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Research Article

Analysing the Effects of Landuse Change on the Physical Environment of Teknaf and Ukhiya Upazila due to the Influx of Rohingya Refugees in Bangladesh

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ABSTRACT

Earth surface isn't a static place, it is always undergoing rapid changes with various anthropogenic al activities and due to this, surrounding physical environment is also changing. Ukhiya and Teknaf are two sub-districts of Cox's Bazar in Bangladesh. It has conveyed a significant standing for the natural resources like, wildlife and the forest cover. The purpose of this research paper is to look at the long-term consequences of the Rohingya Influx on the surrounding physical environment like vegetation coverage, land cover, and Land Surface Temperature (LST) in Teknaf and Ukhiya upazila, Cox's Bazar, Bangladesh. For completing this research, LANDSAT 8 images were collected from Earth Explorer (USGS). The study shows that the area around the Rohingya Camps has gradually lost vegetation density because of massive deforestation as well as the increasing rate of compact housing settlement. According to this study, in 2017 before the influx of Rohingya Refugees, 64% of overall land use was covered by dense vegetation, which gradually reduced after the influx of Rohingya invasion in 2017. Following the August 2017 catastrophe, vegetation cover has dropped to 54% in 2019. According to the findings, land cover change has accelerated and dense vegetation has gradually been decreasing from 58% to 28%. As a result, the Land Surface Temperature (LST) has gradually increased. It implies that deforestation has resulted in the loss of a substantial amount of vegetation, and the LST of this region has altered dramatically.

Keywords: Rohingya refugee; Landuse; Land surface temperature; Remote sensing; Deforestation; Spatial analysis

INTRODUCTION

A refugee is generally a person who is outside their country of nationality and cannot return safely owing to serious and indiscriminate threats to life resulting from generalized violent events like war, forceful expulsion, torture, genocide and other grave rights violations. On August 25, 2017, significant violence erupted in Myanmar's Rakhine state. Nearly 860,000 Rohingya refugees have been living in Cox's Bazar region since December 11, 2017. 655,000 persons have arrived since August 25, 2017. Over a quarter million of them have been settled in Bangladesh for decades. According to the 2011 population census, the Rohingya people, who have been crossing the border from Myanmar into Bangladesh since August 25, 2017, outnumbered the natives in the Ukhiya and Teknaf sub-districts of Cox's Bazar district. Around a million Muslim Rohingyas are reportedly seeking refuge in Cox Bazar, Bangladesh. The bulk of citizens live in the Teknaf and Ukhiya sub-districts of Cox's Bazar, a district bordering Myanmar that has been designated as the main transit point [1]. The impact of refugee crisis on the environment and natural resource of the host country has become an emerging issue in the present world as temporary shelters are often built near environmentally sensitive areas, e.g. national parks, sanctuary, reserve forests or agriculturally marginal areas and it's causing some environmental degradation like deforestation and firewood depletion, land degradation, unstable ground water extraction, water pollution, temperature change, etc [2]. This inflow had a negative impact on the ecology and climate of the region. In the research area, the land with forest provides crucial cover for woodland and wetland habitats. It has a wide variety of trees and also serves as a carbon sink. The study area's protected forest and wildlife are being degraded and lost at an alarming rate, with clear cutting for agriculture, production,

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and timber logging being the primary causes. This degradation and destruction may have a negative impact on the climate, such as soil erosion, disruption of the water cycle, and loss of wildlife habitat. Land cover changes may have an impact on carbon storage potential. It may also create local climate disruption [1].

This research paper aims to examine the changes in vegetation cover of Ukhiya and Teknaf sub-district from 2017 to 2021. And to assess the Land Surface Temperature of the research area over the years along with relationship between vegetation cover and land use change. The analytical timeline is separated into three temporal periods 2017, 2019, 2021. As a result, this temporal split provides a clear grasp of the consequences of Rohinga influx on vegetation coverage of study area.

