RESEARCH ARTICLE OPEN ACCESS

Geospatial Technology Assisted Assessment & Monitoring of Surface Water in Wetlands of Sakoli Tehsil of Bhandara District in Maharashtra state, India

Vikas P.Bawankule[*],Laxman P. Nagpurkar[**]

[*](Department of Agriculture Processing and Engineering, Chetnagiri Biotech LLP, India

Email: vikasbawankule6@gmail.com)

[**](Department of Chemistry, ManoharBhai PatelArt, Commerce &ScienceCollege, India

Email: lp.nagpurkar@gmail.com)

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Abstract:-

In Geospatial Technology, Remote Sensing data are used for Assessment and monitoring water resources by providing a synoptic overview and repetitive information.This studyfocused on water bodies in Bhandaradistrict in eastern Maharashtra, India with the special emphasis on status of surface water in wetlands of Sakolitehsil.The Technology supported accurate and updated maps, as well as spatial and temporal changes in Sakoli tehsil's wetland, that had not yet earlier been investigated, only flora and fauna details have been documented.This study attempts to detect the status of surface water in wetlandsof Sakoli tehsil and to monitor the changesof entire status using remote sensing &GIS techniqueand field investigation.The Remote sensing (Landsat) data used in this research was acquired by Landsat 5, Landsat 7, and Landsat 8 images of the same month in January of 1989, 1998, 2003, 2009, 2016, and 2019 downloaded from the United States Geological Survey (USGS) with 30-meter resolution.Satelliteimage data followed by Visualinterpretation and processing by Normalized Difference Water Index (NDWI) and Modified Normalized Difference Water Index (MNDWI) with the help of QGIS and ArcGIS Software. The ground truth and field investigation for study area has done by author. These methods are scientifically used to classify the data into two categories: water and non-water objects and potentially worked in this study. The result is based on available data analysis of last three-decades, area of surface water bodies of Sakolitehsilhave reducedsignificantly as far as conservation and management of wetland is concerned, it is an urgent need to conserve it to make liveable environment for existence and survival of flora and fauna including fishes, plants, birds, and other wildlife which influence the Global ecosystem and Global climate significantly.

Keywords – **Remote Sensing and GIS, Geospatial Technology, NDWI, MNDWI,SakoliTehsil, Wetlands**

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I. Introduction:–

Maintaining the ecological balance, wetlands have been playing a crucial role in ecosystems in their surroundings. However, looking at the present situation of wetlands,which seems very poor status due to anthropogenic activities to a great extent, it isnow hightime to take immediate and appropriate step to protect and conserve these wetlands for sustainable future[1]Wetlands are areas where water is considered as the primary factor controlling the environment of its flora and fauna and surroundings too[2]. If wetlands are destroyed, there would be an enormous impact on its whole biodiversity.If it ispreserved,the entire ecosystem would be maintained in real sense and associated environmental, social, and economic benefits will also be rendered to stakeholders.Similarly,Erosion control, economic benefits, flood storage,natural products for consumptive uses for human, and great opportunities for recreation, education, and research would have better scope to improve further[1-3].

Wetland populations are declining globally. These wetlands are constantly under threat of massive degradation due to encroachment as well as other human activities too. [4, 5].It is obligatory to generate information for their protection, conservation, and management, and also in view of the vital role of wetlands in ecosystem protection and livelihood of people to a great extent. If it is a long-term change in the study area validates the management agencies to prepare wetland restoration or conservation programs as well, then a better understanding of the dynamics and trends of wetlands resources[6-8].There isneeds to change in attitudes at the local as well government level, and strategy for water resources managementIn India[9]**.** Wetlands provide a variety of services, including irrigation for farming practices, domestic water supply, role in groundwater recharge, flood control, pollution control, carbon capture and storage, as well as freshwater for flora and fauna.[9-11]. The Government of India has Taken many important steps to further strengthen it for protecting and conserving rich diversity of India, including planed programme, policies action planes, legal framework, etc. In 2002, the Parliament enacted Biological Diversity Act, (Biological Diversity Act, 2002) which advice that, for conservation and protection of biological diversity and sustainable use of its component. Since, wetlands are not onlyprovide commodious array of ecosystem goods and servicesbut also support large biological diversity" [4, 12, 13].

