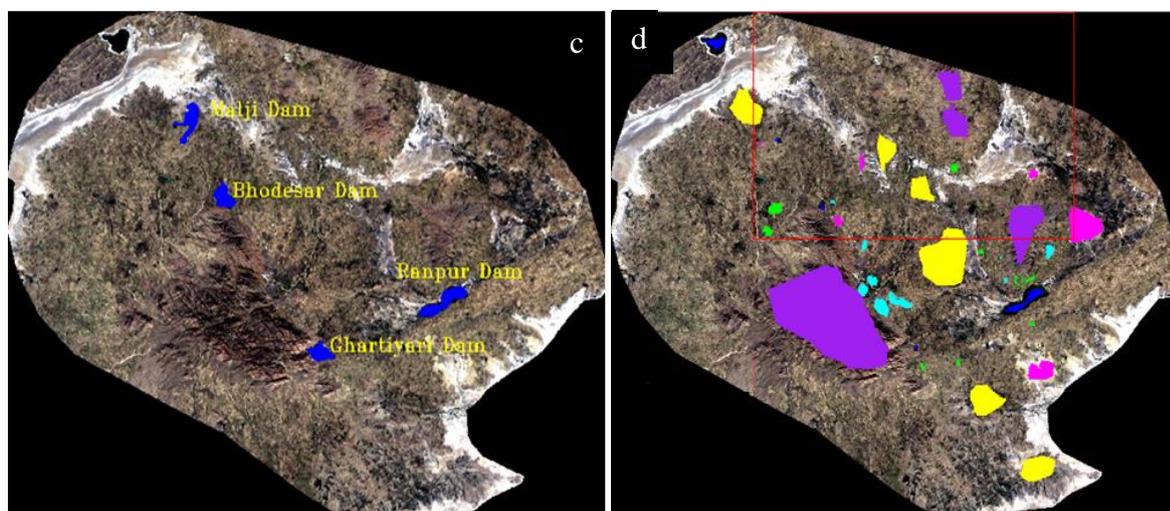


Figure 5(c-d). Represent the study area shapefile and training samples of the classes

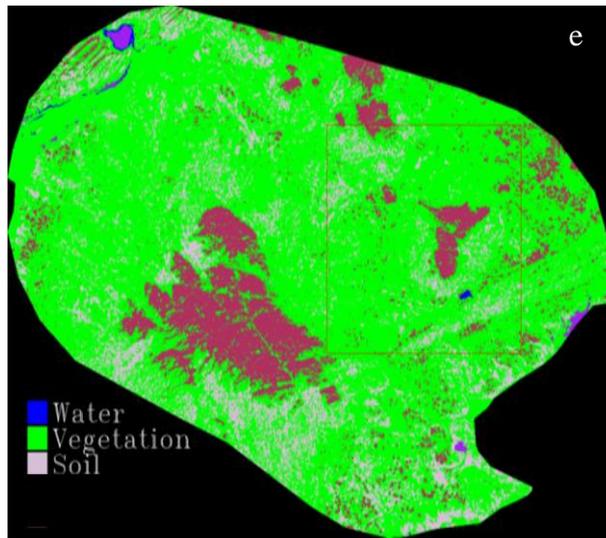


Figure 5(e). Represent the classified image and classification of the classes

4. Results and Discussions

Classified results of the different year’s images before and after the dam’s construction are shown in Table.5 and Figure 6. The year wise detailed results status of the classes for the years 2008, 2009, 2015 and 2016 are also mentioned in the same Table and Figure 6. These results show the variation occurred in each class among the mentioned years that indicate the changings in land cover change. Further more detail description of each class before and after dam construction are described in percentage below Table 6.

Table 5. Year wise results classification summary of the classes before and after the dam’s construction

S. No	Classes	Year 2008	Year 2009	Year 2015	Year 2016
1	Water	4.6888	1.3754	11.5936	5.4008
2	Vegetation	26.5443	10.6500	35.8432	32.8269
3	Soil	31.5468	33.0697	17.5272	16.7809