METHODOLOGY

Study area

Teknaf Upazila covers 388.68 km^2 and is bordered on the north by Ukhiya Upazila, on the south by the Bay of Bengal, on the east by the Arakan State of Myanmar, and on the west by the Bay of Bengal. Teknaf upazila is a Bangladeshi upazila in the country's south-east corner. It's located 86 kilometers south of Cox's Bazar Town. The study area Ukhia and Teknaf are lies in the Cox's Bazar district, and covers the sheltered area of Rohingya refugee camp. It is located closest to the border to Myanmar. Both of Teknaf and Ukhia sub-district are covered by a significant area of tropical evergreen and semi evergreen forest and other vegetation. The study areas have approximately 34 refugee camps where the largest refugee camp was situated in the Ukhia sub-district, known as the Kutupalong mega camp (WFP, 2020) (Figure 1).

Data source

The study is complete based on secondary data gathered from multi-temporal satellite imageries, specifically LANDSAT 8 imageries of specific sensors named Operational Land Imagers and Thermal Infrared Sensor (OLI and TIRS) capture in the years 2017, 2019, and 2021. The information was gathered from the USGS's Global Visualization Viewer (GloVis), which provides basic information for internet access to a subset of satellite and aerial photographic collections from the USGS's Earth Resources Observation and Science (EROS) Center repository.

Data collection and image classification

All the photographs have been collected on the month of February. The primary purpose of this study is to identify changes in vegetation cover between February 2017 and 2021, using data from prior years as well as data for 2021 to compare to the current condition. Images from the LANDSAT 8 satellite were used in the study. These images contain 30 m spatial resolution and OLI and TIRS sensor IDs. The images were taken in different years but within the same months.

The current study used a 1-7 band mix of both satellite images to appropriately identify the landuse specifications. The most common image classifications supervised image classification, were applied for image analysis and identify the landuse condition. The NDVI and Maximum Likelihood Classifier were used in this investigation for supervised classification. For supervised image analysis, a complete land use and land cover classification outline was constructed based on the characteristics of the area. Because Ukhia and Teknaf are frequently flanked by vegetation and agricultural land, a classification scheme was required (Figure 2) [3].

Land Use Land Cover Classification (LULC) measuring method

A post classification change detection technique was used to determine the changes in LULC categories. This process resulted in three change detection maps; (i) 2017–2019; (ii) 2019–2021; and (iii) 2017–2021. This operation helps defining changes in Land use which subsequently aid in assessing vegetation degradation, caused by resettlement of Rohingya populations [4]. Earlier (e.g., 2017) and later (e.g., 2019 and 2021) thematic maps are compared, on a pixel by pixel basis, and transformation of Land use categories is defined to compute changes from a specific land class to other classes (e.g. shrubs to Rohingya camps). The spatial trend is then analyzed, based on the pattern of change between earlier and later periods (Table 1 and Figure 3).

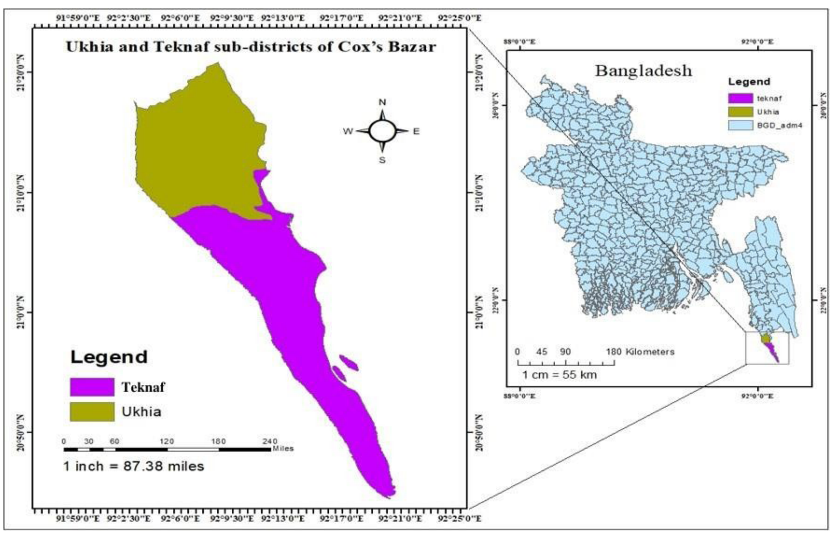

Figure 1: Ukhia and Teknaf sub-districts of cox's bazar.