Generally, to assessment and monitoring of wetland such as field survey and sampling, etc are some traditional methods usually called as too much time consuming, labour intensiveand also expensive.So, Recent more advanced developments in Geographical Information System (GIS) and RS Technologies are providing valuable tools[14]to assistin thearranging,monitoring, assessing and management of wetlands.[15, 16]. It really plays a critical and significant role leads to help in monitoring, assessment of ecological status and action plan preparation for conservation and management[17]. In remotely-sensed digital imagery, to describe open surface water features by skipping others features and also to enhance their presence Normalized Difference Water Index (NDWI) is geospatial tools tool used in GIS[18].Water Storage by the check dam boosts livelihood income, owing to continued cultivation and enhanced water availability for multiple uses. [19, 20].Most dams have been constructed to provide water to mitigated lands, generally for agriculture, households and industries sectors, etc [21, 22].Furthermore, Geospatial Technology performs effectively when processing several data sets relevant to a wetland and water storage assessment project[23].

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Therefore, study areachosen is one of the most biodiversity rich zoneof central India[24, 25]. Study area is in vicinity of two protected areas i.e.Nagzira Wildlife Sanctuary and Navegaon National Park of Nagzira-Nawegaon Tiger Reserve (NNTR) have its connectivity through a forest patch[26]. According to[26] Study,The overall water bodies are decreasing continuously in the corridor and affectingavifaunal species and aquatic floral diversity as well.Remote sensing has become a crucial tool in analysing the Earth's surface characteristics, and hence in providing valuable information necessary for the hydrologic analysis[27, 28]. Moreover, wetlands are known for their ability to support a large human population and hence, sustainable utilization of wetland resources is very important[29].To multiple benefits and services associated with wetlands for people as well as for environment, the critical role of wetlands in achieving Sustainable Development Goals (SDG) cannot be ignored.[30, 31].Therefore, the objective of this study is to monitor and assessment of entire status of wetland in Sakoli Tehsil of Bhandara district in Maharashtra, surface water bodies by using water indices extracted from 1989 to 2019 of geospatial technique and by performing field investigation of the same.

II. Materials and Method: -

A. Study area -

The study is carried out at Sakoli tehsil of Bhandara district in Maharashtra state in India, which is located in the lap of Chulband river (Approximately 3-4 km from the Sakoli city)in north deccan Maharashtra lower plateau in 'Wainganga' sub-basin, and lies between 21.0736° N, 79.8297° E (Figure I).Sakoli tehsil of District Bhandara has a mixed economy in the sense agriculture, manufacturing and forest resources etc. It also includes several ancient temples and historical monuments[25], along with Lakes, Parks and Sanctuaries[32]. Study area is lies between the forest corridor of NNTR,connecting Nagzira Wildlife Sanctuary in northern side andNavegaon National Park in south.Sakoliis well surrounded by hills, forest,lakes, ponds and rivers, hence particularly both BhandaraGondia district is known for its Wetlands and Paddy fields (main agriculture crop).Therefore, the study area has an ecologically enormous potential for assesses study to be carried out[9, 33, 34].

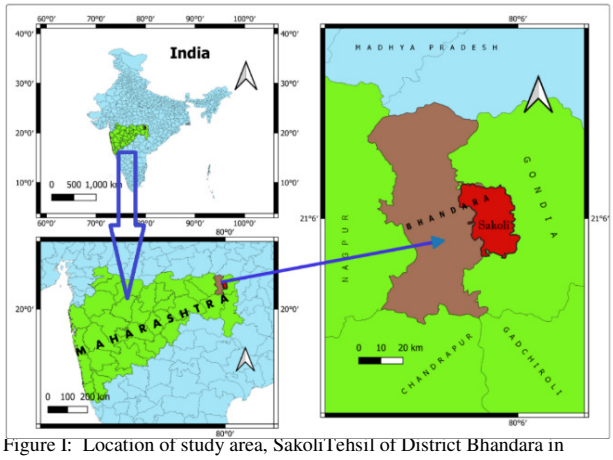

Figure I: Location of study area, SakoliTehsil of District Bhandara in Maharashtra state of india .

B. Dataused:

This study was acquired by Landsat 5, Landsat 7, and Landsat 8 imagesof the month January of year 1989, 1998, 2003, 2009, 2016, 2019depending on availability of data, (Table I)downloaded from the United States Geological Survey (USGS). Pre-processing, Visual interpretation, Unsupervised classification, Surface water extraction followed by accuracy assessment by field investigation and statistical analysis were carried out[35-37]. Images are analysed by Normalized Difference Water Index (NDWI) and Modified Normalized Difference Water Index (MNDWI) with the help of QGIS

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3.2, Arc GIS 10.3, Google Earth software. etc.(Figure II) shows the methodology adopted for this study[38].

