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VEGETATIONAL CHANGE DETECTION USING MACHINE LEARNING IN GIS TECHNIQUE: A CASE STUDY FROM JAMNAGAR (GUJARAT)

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ABSTRACT
The change detection in Chlorophyll concentration in stressed plants is frequently used as a plant health indicator. Chlorophyll, a major photosynthetic pigment in plants influences photosynthetic capability and hence promotes plant growth. The normalized Difference Vegetation Index (NDVI) is the most widely used index for vegetation mapping. It was one of the remote sensing analytical methods with reduced complexity of multi-spectral data and finding the vegetation cover of the study area. These attributes make the technique hugely used due to the fact that landsat 8 sensor with a Band 4 Red (0.64 - 0.67 µm) 30 m Band 5 Near-Infrared (0.85 - 0.88 µm) 30 m can compute the NDVI. Remote sensing data gives information on criteria that aid in vegetation priority, such as vegetation size and area. A comparative study with the change detection in NDVI was made. The study includes the detection of yearly average NDVI, with the greenish-yellow pixels indicating more vegetation area. Compared with other detection analytical techniques, NDVI is a cost-effective means of characterizing changes in any land use class. The study reveals that presently there has been a increase in agricultural land, and hilly terrain with vegetation whereas, dry vegetation was recorded during the last decade. The NDVI threshold value was found to vary significantly with value of 0.20 and above during the study period, where the seasonal change also impacted the change in vegetational cover.
Keywords: APTI, Chlorophyll Content, Multispectral Data, NDVI, Vegetation Index

1.0 INTRODUCTION

Chlorophyll is an essential pigment for photosynthesis. Solar energy is captured during photosynthesis and transformed into chemical energy in the form of glucose using water and carbon dioxide. for plant development. The photosynthetic reaction may be broken down into three stages: (1) the initial process, (2) photosynthetic electron transport and photophosphorylation, and (3) carbon absorption. Chlorophyll a and b absorb sunlight at specific wavelengths (Chlorophyll a largely absorbs red-orange visible light and Chlorophyll b absorbs blue-purple visible light), it's assumed that the total amount of leaf chlorophyll content (Chlorophyll a + b) and the allocated ratio (Chlorophyll a/b) have a direct influence on plant photosynthetic capacity [1]. The amount of chlorophyll in a plant's leaves is an indirect measure of its health and nutritional state [2].
The NDVI index is amongst the most significant spatial data indicators for classifying vegetation cover across time and cover land [3]. The NDVI is defined as the measurement of

the balance of energy absorbed and released by earth objects. The most extensively used metric for evaluating vegetation is the Normalized Difference Vegetation Index (NDVI) [3]. It was among the earliest satellite remote sensing analytical products used to change the complex of multi-spectral representations [3], [4].

NDVI is a means of extracting different features based on its spectral data, such as the vegetation cover, land use/cover category [4]. On a national and worldwide scale, researchers frequently have documented employing NDVI for vegetation observation, crop cover analysis, drought monitoring, and agricultural drought evaluation [3], [5].

Remote sensing knowledge has become increasingly popular in recent years to facilitate and monitor the ever-changing vegetation structure [6]. The timing impact in spectral reaction variance is called change detection [4], [6].

A Vegetation greenness or photosynthetic activity is measured using the Normalized Difference Vegetation Index (NDVI). It is a method for extracting various characteristics based on their spectral signatures, such as vegetation cover, land use/cover identification, urban areas, and barren land areas in an image [7]. The NDVI differencing approach was used in this work to analyze the change in plant cover from 1990 to 2021 using Landsat 5 TM data and Landsat 8 OLI [8], [9]. Multi-spectral data sets from Multi-spectral Remote Sensing give useful information and a better understanding of the Earth's condition. A satellite image displays many indications that highlight vegetation-bearing regions. Satellite imagery is a type of essential information that is widely utilized in calculating land use/cover estimations [10].

At a given place, the spectral characteristics of vegetation or other covering types fluctuate throughout time. For plants, the NDVI is a grade or photosynthetic index. This approach is widely used and simple to compute [11].

NDVI is a basic statistical index for synthetically active radiation (SAR), mostly used to measure the viewpoint of leaves and foreshadow vegetation on the troposphere across a large area [12].

In this measure, the photosynthesis, vegetation area, biomass, and Leaf Area Index (LAI) are seen as positive relation [13]. The NDVI is determined by subtracting red reflectance values from near-infrared readings and dividing them by the total of the near-infrared and red bands [11], [12].

2.0 MATERIALS AND METHODS

2.1 Study Area

Jamnagar is a city in Gujarat state, in the Saurashtra region, on India's western coast. Jamnagar is situated between latitudes 22.47°N and 70.07°E. It lies 337 kilometres west of Gandhinagar, the state capital, and is on the Gulf of Kutch's southern coast. Jamnagar's climate is hot and semi-arid (Fig. 1). The year is divided into three separate seasons. The "warm" season, which usually lasts from March to May and is extremely warm and humid, is pursued by the "humid" season. Tropical cyclones might hit the region at any point throughout this season. The "cool" season, which lasts from October to February, is the most pleasant time of year due to low humidity, little rainfall, and chilly nights [14], [15].

