Assessment of Environmental Changes using GIS Applications

C. Prakasam, Saravanan R, Varinder S Kanwar, M.K. Sharma, Monika Sharma

Abstract*: *Hydropower is one of the prominent sources of electricity and renewable. It is also one of the key sources of economic growth for the Himachal Pradesh state. With the idea of an increase in hydropower projects increase the economy, the state is building more hydropower projects. The construction of hydropower projects has a significant impact on the environment both positive and negative. This work focuses on assessing the environmental changes in the Pandoh hydropower project's basin in terms of sufficiency of the environmental flow for the sustenance of agriculture's health and vegetation. Pandoh hydropower project was established in 1977 in the Mandi District, Himachal Pradesh producing up to 990 MW. It is situated along the downstream side of the Larji hydropower project and sources of water are the releases from the Larji reservoir. It is also a source for the Dehar hydropower project downstream to the Pandoh dam. The assessment has been done using the Normalized Difference Vegetation Index and Land Use Land Cover Change. The analysis is carried out for two periods, healthy (August to October) and lean period (November to February), that too before and after the construction of the dam. The results show that the impact prevails in the study area with a decrease in agricultural land and an increase in urbanization.

Keywords: Impact assessment, Agriculture, LULC, NDVI, Hydropower project

I. INTRODUCTION

In India, hydropower is the predominant inexhaustible vitality source. Hydropower contributes to the vast majority of the nation's vitality needs. The vitality prerequisites are relied upon to be significantly increased soon. So as to tap the capability of these sustainable power sources, there is a need to survey the accessibility of the assets spatially. GIS has been applied to a wide scope of various projects assessing the impact. The most widely recognized GIS applications for the effect assessment include road projects, coastal impact, water resources projects, and all infrastructures, etc. Dams may have a progression of ecological outcomes that can or can't be envisioned. Some of these are managed in more prominent detail somewhere else, for example, subsidence, seismic tremor setting off, the transmission and extension in the scope of living beings, the development of soil saltiness, changes in ground-levels making slant shakiness, logging. In any case, dams can be affected by the physical condition where they are fabricated. The process of assessing environmental changes from time to time has become a must practice in recent times. Due to the time-consuming process of traditional practices, incorporation of both GIS and Remote sensing has become a trending technique of modeling the existing natural environment and monitor the change spatially, temporally. This helps us in saving time and a lot of data while making policies, administrators for its capabilities of accurate LULC data. For the synoptic view, environmental changes are done at a regional 30-m scale in Landsat which offers possibilities for monitoring the change. The acquisition and refreshing of data about the present condition and the nonstop dynamic changes of our world's surface in remote high-mountain districts are where remote detecting innovations can best show them favorable circumstances. LULC appraisal is one of the most significant parameters to definitively plan for land assets on the board. LULC inventories are expecting expanding significance in different asset areas like horticultural arranging, settlement reviews, ecological examinations, and operational arranging in view of agro-climatic zones. The land use data is basic for the appropriate administration and monitoring of normal projects. Satellite remote detecting symbolism is a feasible wellspring of social event quality land spread data at the neighborhood, provincial furthermore, worldwide scales. The NDVI can demarcate the vegetation topographies potentially and offers useful data as an RS technique.

The level of feature's accuracy depends upon the resolution of the image and the incorporation of both spatial and spectral information helps in information extraction to be more effective [1]. The urbanization can impact the hydrological circle and soil erosion rate as the land-use change from rural to urban. [2]. Mapped, monitored the thermal power project impact on the environments, forests at a 1: 50,000 scale using temporal satellite data. The land sat MSS, TM, and LISS-II sensors, FCCs, etc., were employed for analyses. The environmental impact was briefly analyzed showing the impact regions spatially. [3]. assessed the open cast mining impact on water and land in Goa regimes using remote sensing. LULC maps derived with the aid of six topo sheets, MSS, TM, SPOT, and IRS data for six years covering study area were prepared. The aerial photographs covering the mine area of 1973 and 1978 also helped in mapping the LULC. [4] [5]. Provided the comprehensive LULC analysis for the Chenab Canal in the lower part of the irrigated region for a span of 2005 to 2012 in Pakistan for land use change detection. MODIS with a spatial resolution of 250 by 250 m helped in demarcating the major crop types by means of NDVI temporal profiles. The result shows that the change detection for the wheat and rice has low instability of change. [6].