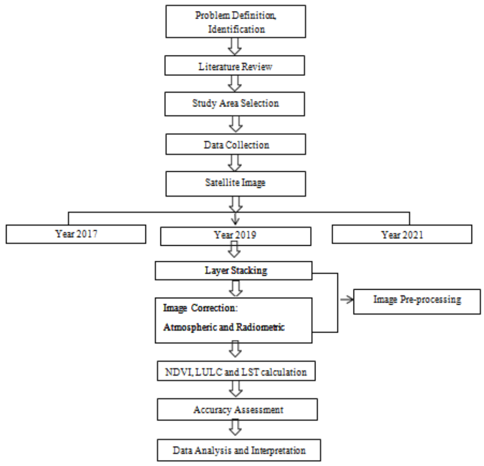

Figure 2: Methodological framework.

Table 1: Land cover classification scheme used in this study area are given below the table.

Land cover category	Description
Water Bodies	River, open water, surrounding seawater, inland water, low land, wet land and reservoirs
Vegetation	Hilly forest, trees, garden, parks, shrub land, , mixed forest lands, and others
Settlements	Temporary and permanent houses, villages, temporary and permanent houses, Services infrastructure, villages, man-made structures.
Bare land	Bare soil, sea beach area, sand coverage, transitional area, open space, land surface without vegetation, unfertile land etc.
Agricultural land	Cultivated land, shrimp cultivation, crop lands, Salt cultivation, fallow lands.

Figure 3: Supervised image classification workflow.

Normalized Difference Vegetation Index (NDVI) measuring method

The primary goal of this study is to use the Normalized Difference Vegetation Index (NDVI) to measure the changes in vegetation cover in Teknaf and Ukhiya sub-district. Since this study used LANDSAT-8 images, band 5 was assigned to Near Infrared (NIR) and band 4 to Red for the analysis. The formula of NDVI is given below.

$$NDVI = \frac{Band5 - Band4}{Band4 + Band5}$$

As there are no uniform method of classification of vegetation in remotely sensed data in Bangladesh, the United States Geological Survey's general system of classification has been followed in this paper [1]. On which the NDVI value is ranging from minimum −1 to maximum +1. Based on NDVI values, a total of three levels of ground cover have been identified as ≤ 0.15 is Non-vegetation, >0.15 to ≤ 0.3 is light Vegetation, and >0.3 to ≤ 1 is Dense Vegetation. In general, a dense vegetation area consists a wide variety of trees and plants cover the area in an indeterminate manner and it must be covered with 60% to 100% greeneries. For light vegetation it is 10% to 50% by trees including steppes, tundra, lichen heath, and scattered high-altitude plants [5].

Land Surface Temperature (LST) measuring method

The Land Surface Temperature (LST) was derived from atmospherically corrected from Landsat 8 TIRS (band 10) through the raster calculation in ArcGIS. In this study, the supervised classification was used to estimate the land cover categories. The following method has been used in measuring land surface temperatures, steps are mentioned below:

Step 1: Top of Atmosphere (TOA) Radiance conversion:

Using the radiance rescaling factor, Thermal Infra-Red Digital Numbers can be converted to TOA spectral radiance.

$L\lambda$ - ML* Qcal + AL-Oi

$L\lambda$ - 0.0003342* Band 10+0.10000–0.29

Where:

LA-TOA spectral radiance (Watts/(m^2 srum)) ML-Radiance multiplicative Band (No.)