2.2 Experimental

Data acquisition and selection: The satellite data of the research region was obtained using minimal cloud cover standard FCC image created utilizing a mix of spectral bands. Landsat imagery is one of the most essential and precise data available from the US Geological Survey (USGS) for understanding the global land use/cover condition. Two Landsat images of the same route and row (150/44-45) were acquired from www.glovis.usgs.gov in 1990 and 2021 for the identification of changes in vegetation cover in the research region. The 1990 image is Landsat 5 TM (Thematic Mapper), while the 2021 image is Landsat 8 OLI (Operational Land Imager) [16]. There use study area scale 1:750,000.

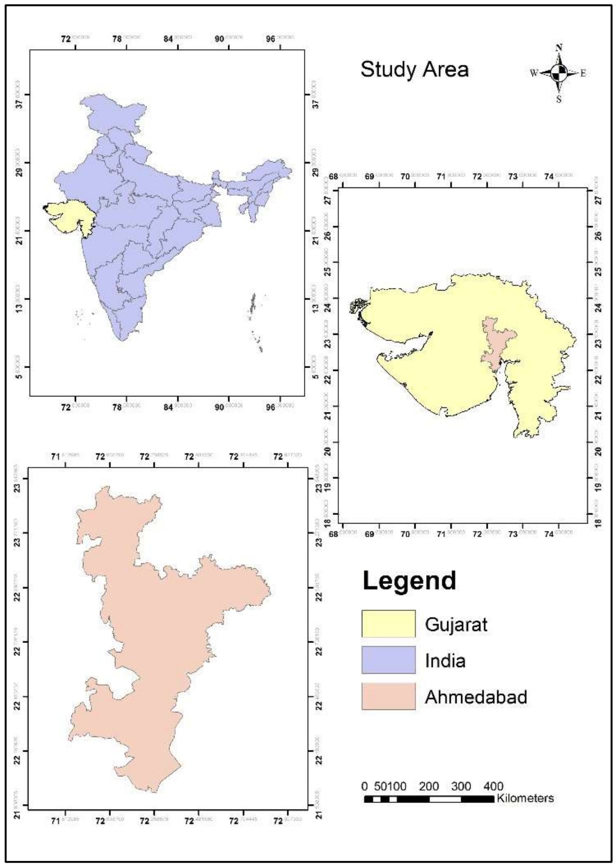


Figure 1: Map showing the study area of Jamnagar (*Source:* Figure generated by the researcher).

The NDVI approach is utilized in this section to disclose a quantitative evaluation of plant cover change in a region of Gujarat's Jamnagar district [14], [15].

The use of bands, such as near-infrared, increases the spectral separation and can enhance the interpretability of data. This band combination is valuable for gauging plant health. Plants reflect near-infrared and green light while absorbing red. Since they reflect more near-infrared than green, plant-covered land appears deep red [17], [18]. Near-infrared (red), green (blue), red (green). This is a traditional and popular band combination useful in seeing changes [9].

To address the aim of the study, digital image processing, remote sensing and GIS-based software (QGIS) were utilized for image processing, categorization, analysis, and NDVI map creation, respectively. QGIS is used to create the false-color composite by mixing near-infrared (NIR), red, and green data from (Landsat 5 1990) and other sources (Landsat 8 2021). The NDVI differencing method was used to assess changes between 1990 and 2021 [8], [9].

NDVI was calculated based on the general normalization difference between (near-infrared-NIR) and (visible red-RED) bands from two Landsat pre-processed data. (1990 and 2021 - eq. 1) [6], [11], [12]:

NDVI = $\frac{NIR-R}{NIR+R}$ ……………. (Eq. 1)

To assess the NDVI image, the generated pictures were subtracted with positive (NDVI boost) and negative (NDVI drop) changes. (eq. 2):

$\Delta NDVI = NDVI_{2021} - NDVI_{1990}$ …………… (Eq. 2)

This mixture of false color was used to identify vegetation. It was the categorization of chlorophyll as a consequence of plants that reflect well in the near-infrared spectrum rather than the visible range. The NDVI was utilized to detect changes in vegetation regions and evaluate various year-by-year quantitative data from NDVI utilizing remote sensing, GIS software, and computers. The normalized vegetation difference index (NDVI) was utilized in this study [19], [20]. The NDVI has been frequently utilized to investigate the relationship between spectral variability and variations in Vegetation growth rate. It is also important for assessing biomass productivity and detecting Vegetation cover.

2.3 Image Analysis: When red, green and blue values do not match the true colours of red, green, and blue, the image is said to be false-colored. The very-near infrared, red, and green of most false-color photographs are represented as red, green, and blue, respectively. An artificially created colour image in which the colours blue, green, and red are allocated to wavelength ranges where they do not naturally belong [21]. The false color composition is shown in below Fig. 2.