Table I:Satellite images used for study area

Sr. No	Satellite Sensor	Acquisition date	Spatial resolution (m)	Path/Row
1	Landsat 5 TM	14/01/1989	30	143/45
2	Landsat 5 TM	23/01/1998	30	143/45
3	Landsat 7 ETM	29/01/2003	30	143/45
4	Landsat 5 TM	21/01/2009	30	143/45
5	Landsat 8 OLI	29/01/2016	30	143/45
6	Landsat 8 OLI	17/01/2019	30	143/45

C. Image Processing -

In the present study the QGIS and ArcGIS software were used for the processing of satellite data. The information stored in satellite imagery is not in real spectral indices but it is in the form of digital numbers (DN)[38]. The radiance was calculated from these digital number, from which reflectance was calculated. Different software use while processing data according to their function (TableIV).Unsupervised classification of NDWI images includes identifying and calculating surface water bodies with in area of study. Reflected green light is included in the green band, and NIR stands for reflected near-infrared radiation to find pixels with similar properties[18, 39]14]. False colour composite (FCC) of Jan 1989 and Jan 2019 Landsat image of study area gives brief idea by Visual Interpretation of changes in study area so far. (Figure V)

D. Method of water body information extraction: -

By estimating the actual difference between two images bands of remote sensing data, spectral water indices have been applied to recover surface water bodies.Furthermore, Extract satellite image data and separate the findings into two categories: water and non-water features using a suitable threshold.Out of 11 bands mentioned in (Table:II)of Landsat Satellite data, onlytwo bands have been used in study. The main theme of spectral band is based on the actuality is that "water absorbs energy at near-infrared (NIR) and shortwave-infrared (SWIR) wavelengths"[14, 38].The arithmetic operation enhances the spectral signals by contrasting the reflectance between different wavelengths as well as cancels out a large portion of the noise components by using different software's(Table:III). Normalized Difference Water Index (NDWI) is used in this study was first suggested by (McFeeters1996)[18].The Quantitative assessment of surface water, for examine surface waters in wetlands. Furthermore, NDWI is unable to extract and differentiateshallow parts from the built-up and others too.[39][18].So, it alsoenhances the level of accuracy of the result as well, it is modification in NDWI hence it named as modified NDWI (MNDWI), where the equation between NDWI and MNDWI (TableIV).According to (McFeeters 1996) stated that,"The NDWI value ranges from - 1 to +1. set zero as the threshold.If NDWI is ≥0, the area is considered as having occupied by water and it is non-water type, if the NDWI is ≤ 0" [18]. It means, if there is presence of Vegetation and other features generally related to zero or negative values and is omitted[39].from study area using NDWI and MNDWI can be seen in (Table IV).

Table III. Software used and Software Function

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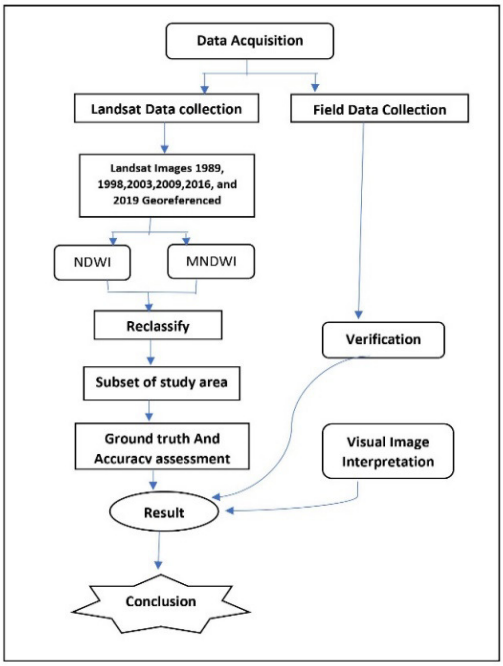

Figure II:Flowchart of NDWI Study

Table IV: Equation of NDWI and MNDWI

Multiband index	Remark	Equation	References
Normalized Difference Water Index	Water has positive value	NDWI = Green-NIR)/(Green+NIR)	[18]
Modified Normalized Difference Water Index	Water has positive value	MNDWI = (Green-SWIR_1)/(Green+SWIR_1)	[39]