AL-Radiance Add Band (No.)

Qcal=Quantized and calibrated standard product pixel values (DN)

Oi-correction value for band 10 is 0.29

Step 2: Conversion to Top of Atmosphere (TOA) Brightness Temperature

(BT)-Spectral radiance data can be converted to top of atmosphere brightness temperature using the thermal constant Values in Meta data file.

Kelvin (K) to Celsius (°C) Degrees BT=K2/In (kl/$L\lambda$ +1)–273.15

BT=(1321.0789/Ln (774.8853/ToA+1))–273.15

Where:

BT-Top of atmosphere brightness temperature (°C)

LA=TOA spectral radiance (Watts/(m^2*sr*µm))

K1=K1 Constant Band (No.)

K2=K2 Constant Band (No.)

Step 3: Normalized Difference Vegetation Index (NDVI):

The NDVI (Normalized Differential Vegetation Index) is a normalized vegetation index calculated with the Near Infrared (Band 5) and Red (Band 4) bands.

NDVI=(NIR-RED)/(NIR + RED)

NDVI=(Band 5-Band 4)/(Band 5+Band 4)

Step 4: Land Surface Emissivity (LSE)

Land Surface Emissivity (LSE) is the average emissivity of an element of the surface of the Earth calculated from NDVI values.

PV=((NDVI-NDVI min)/(NDVI max-NDVI min))2

Where:

PV=Proportion of Vegetation

NDVI=DN values from NDVI Image

NDVI min=Minimum DN values from NDVI Image NDVI max=Maximum DN values from NDVI Image

E=0.004 × PV+0.986

B-Land Surface Emissivity

PV=Proportion of Vegetation

0.986 corresponds to a correction value of the equation

Step 5: Land Surface Temperature (LST):

The Land Surface Temperature (LST) is the radiative temperature which calculated using Top of atmosphere

brightness temperature, Wavelength of emitted radiance, Land Surface Emissivity.

LST=BT/(1+ (λ × BT/C^2) × In(E))

Here, C^2=14388 m K

The Values of 2 for Landsat 8: For Band 10 is 10.8 and for Band 11 is 12.

Where

BT=Top of atmosphere brightness temperature (°C)

λ=Wave length of emitted radiance

E=Land Surface Emissivity

C^2=h*c/s=1.4388*10^{-2} m K=14388 m K

h=Planck's constant -6.626×10^{-34} Js

s=Boltzmann constant -1.38×10^{-23} JK

v=velocity of light=2.998 × 10^8 m/s [10]

RESULTS AND DISCUSSION

Land Use Land Cover (LULC) Classification of rohingya refugee occupied area

In the earlier the Land Use, Land Cover (LULC) area classification map has been prepared over different period using the method of supervised classification. In the Table 1 how the land use, land cover areas have been changed during the period of 2017 to 2021 is summarized according to its area (Figure 4).

The land-use classification for the Landsat 8 OLI of 2017 image indicated that the majority of the study area was under vegetation measuring about 35114.73 hectare as described in Figure 2. In the particular year of 2017, the area of agricultural land, settlements, bare land and water bodies represented about 6577.13 (11%), 8038.207 (14%), 1653.24 (3%) and 5894.75 ha (8%), respectively. The LULC classification for vegetation cover in 2019 was mainstream, about 30908.619 hectares (54%) [6]. Water body, bare land, settlement and agricultural and is 3631.79 ha (6%), 703.79 ha (1%), 17394.89 ha (30%) and 4837.6 ha (8%) respectively. It specifies the vegetation cover was the most dominant category among all land use characteristics throughout the year. In 2021 the mentionable LULC was vegetation and water body and the amount was 32120.04 ha (59%) and 3701.766 ha (7%) respectively whereas only 10945.67 ha (23%) was found as settlement area, 754.408 ha (1%) was bare land and 5456.47 ha (10%) was found as agriculture.