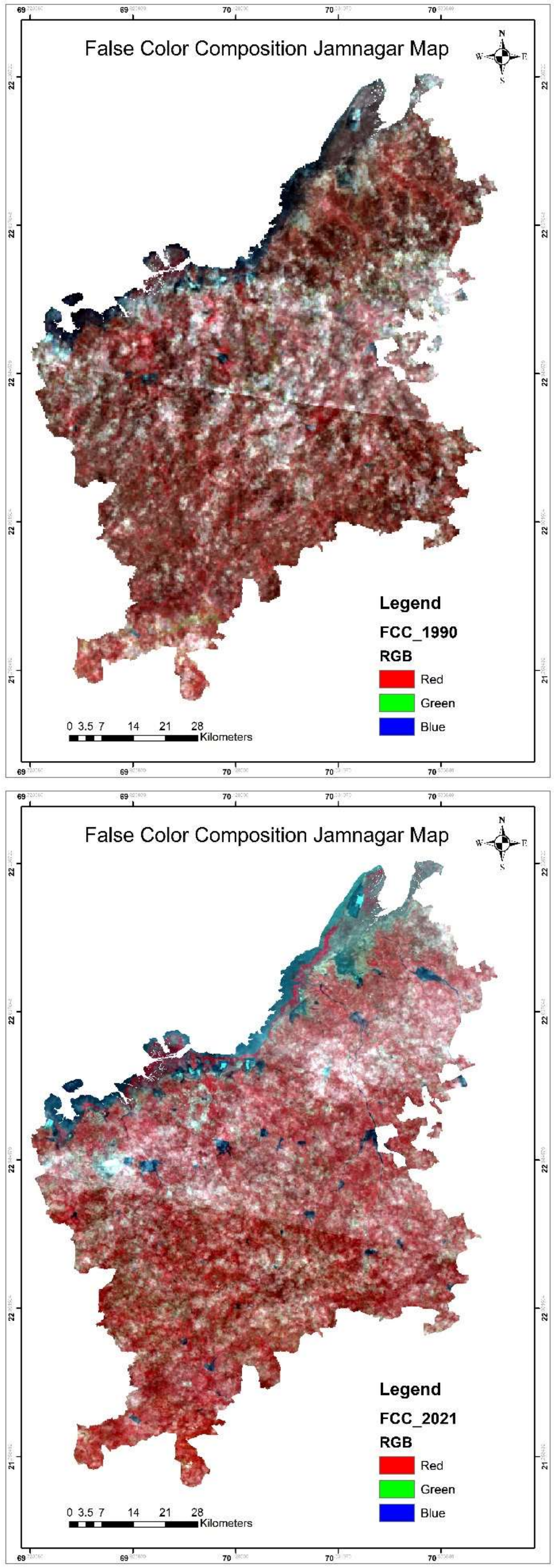


Figure 1: False color composition of Jamnagar (the years 1990 and 2021) (*Source:* Figure Generated by the Researcher).

2.4 Measurement of Chlorophyll Content

Leaves were washed to eliminate dirt and other pollutants before being used to extract chlorophyll for validation purposes. The chlorophyll content of samples extracted with 80% acetone was determined using a spectrophotometer. The leaves were incubated at room temperature for at least 24 *Hrs* in the tube with acetone solution by centrifugation. A spectrophotometer was used to measure the absorbance of the supernatant at wavelengths of 645 and 663 nm in this investigation[1], [2]. Chlorophyll concentration was estimated following Arnon's equations as follows:

Chlorophyll a ($\mu g/mL$) =12.7 (A663) −2.69 (A645)......................... (Eq. 3)

Chlorophyll b ($\mu g/mL$) =22.9 (A645) −4.68 (A663)......................... (Eq. 4)

Total chlorophyll (a + b) ($\mu g/mL$) =20.2(A645) +8.02 (A663)........................ (Eq. 5)

3.0 RESULTS AND DISCUSSION

3.1. Vegetation cover: NDVI: The result of the study site is as given below, showing the Vegetational cover using NDVI techniques which identifies vegetation of an area (Fig. 3).