Collection of Ground truth data is an essential part in geoinformatics in order to know surface features and its biophysical characteristics [40].To check the accuracy of the surface water bodies mapping with the help of Ground survey and field investigation by noting observation and Recording Measurementswas carried out by author The filed visits were carried out by author at selected sites in study area. Ground truthing data collection done with helps of Google Maps, Proforma sheet, Digital Camera (NIKON D5200 with Zoom lens AF-S NIKKR 55-200), Binocular(OLYMPUS-10X50 DPS I), Mobile GPS (Redmi Note 8), etc.[40, 41].Furthermore, if necessary, the error matrixcanarrange in a frame to produce and to find overall accuracy of classified imageswere analysed,which is the betoken of the correctly and incorrectly classified pixels.

III. Results and Discussion-

A. Normalise Difference Water Index: -

The result of the Normalized Difference Water Index (NDWI) disclosed that, the surface water bodies of Sakoli tehsil have been experiencing a decrease of 586 ha. area from 1989 to 2009 and increases from 2009 to 2019. In 1989, the surface water area was 1094 ha. while in 2003 it went down to871 ha. and in 2009 it reaches to 508 ha. The distribution of surface water (Table IV) shown changes in surface water bodies in three-decade surface water bodies of Sakoli tehsil 1989 to 2019 and NDWI analysis can be seen in (Figure VI).

Table V: Surface area changes with respect to years.

Year	Surface Of Study Area In Hectare	
	NDWI	MNDWI
1989	1094	1191
1998	1079	1079
2003	871	922
2009	508	519
2016	1010	1461
2019	1058	1161

Software Application	Function
Google Earth	KML file of study area, Accuracy assessment
Q GIS 3.18	To clip study area, To Prepare Map of Study area
ArcMap10.3.1	Layer stacking, To calculate NDWI & MDWI, Image Classification, Reclassify, To prepare map layout, etc

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To separate the surface water using Geospatial technique from land and other features to mapping and assessment ofthe surface water correctly.This is the main cause to classifying NDWI images. As a matter of fact, the NDWI images were divided into two types: water and non-water[18]. Non-water pixels belong to a different class than water pixels. MNDWI was created by modifying NDWI in order to find the best method for detecting surface water area. Modified Normalized Difference Water Indices (MNDWI) are indeed a better method than NDWI for further increasing the additional accuracy of water extraction as well as more effectively removing built-up and land noise and other features[39].

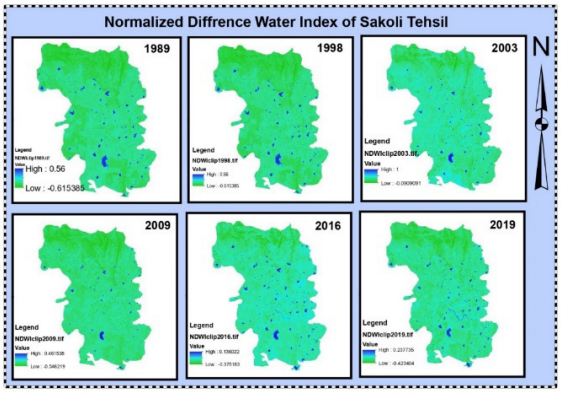

Figure III: NDWI of SakoliTehsil in Bhandara district of Maharashtra state, India

B. Modified Normalise Difference Water Index: -

MNDWI can be concluded more detail detecting water surface than NDWI[39].Changes in the surface water bodies of Sakoli tehsil in three-decade 1989 to 2019 (Table IV). In 1989, the surface water area was 1191 ha. while in 2003 it went down to 922 ha. and in 2009 it further reaches to 519 ha.

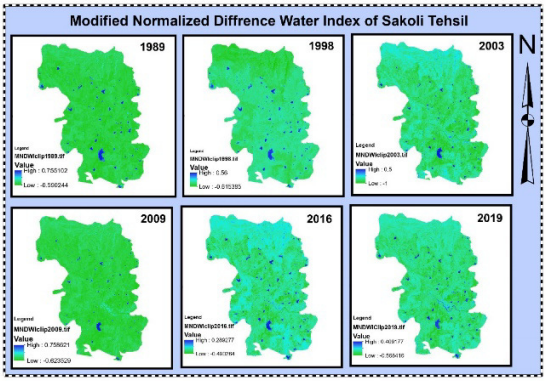

Figure IV: MNDWI of Sakoli Tehsil in Bhandara district of Maharashtra state, India