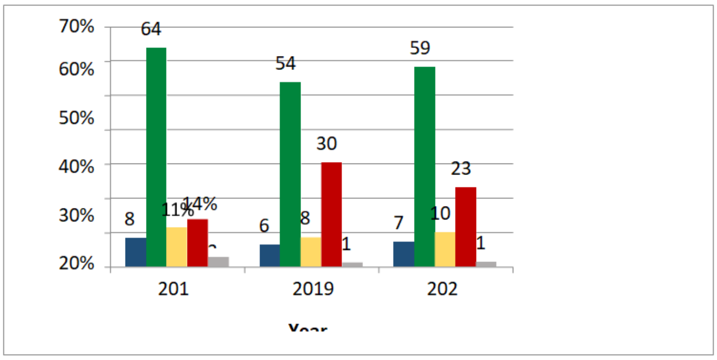

Figure 4: Landuse Area of Ukhiya and Teknaf Upazila (in percentage). **Note:** (■) Water Body; (■) Vegetation; (■) Agricultura; (■) LandSettlement.

Land Use Land Cover (LULC) change analysis (2017-2021)

The rate of change in the land use and land cover was calculated by the classified image from years of 2017, 2019 and 2021 the multi-temporal comparison at diverse periods of time. In duration 2017 to 2019, the vegetation loss is highly noticeable in Figure 5. The greener part has greatly decreased from 2017 to 2019; the percentage has decreased to 6121.7 ha 16% which indicates the threat of forest cove [7]. However, this decreasing trend occurred due to a massive influx of Rohingya refugees in August 2017. In this time water body decreased 38%, agricultural land approximately 1740 ha (26%), bare land 26% and settlement increased approximately 9356 ha. Mostly this settlement area replaced a noticeable portion of vegetation from 2017 to 2019 (Figure 5).

Figure 5 reflects the overall trend of changes in vegetation where the vegetation cover has increased 1212 ha (3%) from 2019 to 2021. Settlement area was also the second dominant land use category followed by vegetation accounting for about 30% and 23% for the 2019, and 2021 respectively. In 2019 to 2021 settlement decreased about 37% comparing with 2019 and the rate of bare land decreased 3% and agricultural land 12% (Figure 6).

From 2017 to 2021 settlement area was increased, approximately 2907.45 ha (29%) because it was the time of Rohinga influx. The changing periods of 2017-2021, agricultural land has been decreased approximately 1120.65 ha (21%) indicating fluctuation for the mixed agricultural land cover due to barren land and salt-shrimp cultivation [8]. Sandy land, Water bodies were the remaining areas of land cover, bare land 54% and water body 37% respectively (Table 2).

The above table clearly reveals that the bare land is becoming declining as the Rohinga refugees used the land for making settlement or any other purposes. The pressure of Rohinga influx has gone to the agricultural land, water body and vegetation.

Normalized Difference Vegetation Index (NDVI) analysis

The NDVI change analysis was calculated using ArcGIS software. Since the NDVI value range is -1 to +1, therefore, the threshold values of <0.15 considered as no vegetation, the values range between 0.15 to 0.3 considered as light vegetation and the threshold values of >0.3 considered as dense vegetation to classify each image of this study.

The images of 2017, 2019, and 2021 were classified into three classes each. These are non-vegetation, light vegetation, and dense vegetation.

Besides, the percentage of changing vegetation coverage in 2017, 2019 and 2021 of the study area. It clearly reveals that the dense vegetation area has declining and no vegetation area has increased from 13% to 20% (Figure 7). As can be perceived from Figures 8 and 9, the change periods of 2017-2019 and 2017-2021 increased the non-vegetation cover, around 4708 (62%) and 3720 ha (49%) respectively [9]. However, the change periods of 2019-2021 was declined, about 1079 ha (8%) for the same land cover. Hence, the increase of non-vegetation cover area might signify the growth of settlements, bare land, human-made structure etc.