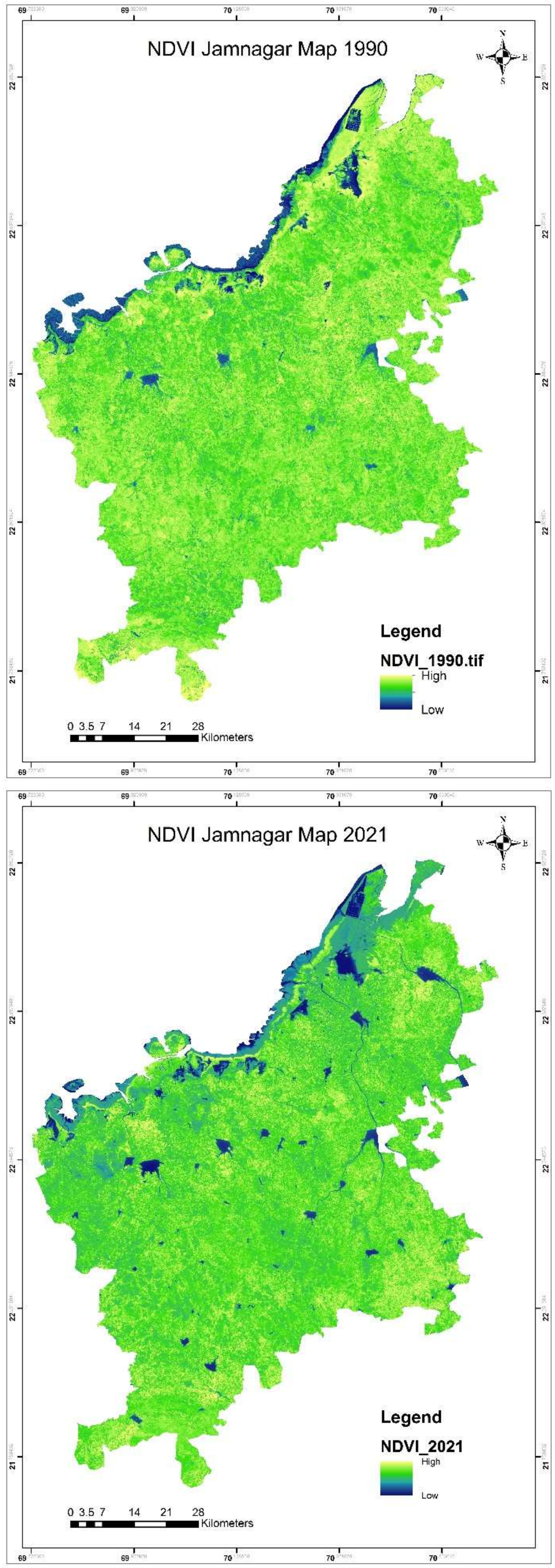


Figure 2: Normalized Difference Vegetation Index (NDVI) map for the years 1990 and 2021 (*Source:* Figure Generated by the researcher).

3.2. NDVI Change

NDVI always falls between -1 and +1. For instance, when you get negative numbers, water is probably the cause. On the other side, there is a good chance that it is dense green foliage if the NDVI score is close to +1. However, if the NDVI is close to zero, there are no green leaves and the area might even be urbanised. [22].

This satellite image analysis is shown in Figure 2. The multispectral photos' near-infrared, red, and green bands have been used to create a false colour composition. In Figure 2, the multispectral images provide the best results for all features at the NDVI value. The second image in this study, Figure 3, shows good results for all the characteristics with an NDVI value ranging from 0.01 while the NDVI value in this work varied from 0.20. As can be observed, the region covered by vegetation has the highest NDVI values, followed by the habitation and, ultimately, the water body, which has the lowest values. Fig. 4 and 5, depicts the change in NDVI values for several classes at various threshold settings, between the year 1990 and 2021. It shows increase in the vegetation during 2021 in non-vegetation classes of 1990.

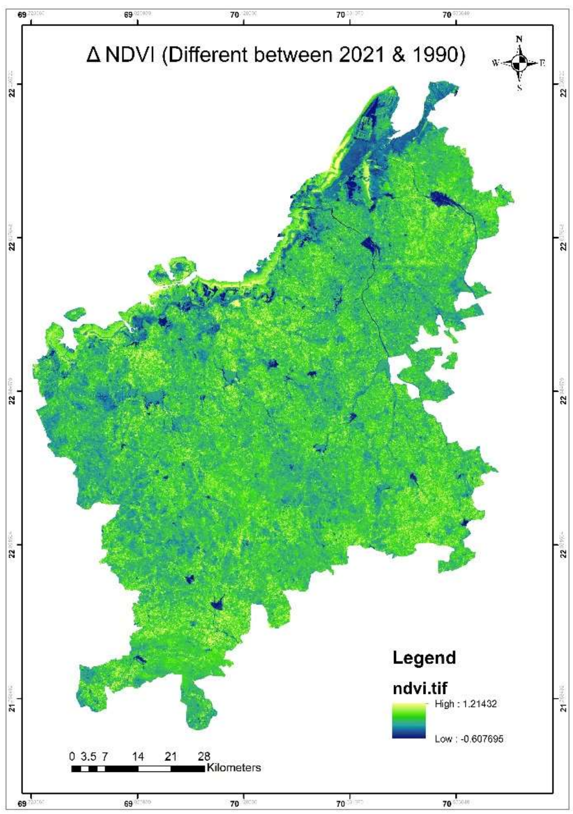


Figure 3: Differential NDVI between 2021 and 1990 (*Source:* Figure generated by the researcher).