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took the assistance of the MODIS data and Landsat for developing the LULC analysis for the Mekong Basin in the lower part for planning the basin. The 2010 MODIS data such as MOD09 and MYD09 data were divided into NDVI monthly then classified as LULC types. [7]. Studied the LULC change in Lodhran district using the GIS and remote sensing technology for 40 years and thereafter conducted the NDVI and NDBI analysis, mapping using satellite data. The analysis involved the prior effects of an incidence quantitatively thereby helping the indention and changes. [8]. [9] identified the impact in the environment due to a small hydropower plant in Slovakia. It additionally surveys the options in contrast to the particular water-powered structure by a quantitative assessment from the perspective of the character of the effects, their importance, and their span. The finish of the work incorporates the choice of the ideal option of the evaluated development and recommends estimations to lessen the harmful effects.

The impact assessment has a wide scope and this paper particularly focuses on the environmental flow maintenance in the hydropower project and its concentric study area. The environmental flow of 15% average lean season flow should be maintained in the downstream side of the river to maintain the health of the ecosystem. This analysis will help us in understanding whether the maintenance is sufficient or not. Hence data were acquired before construction of the dam and after i.e., the dam was constructed in 1977 hence 1972 and 2018 data has been used for the analysis. The lean period and high flow period were also compared for these years to understand the environmental variation in the Pandoh in accordance with the construction and operation of the hydropower project.

II. STUDY AREA

Pandoh dam is part of the Beas river basin and it is of 2134 m in length,457m in width, and a depth of 15.58m are situated in Mandi district of 134 hectares' catchment area encompassed by Shivalik mountains at 899 m altitudes. It is owned by the Bhakra Beas Management Board (BBMB) and completed in 1977. The lake pursues a strait and expansive course between three soak slope slants.

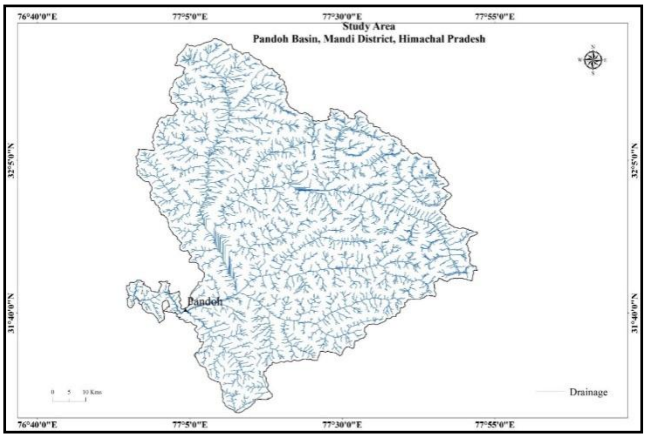

Fig.1. Pandoh Dam

The wellsprings of water to the lake are watershed, atmospheric inputs, and baseflow. For the generation of hydroelectric power, an earth-shake fill dam. The Pandoh Block of Mandi district is surrounded by temperate forests. These forests are having high diversity that supports a variety of flora and fauna. The catchment contribution by the Pandoh dam's upstream to the Beas basin 5278 km2. About 14% of the upstream catchment is covered with snow and ice permanently. The altitude of the location of the Pandoh dam is between 900 - 5000 m m.s.l. The major tributaries that join the Beas River in the upstream side of Pandoh Dam are Parvati, Tirthan and Sainj, Sabari Nala, Bakhli Khad rivers. The forests contain adult trees of Oak, Pine, Cycas, etc. They are mainly gymnosperms. Other types of the lower group of plants (bryophyte and Pteridophyta) and high order plants (angiosperms) are a common occurrence. This region is very important in terms of the commercial production of apple and cherry. The grass of Cannabis Sativa is common in the occurrence which is a source of bhang, ganja, churus, etc.