Vegetation change analysis through NDVI (2017-2021)

The change periods of 2017-2019, it can be seen that the light vegetation cover has changed 62% comparing with 2017. Dense vegetation decreased about 49%. Some dense vegetation places converted into light vegetation area due to anthropogenic activities. In 2017-2019, light vegetation coverage accounting for about 68% whereas from 2019-2021 light vegetation was nearly 8% (Figure 8).

The changing periods of 2017-2019 and 2019-2021 indicating the declining rate of dense vegetation cover, approximately 16008 ha (48%), 1570 ha (9%) respectively. The increased period of light vegetation was 2017-2019 and 2019-2021, about 68% and 8%. A significant decline in dense vegetation consists of various anthropogenic activities for example-settlements, refugee camps, agricultural activities, and other activities [10]. All of the vegetation land (e.g. dense vegetation, light vegetation and no vegetation land) covers are connected to one another. That means a shift in one type may have influenced shifts in others. Due to exploitation or plantation, even one type of vegetation cover might be changed into another (Figure 9).

Over the years, the uneven change of the three vegetation coverings demonstrates their inter-connected properties. Figure 9 discovered that the forest cover of the refugee occupied areas has been significantly diminished, the area of refugee settlements has been enlarged in response. After the 2017 Influx of Rohinga, the majority of refugee camps were started to build where the area was filled with dense vegetation and now it has been expanded (Table 3).

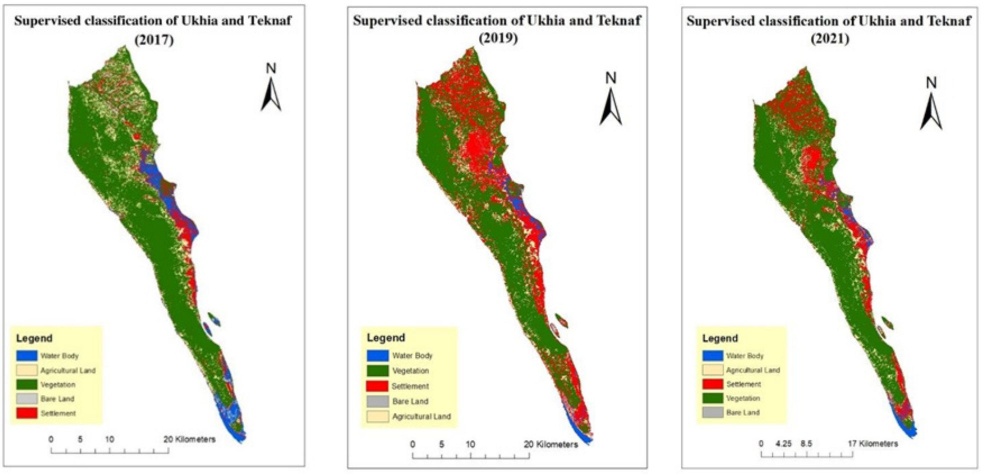

Figure 5: LULC of Ukhia and Teknaf, 2017, 2019 and 2021.