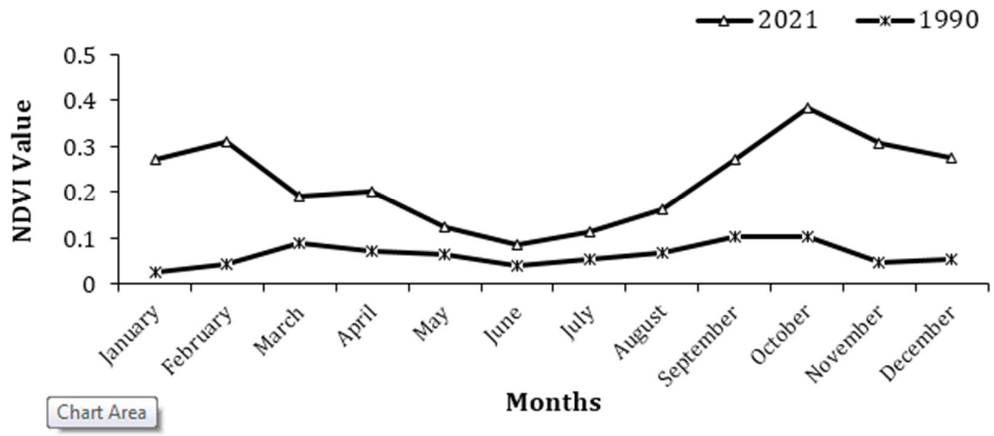


Figure 5: NDVI value of Jamnagar for the years 1990 and 2021 (*Source:* Figure generated by the researcher).

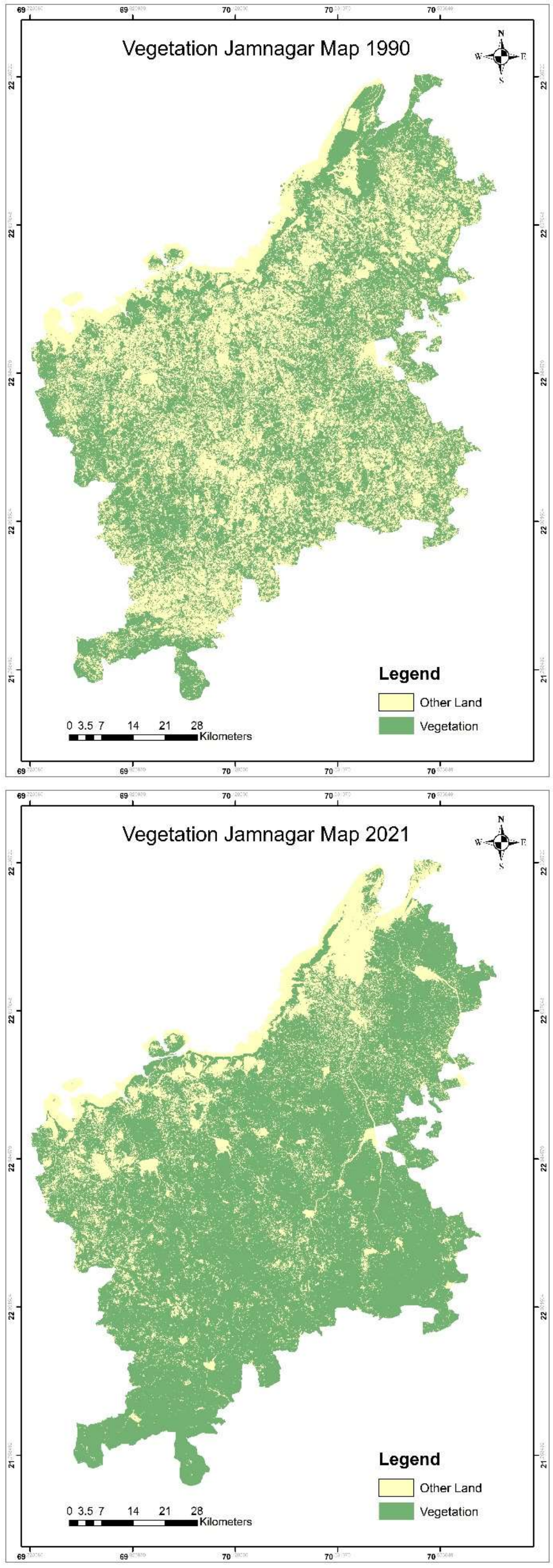
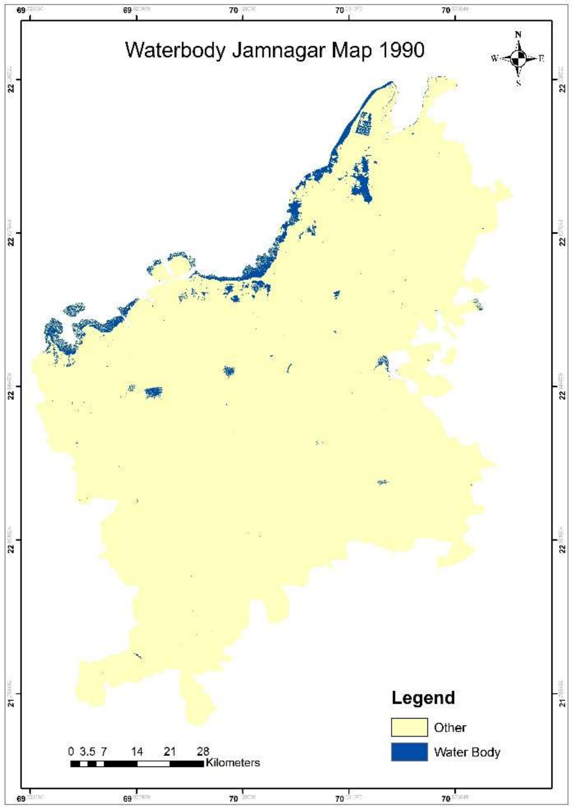