III. MATERIALS AND METHODS

The evaluation of water resources projects includes setting up the sum, quality, what's more, accessibility by assessment of the potential outcomes of continuing their advancement, the board, what's more, control. Maximum Likelihood classification is the commonly used and accurate method of classifying the land use. For this study purpose, since the concentration is much on the water and vegetation the classes consist of Agriculture, built-up land, barren land, forest, river, Glacier. The study area is prone to glacier contribution. The class was classified according to the National Remote Sensing Centre LULC scheme classification. The training samples were obtained with the help of the toposheets and field visits. It is saved as a signature file with a minimum of 20 sample size for one particular class. Once the training sites were resolved, a managed characterization was performed on both pictures utilizing the Maximum Likelihood calculation in ERDAS. The supervised classification is used, on the grounds that the information of the examination region is accessible and the creator has earlier information on the examination region. It is considered to give very precise outcomes and was applied to arrange and to delineate spread. For change detection, Landsat 4, Thematic Mapper (TM), and Landsat 8 OLI images were acquired for before and after the construction of dam i.e., the dam was constructed in the year 1977 hence data acquired in 1972 and 2018. Since the focus is on primarily environmental flow, the comparison is made for a lean period and a high flow period. The bands of the Landsat data were composed using the Layer stacking and clipped using the Arc GIS 10.1 software. [10]. The NDVI analysis has been carried out using the Landsat 8 and Landsat MSS data. For the Landsat 8, the band 5 and band 4 come into play and MSS data band 6 and band 5 has been used. The calculation ratio between the sum and difference of the infrared, red bands correspond to the NDVI results.

IV. RESULTS

In order to represent the impact on the ecosystems spatially and temporally, the NDVI analysis was performed with satellite images as input to detect the differences in the state of vegetation covers before and after the construction of the dam. NDVI has a correlation with the amount of chlorophyll. NDVI varies between -1 until +1. More close to +1 of NDVI, more presence of vegetation crown density. The very low values of NDVI (less than 0.1) match up to barren land of sand, rock, or snow.

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From 0.2 to 0.3 correspond to shrub and grassland and Values from 0.6 to 0.8 indicate forest cover. For the pandoh dam, from 1976 to 2018 during the lean period, the spatial extent of the level of greenness has decreased at a greater level from 0.79 to 0.51 (Figure. no.2). The greenness is rich in the 1976 data. The development of cultured areas, exposed farms, and developed areas are evident in the NDVI study. These zones were shown as dark red and NDVI values are less than 0.0 as an average ranging near the negative values (Figure. no.3). This implies that numerous areas that were vegetative in nature are now affected by the construction and operation of the dam. The water resource in the region is also very meager and barren lands have also increased in range due to poor maintenance of minimal flow in the dam. The neighborhood issues must be mulled over.

In the case of the Pandoh dam, which is in the downstream side of the larji dam accumulates the same water with the addition of 447.5 sq.km land use as part of its watershed. Table.no.1 shows the LULC area calculation for the Pandoh and the percentage of area is given as bar diagram in Figure.no.4. The trend change is from 1976 to 2018 as the agricultural land use decreased up to 6.5 % with the increase in barred land of 7.3 % as most of the vegetation cover turned to be barren land with the forest as a 5.2% decrease (Figure. no.5). The glacier contribution is almost the same with a 4.4 % increase in percentage. The water level is almost dry during the lean season with a 0.2% change.

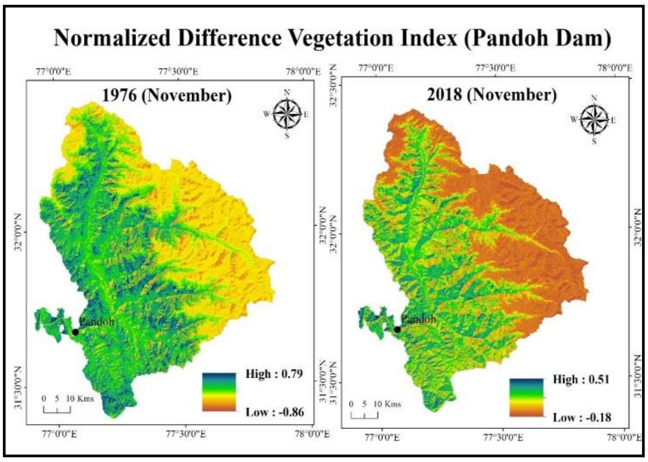

Fig.2. NDVI for Pandoh (Lean Period)