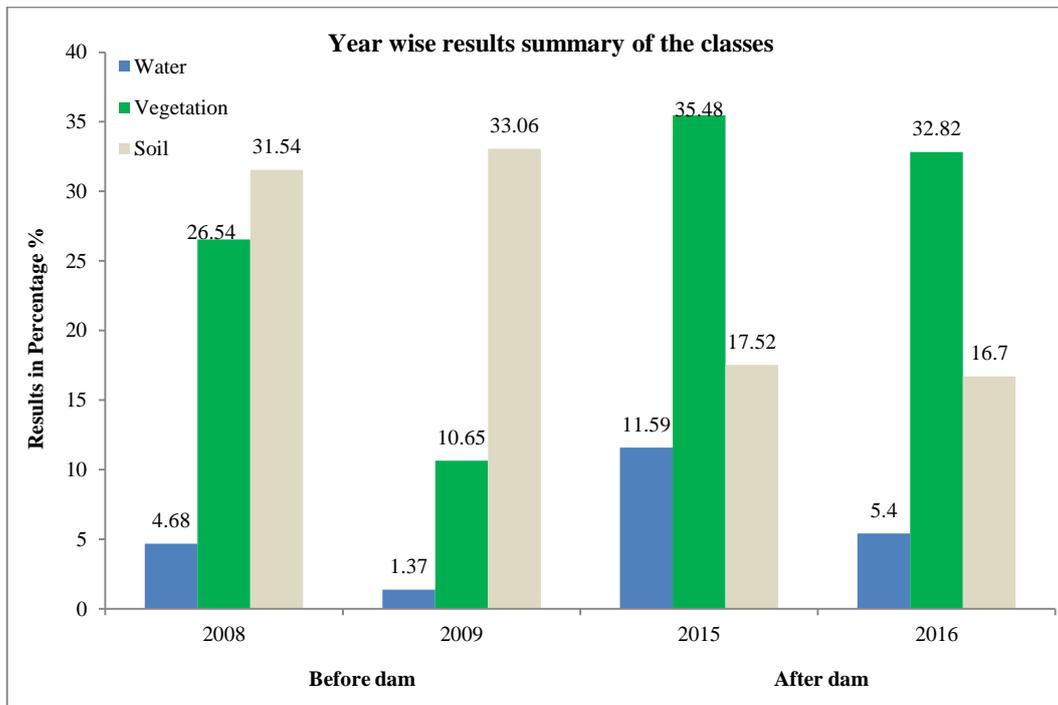


Figure 6. Year- wise results classification summary of the classes before and after dam construction

Table 6. Average results summary of the classes before & after dam and improvement occurred after the construction dams

S. No	Year	Class	Average result %	Av: Improvement%
Before dam construction				
1	2008-2009	Water	3.0321	
		Vegetation	18.5971	
		Soil	32.3082	
After dam construction				
2	2015-2016	Water	8.4972	5.47 increased
		Vegetation	34.3350	15.18 increased
		Soil	17.1540	15.15 decreased

Before the dam's construction, results of the classes for the years 2008 and 2009 were found different. In 2008 water availability, vegetation and soil cover was found 4.68 %, 26.54 %, and 31.54 % respectively. Similarly, in the year 2009 the results of the mentioned classes were found at 1.37%, 10.65%, and 33.06% respectively. While after the construction of dams, the results of the classes for the year 2015 and 2016 were also found different like 2008 and 2009. Water availability, vegetation cover and soil cover rate were found 11.59 %, 35.84%, and 17.52 % respectively in the year 2015, while 5.40%, 32.82%, and 16.78% during the year 2016. Average results of the mentioned classes of both years 2008 and 2009 before dam construction were found 3.02%, 18.52%, and 32.3% respectively, same way average results of both year 2015 and 2016 were found 8.49 %, 34.33 %, and 17.15 %. After the construction of dams, variation was found positive in all three classes, variation revealed that water availability and vegetation cover increased by 5.47 % and 15.18%, while soil cover decreased by 15.15%. It is clear from the results that the dam's construction has a positive impact in the arid area.

5. Conclusion

The construction of small dams has shown a considerable effect over the land cover in the arid region of Sindh, Pakistan. The results extracted from the proceed satellite images suggest that a notable variation among the results before and after the small dam's exist. Variation in land cover as a result of the regular supply of water from the small dams, the water and vegetation cover increased by 5.47% and 15.18% respectively while the bare land decreased 15.15 % after the construction of dams. The results ascertained that bare land was rejuvenated and occupied by vegetation that was measured from the satellite images of four years. It was very clear from the classification result summary of the satellite images that water availability and vegetation cover rate were low, while the soil cover rate was high in the area before the dam's construction. However, after the dam's construction, the presence of water availability and vegetation cover increased, while the soil cover rate decreased.

It is concluded that the constructions of small dams has a positive impact not only on land cover changes but also on population, agriculture, livestock, resettlement and livelihood resources in a direct and indirect way and also play a very important role on the socio-economic conditions of the settled communities of the arid area, also reduce the wastage of water and store the water for future need.

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7. Conflicts of Interest

The authors declare no conflict of interest.

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