Figure 6: Vegetation map of Jamnagar for the years 1990 and 2021 (*Source:* Figure generated by the researcher).

Fig. 6 shows the vegetation change detection for the year 1990 and 2021. The results shows increase in Vegetational area during the study period. Also, it has been observed that other land covers of non-vegetation were converted into vegetation like barren land covers from the site of study.



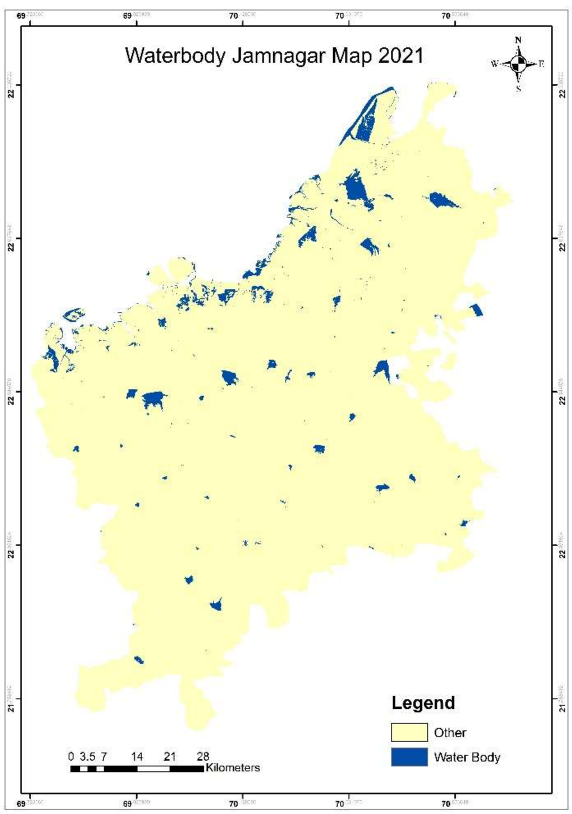


Figure 7: Water body map of Jamnagar for the year 1990 and 2021 (*Source:* Figure generated by the researcher).

Fig. 7 reveals that the area of the water body increased during the study period. During this period, a new check dam was constructed as the water reservoir in the Jamnagar area. This significantly impacted the Vegetation cover in the study area. An increase in the water catchment area resulted in increased Vegetation in the barren lands as well.

3.3 Total Chlorophyll content

Acetone extraction was used to determine the total chlorophyll content. Pollution reduces Air Pollution Tolerance Index readings by affecting chlorophyll concentration and other physiological processes. R^2=0.0009 is the regression result for APTI and total chlorophyll.

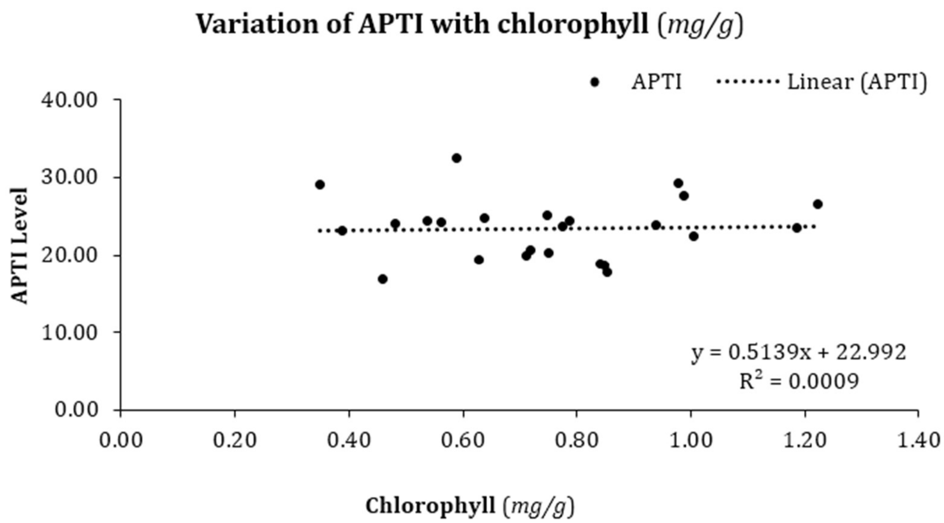


Figure 8: Comparison of Chlorophyll Content with Air Pollution Tolerance Index (*Source:* Figure compiled by the Researcher).