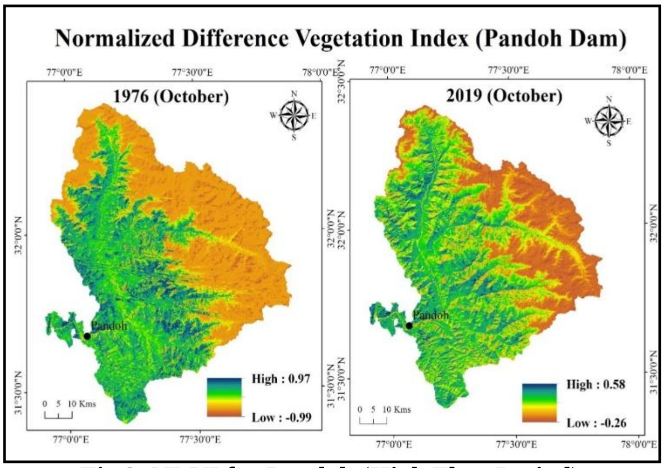

Fig.3. NDVI for Pandoh (High Flow Period)

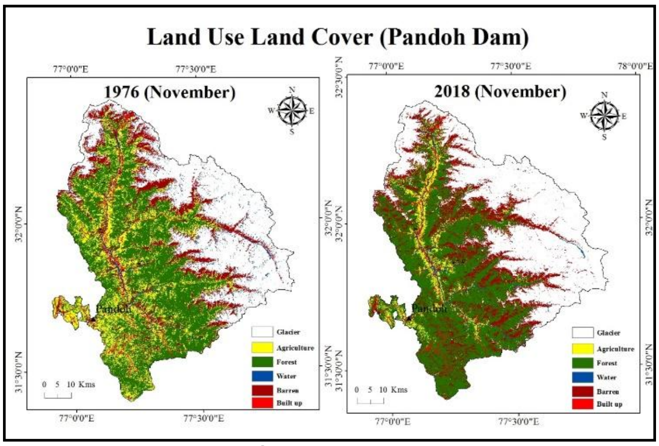

Fig.4. LULC for Pandoh (Lean Period)

Table-I: LULC area Calculation for Pandoh (Lean Period)

Date	3/11/1976		26/11/2018	
LULC	Area (Sq. Km)	In (%)	Area (Sq. Km)	In (%)
Agriculture	745.87	13.3	382.36	6.8
Barren	1120.01	20.0	1525.68	27.3
Built up	50.77	0.9	63.92	1.1
Forest	1883.47	33.7	1591.90	28.5
Glacier	1738.84	31.1	1982.93	35.5
Water	49.24	0.9	41.41	0.7
Total	5588.20	100.0	5588.20	100.0

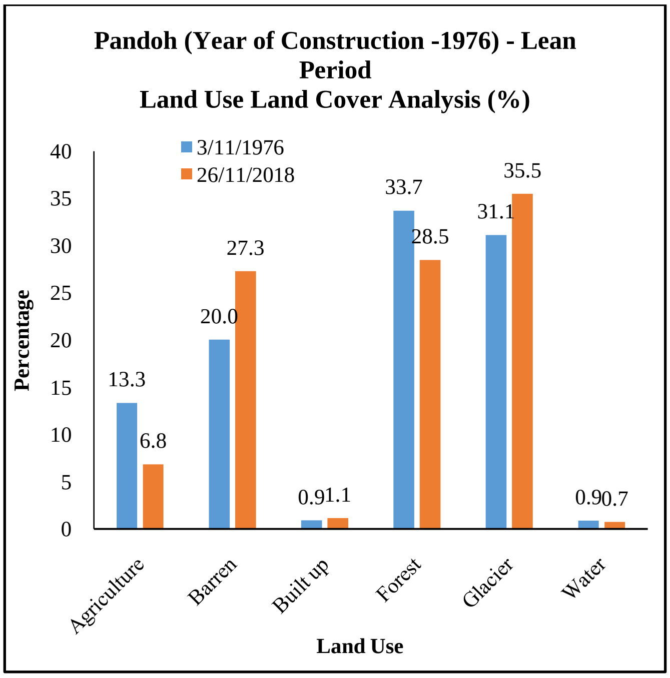

Fig.5. LULC area in % for Pandoh (Lean Period)