C. About NDWI and NMDWI: -

NDWI and MNDWI both are the most accurate methods because they can assortment into two classes consisted of water and non-water areas as well. To detect, Assessment andMonitor the surface water bodieswith help of NDWI and MNDWI indices.This study is carried out using Geospatial technique, surface water area in Sakoli tehsil of district Bhandara in Maharastra State. In the last 30 years since 1989 to 2019,Variation of Surface water in study area with respect to time (Graph I).The combined use of satellite images and NDWI & MNDWI techniques has proved that there should be pervasive focus on wetland conservation and management in study area (Table: IV)

In Both NDWI and MNDWI, the surface water area from 1989 to 2003 to 2009 has decreasedto great extent, whereas in 2019it seems slightlyincreased due to check dam.Therefore, check dam is highly effective to increases surface water bodies in Chulband river is observed (Figure VI).Furthermore,In 1989 surface area was 1094 ha. and 1191 ha. As per as NDWI and MNDWI study respectively, was not found again

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in last 30-year spatial data analysis. Hence,it becomes a matter of concern in future point of view.[8, 42, 43]It clearly indicates that, In terms of management and conservation of wetlands, it received much less attention in the National water sector agenda.

Wetland Management and Conservation Rules were formed in 2010. India is a signatory to the Ramsar Convention on Wetlands. But three is still no meaningful progress on the ground. i.e.

the conservation and Management and wise use of wetlands[44, 45].Inmany of the wetlands of rural areas are subject to anthropogenic pressure like agricultural practices, encroachments in the catchment, land use changes in the catchment, pollution from households, and over exploitation of their natural resources. Wetlands has become an important source for livelihood[46], for many fishing communities in the villages[2], Irrigation for Agricultural practices[47], Trapp cultivation, and its resource-based economy too[48]. Moreover, this is a cause of great concern andurgent need to protectwetland ecosystem and its habitat because this is one of the imperative components for sustaining balance in our ecosystem.

Figure VI: Field Visit for Ground Truthing of study area at different wetlands at Sakoli Tehsil in Bhandara district of Maharashtra state, India

D. Identified anthropogenic activities, pressure during field investigation: -

The wetlands are suffered from encroachment for Agricultural practices in catchment area and it is major issue in study area.New settlement, garbage dumping in wetland, cattle grazing resulting into decrease in water holding capacity of wetland which causes sometimes flash flood etc in study area. Moreover,wetland resources also supplementary contribute to the household economy of people living near wetlands. Wetlands has become an important source of livelihood for many fishing communities in the villages, Irrigation for Agricultural practices, Trapp cultivation, and its resource-based economy too. During field visit at study site and discussion with local wetland dependent communities seems that, lack of awareness about wetlands resource, its potential values, its importance for livelihood of stakeholders and maintaining climatic sustainability too.Study area has more significantly rich aquatic flora and fauna. Therefore, the objective of this study is to monitor and assessment of entire status of wetland in Sakoli Tehsil of Bhandara district in Maharashtra.

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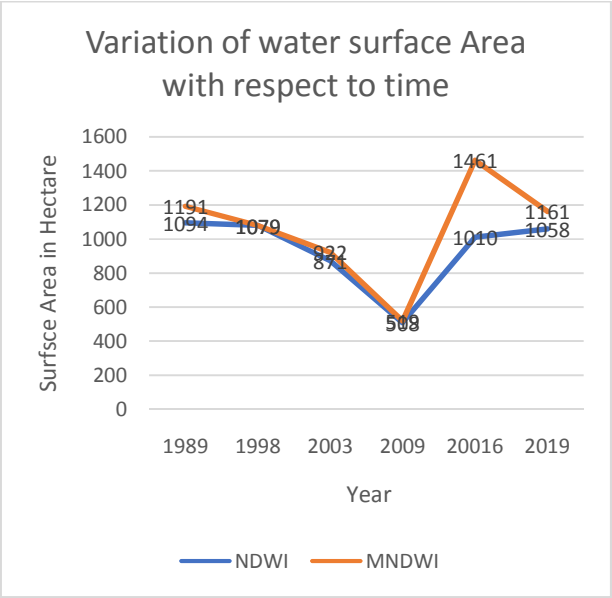

Graph I : Variation of Surface water area (Ha) with respect to time (Year)