The linear regression plots of the Chlorophyll variables with APTI were displayed in Fig. 8. The relationship between the phytochemical parameters of chlorophyll and APTI was shown to be positively correlated. In addition, it was found that APTI and chlorophyll concentration are interrelated (r = 0.0009). This suggests that the most important and determining elements that affect tolerance are found to be the chlorophyll content of the leaf.

4.0 CONCLUSION

Chlorophyll content is widely utilised as a sign of plant health analysis in stressed plants. The primary photosynthetic pigment in plants, the chlorophyll, influences photosynthetic capacity and so supports plant development. The most popular matrix for mapping vegetation is the Normalised Difference Vegetation Index (NDVI) using remote sensing. The present study compared the chlorophyll content and APTI by mapping with NDVI remote sensing data. It has been observed that vegetational cover study using NDVI showed increase in the vegetation during 2021 than that of 1990. Also the results showed positive correlation between chlorophyll and APTI during the study period. The parameters like NDVI of vegetational cover, chlorophyll contents are impacted by the photosynthetic activity influenced by the air pollution of the selected site. The study results may contribute to the development of further sound environmental management system on water shed arrears, animal husbandry, agriculture and like in the site.

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DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

AUTHOR CONTRIBUTIONS

All authors contributed to the study's conception and design. Material preparation, data collection, and analysis were performed by ABR, PBS, JA, ST and RS. The first draft of the manuscript was written by JA, ST, RS and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

REFERENCES

[1] Y. Li *et al.*, “Factors Influencing Leaf Chlorophyll Content in Natural Forests at the Biome Scale,” *Front. Ecol. Evol.*, vol. 6, p. 64, Jun. 2018, doi: 10.3389/fevo.2018.00064 URL: https://www.frontiersin.org/article/10.3389/fevo.2018.00064/full.

[2] Y. Liang, D. Urano, K.-L. Liao, T. L. Hedrick, Y. Gao, and A. M. Jones, “A nondestructive method to estimate the chlorophyll content of Arabidopsis seedlings,” *Plant Methods*, vol. 13, no. 1, p. 26, Dec. 2017, doi: 10.1186/s13007-017-0174-6 URL: http://plantmethods.biomedcentral.com/articles/10.1186/s13007-017-0174-6.

[3] S. Huang, L. Tang, J. P. Hupy, Y. Wang, and G. Shao, “A commentary review on the use of normalized difference vegetation index (NDVI) in the era of popular remote sensing,” *J. For. Res.*, vol. 32, no. 1, pp. 1–6, Feb. 2021, doi: 10.1007/s11676-020-01155-1 URL: https://link.springer.com/10.1007/s11676-020-01155-1.

[4] R. Srivastava, S. Singh, and A. Oran, “Changes in Vegetation Cover Using GIS and Remote Sensing: A Case Study of South Campus BHU, Mirzapur, India,” *JSR*, vol. 64, no. 02, pp. 135–141, 2020, doi: 10.37398/JSR.2020.640219 URL: https://www.bhu.ac.in/research_pub/jsr/Volumes/JSR_64_02_2020/19.pdf.

[5] A. K. Bhandari, A. Kumar, and G. K. Singh, “Feature Extraction using Normalized Difference Vegetation Index (NDVI): A Case Study of Jabalpur City,” *Procedia*

Technology, vol. 6, pp. 612–621, 2012, doi: 10.1016/j.protcy.2012.10.074 URL: https://linkinghub.elsevier.com/retrieve/pii/S2212017312006196.

[6] G. M. Gandhi, S. Parthiban, N. Thummalu, and A. Christy, "Ndvi: Vegetation Change Detection Using Remote Sensing and Gis – A Case Study of Vellore District," *Procedia Computer Science*, vol. 57, pp. 1199–1210, 2015, doi: 10.1016/j.procs.2015.07.415 URL: https://linkinghub.elsevier.com/retrieve/pii/S1877050915019444.

[7] R. Sanjeevi, Ankitkumar B. Rathod, Prashantkumar B. Sathvara, Aviral Tripathi, J. Anuradha, and Sandeep Tripathi, "VEGETATIONAL CARTOGRAPHY ANALYSIS UTILIZING MULTI-TEMPORAL NDVI DATA SERIES: A CASE STUDY FROM RAJKOT DISTRICT (GUJARAT), INDIA," *Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/ Journal of Tianjin University Science and Technology*, vol. 55, no. 04:2022, pp. 490–497, 2022, doi: 10.17605/OSF.IO/UGJYM URL: https://osf.io/ugjym/.

[8] "Landsat 7 (L7) Data Users Handbook," *U.S. Geological SurveyEROS Sioux Falls, South Dakota*, p. 151, 2019 URL: https://www.usgs.gov/media/files/landsat-7-data-users-handbook.