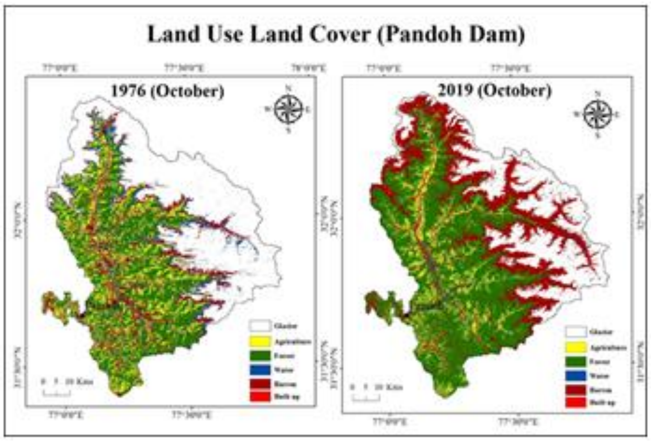

Fig.6. LULC for Pandoh (High Flow Period)

Table-II: LULC area Calculation for Pandoh (High flow Period)

Date	16/10/1976		28/10/2019	
LULC	Area (Sq. Km)	In (%)	Area (Sq. Km)	In (%)
Agriculture	689.62	12.3	439.62	7.9
Barren	1050.45	18.8	1713.14	30.7
Built up	51.86	0.9	64.13	1.1
Forest	1752.58	31.4	1681.90	30.1
Glacier	1982.16	35.5	1635.06	29.3
Water	61.53	1.1	54.36	1.0
Total	5588.20	100.0	5588.20	100.0

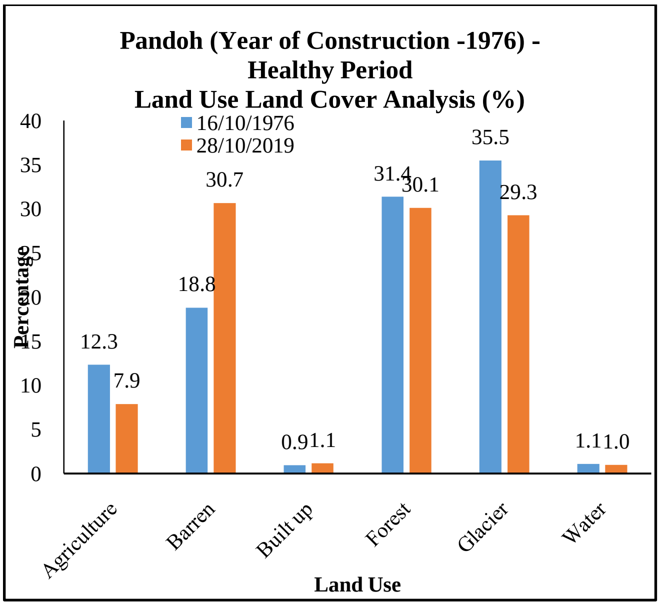

Fig.no.7. LULC area in % for Pandoh (High Flow Period)

The overall LULC analysis shows that there prevails a significant change in LULC after the construction of the dam. However, pertaining to the focus of the environmental flow and its related impact, the water level seems to be the same in both a lean period and a healthy period. Also, the vegetation cover decreased overall both the agriculture and the forest after the construction. One of the significant changes is the increase in the settlements as these areas became prone to urbanization in the late years. With high flow year as a reference, the land use for the lean period is comparatively similar which in turn answers to the question about hydropower impact in terms of environmental flow during the lean season.

V. CONCLUSION

The change detection and the NDVI analysis evident us that the impact prevails in the study area but the conclusion cannot be made that the impact is due to the improper maintenance of the environmental flow. On the other hand, the conclusion can be made that the impact can be mitigated if the environmental flow is maintained as per the standards. The drastic urbanization caused apparent natural effects as far as overflow and quality of water. At the point when one sort of utilization replaces another, the impacts will, in general, be superimposed and combined. During the procedure of urbanization, when provincial territories are changed over to urban land utilizes, hydrological circle and paces of soil disintegration will change as needs are. Assessment of the impact of the endeavor on nature is considered as an instrument that restricts the execution of activities which could in any way conversely intrude with the earth and at the same time allows picking the perfect plan from the proposed choices of the endeavor execution—the choice with the tiniest negative impact of a proposed development on the condition. Although the difference between the high flow period and the lean season is negligible both positively and negatively, the key focus of water is relatively less as most of the Khad and river path turned out to be barren land in both the period. The suggestion in terms of GIS analysis for the sufficiency of environmental flow percentage can be increased up to 17 % so that the river won't turn dry during both the season. As far as the impact change is concerned, the change is persistent towards the current year for the vegetation cover due to the increase in urbanization and various other anthropogenic activities.

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