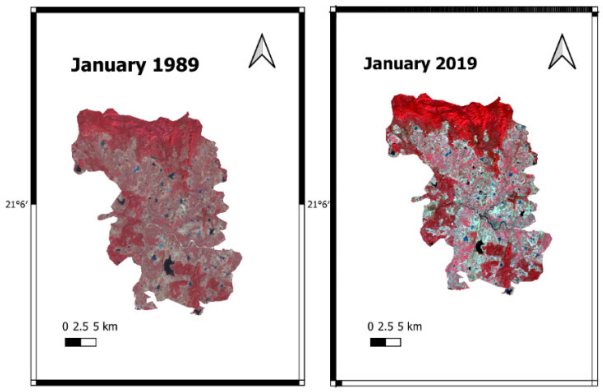

Figure V: False colourcomposite (FCC) of Jan 1989 and Jan 2019 Landsat image of study area.

IV. Conclusions:-

The entire study reveals that, the existing situation of wetlands is not satisfactory as far as surface water is concerned. The overall water bodies, its water holding capacity and areas are decreasing continuously. Normalized Difference Water Index (NDWI) and Modified Normalized Difference Water Index (MNDWI) of Geospatial technology with ground truth and field investigation studywhich was carried out by authors (Figure VI). Result shows that,during the last three-decades, area of surface water bodies of Sakoli Tehsil is decreasing which is suspectedby remote sensing and GIS technique. The surface water area from 1989 to 2003 and 2003 to 2009 has decreased to great extent, whereas in 2019 it seems slightly increasing due to check dam at Chulbandriver. Which showsthe need of check dam as the surface water storage throughout the year is very significant.Meanwhile, The Government of India had Taken many important steps to further strengthen for protecting and conserving rich diversity of India, which including planed programme, policies, action planes and legal framework as well as awareness among local people about wise use natural resources[12].

Furthermore, in 1989 surface area was 1094 ha. and 1191 ha. As per NDWI and MNDWI study, which was not repeated which was existed previously.Hence, it becomes a matter of concern and it's an alarming situation in future point of view. It also clearly indicates that, Wetland Management and Conservation Rules no implemented till date. Therefore, paying attention to this, it is argentan appropriate measureneeds to be taken by the local administration and government to prevent further decline of the wetland as soon as possible surface water area to its original status. Therefore, it is suggested that, community-based conservation to develop enterprises and ecotourism to reduce resource dependency in study area.Many of the wetlands in the areas of study are subject to anthropogenic pressures, such as transformation of catchment areas to agricultural land, soil erosion into the wetland, and overexploitation of natural resources.Also, there is lack of awareness about its protection, conservation and long-term benefits among local peoples about wise use of

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water resources. If the present scenario of degradation of water bodies were continued, the existing area would be severely put towards decline, itwould affect aquatic flora and fauna too which causes massive damage to its ecosystem and biodiversity.

Acknowledgement: -

The authors gratefully acknowledge to United State Geological Survey for providing Free Landsatsatellite data. Also acknowledge to local administration for providing necessary information and opportunity to study.

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Bands	Landsat 8		Landsat 7		Landsat 5	
		Wavelength (Micrometer)		Wavelength (Micrometer)		Wavelength (Micrometer
Coastal aerosol	Band 1	0.43-0.45	--	--	--	--
Blue	Band 2	0.45-0.51	Band 1	0.44-0.51	Band 1	0.45-0.52
Green	Band 3	0.53-0.59	Band 2	0.51-0.60	Band 2	0.52-0.60
Red	Band 4	0.64-0.67	Band 3	0.63-0.92	Band 3	0.63-0.69
Near infrared (NIR)	Band 5	0.85-0.88	Band 4	0.77-0.89	Band 4	0.76-0.90
SWIR 1	Band 6	1.57-1.65	Band 5	1.54-1.74	Band 5	1.55-1.75
SWIR 2	Band 7	2.11-2.29	Band 7	2.06-2.34	Band 7	2.08-2.35
Panchromatic	Band 8	0.50-0.68	Band 8	0.51-0.89	--	--
Cirrus	Band 9	1.36-1.38	--	--	--	--
Thermal Infrared (TIRS 1)	Band 10	10.60-11.19	Band 6	10.31-12.36	Band 6	10.40-12.50
Thermal Infrared (TIRS 2)	Band 11	11.50-12.51	--	--	--	--

Table II: Specification of Bands of Satellite data used for study area(www.usgs.gov)

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