[9] "Landsat 8 (L8) Data Users Handbook," *U.S. Geological SurveyEROS Sioux Falls, South Dakota*, p. 114, 2019 URL: https://www.usgs.gov/media/files/landsat-8-data-users-handbook.

[10] P. Singh and O. Javeed, "NDVI Based Assessment of Land Cover Changes Using Remote Sensing and GIS (A case study of Srinagar district, Kashmir)," *Sust. Agric. Food Env. Res.*, vol. 9, no. 4, Mar. 2021, doi: 10.7770/safer-V0N0-art2174 URL: https://portalrevistas.uct.cl/index.php/safer/article/view/2174.

[11] A. Zaitunah, Samsuri, A. G. Ahmad, and R. A. Safitri, "Normalized difference vegetation index (ndvi) analysis for land cover types using landsat 8 oli in besitang watershed, Indonesia," *IOP Conf. Ser.: Earth Environ. Sci.*, vol. 126, p. 012112, Mar. 2018, doi: 10.1088/1755-1315/126/1/012112 URL: https://iopscience.iop.org/article/10.1088/1755-1315/126/1/012112.

[12] R. P. Singh, N. Singh, S. Singh, and S. Mukherjee, "Normalized Difference Vegetation Index (NDVI) Based Classification to Assess the Change in Land Use/Land Cover (LULC) in Lower Assam, India," *IJARSG*, vol. 5, no. 1, pp. 1963–1970, Oct. 2016, doi: 10.23953/cloud.ijarsg.74 URL: http://technical.cloud-journals.com/index.php/IJARSG/article/view/Tech-674.

[13] T. N. Carlson and D. A. Ripley, "On the relation between NDVI, fractional vegetation cover, and leaf area index," *Remote Sensing of Environment*, vol. 62, no. 3, pp. 241–

252, Dec. 1997, doi: 10.1016/S0034-4257(97)00104-1 URL: https://linkinghub.elsevier.com/retrieve/pii/S0034425797001041.

[14] “District Jamnagar, Government of Gujarat | India.” URL: https://jamnagar.nic.in/ .

[15] “Jamnagar,” *Wikipedia*. May 07, 2022. Accessed: May 22, 2022. [Online]. Available URL: https://en.wikipedia.org/w/index.php?title=Jamnagar&oldid=1086629486

[16] “EarthExplorer.” URL: https://earthexplorer.usgs.gov/ .

[17] E. F. Lambin and D. Ehrlich, “The surface temperature-vegetation index space for land cover and land-cover change analysis,” *International Journal of Remote Sensing*, vol. 17, no. 3, pp. 463–487, Feb. 1996, doi: 10.1080/01431169608949021 URL: https://www.tandfonline.com/doi/full/10.1080/01431169608949021.

[18] G. T. Yengoh, D. Dent, L. Olsson, A. E. Tengberg, and C. J. Tucker, “The use of the Normalized Difference Vegetation Index (NDVI) to assess land degradation at multiple scales: a review of the current status, future trends, and practical considerations,” *Lund University Centre for Sustainability Studies – LUCSUS*, p. 80, 2014 URL: https://www.stapgef.org/sites/default/files/stap/wp-content/uploads/2015/05/Final-report-The-use-of-NDVI-to-assess-land-degradation-G.-Yengoh-et-al..pdf

[19] Z. Jiang, A. Huete, K. Didan, and T. Miura, “Development of a two-band enhanced vegetation index without a blue band,” *Remote Sensing of Environment*, vol. 112, no. 10, pp. 3833–3845, Oct. 2008, doi: 10.1016/j.rse.2008.06.006 URL: https://linkinghub.elsevier.com/retrieve/pii/S0034425708001971.

[20] J. R. G. Townshend and C. O. Justice, “Analysis of the dynamics of African vegetation using the normalized difference vegetation index,” *International Journal of Remote Sensing*, vol. 7, no. 11, pp. 1435–1445, Nov. 1986, doi: 10.1080/01431168608948946 URL: https://www.tandfonline.com/doi/full/10.1080/01431168608948946.

[21] A. Al-Hanbali, B. Alsaaideh, and A. Kondoh, “Using GIS-Based Weighted Linear Combination Analysis and Remote Sensing Techniques to Select Optimum Solid Waste Disposal Sites within Mafraq City, Jordan,” *JGIS*, vol. 03, no. 04, pp. 267–278, 2011, doi: 10.4236/jgis.2011.34023 URL: http://www.scirp.org/journal/doi.aspx?DOI=10.4236/jgis.2011.34023.

[22] Y. Julien *et al.*, “Temporal analysis of normalized difference vegetation index (NDVI) and land surface temperature (LST) parameters to detect changes in the Iberian land cover between 1981 and 2001,” *International Journal of Remote Sensing*, vol. 32, no. 7, pp. 2057–2068, Mar. 2011, doi: 10.1080/01431161003762363 URL: https://www.tandfonline.com/doi/full/10.1080/01431161003762363.