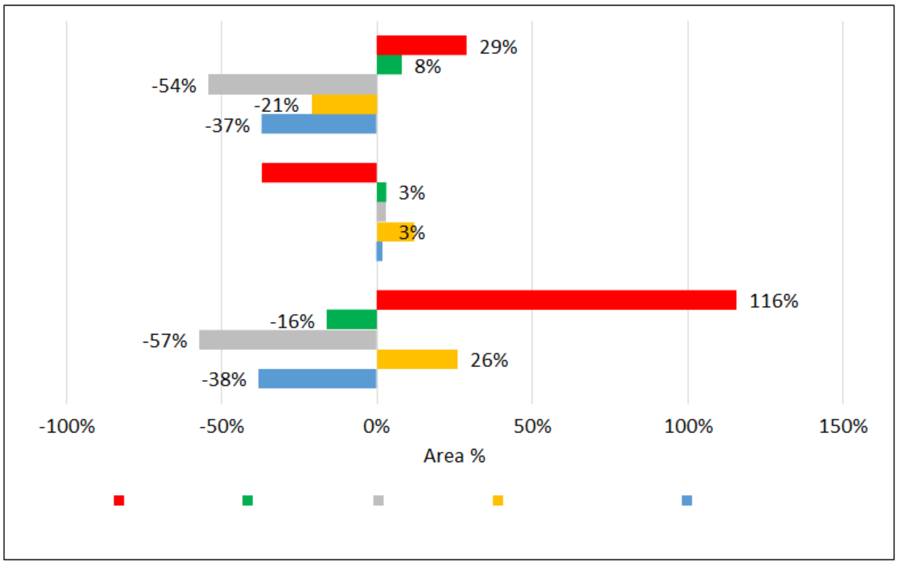

Figure 6: Rate of change of LULC (percentage/year).

Table 2: Relative change (%), where positive values specify increasing and negative values specify decreasing trends.

LULC area types	Year			LULC area changes (2017 to 2021) %		
	2017 ha	2019 ha	2021 ha	2017-2019	2019-2021	2017-2021
Water Body	5894.745	3631.794	3701.766	-38%	2%	-37%
Vegetation	35114.733	30908.619	32120.042	-16%	3%	8%
Bare Land	1653.248	703.794	754.408	-57%	3	-54%
Settlement	8038.207	17394.895	10945.665	116%	-37%	29%
Agricultural Land	6577.13	4837.578	5456.473	-26%	12%	-21%

Abbreviation: ha: Hectare

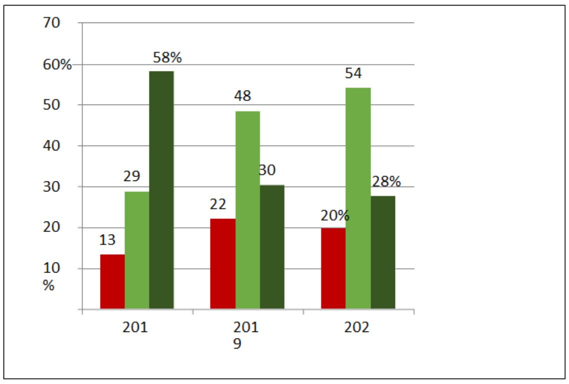

Figure 7: Analysis of Vegetation coverage in Ukhia and Teknaf sub-district (2017, 2019 and 2021). **Note:** (■) No Vegetation; (■) Light; (■) Vegetation.

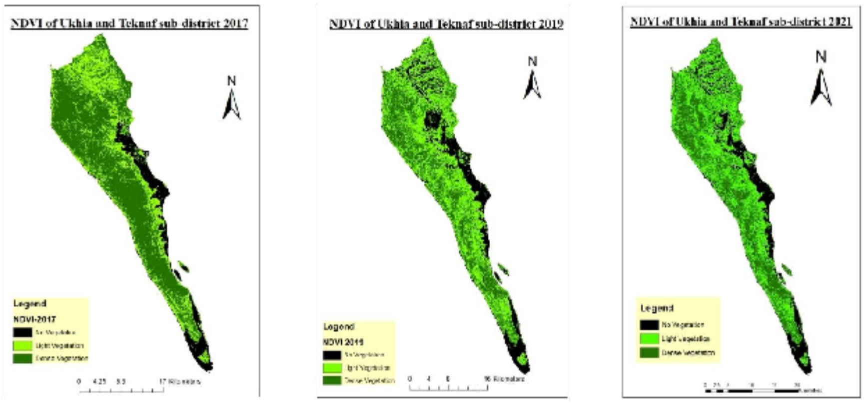

Figure 8: Analysis of Vegetation coverage in Ukhia and Teknaf sub-district (2017, 2019 and 2021).

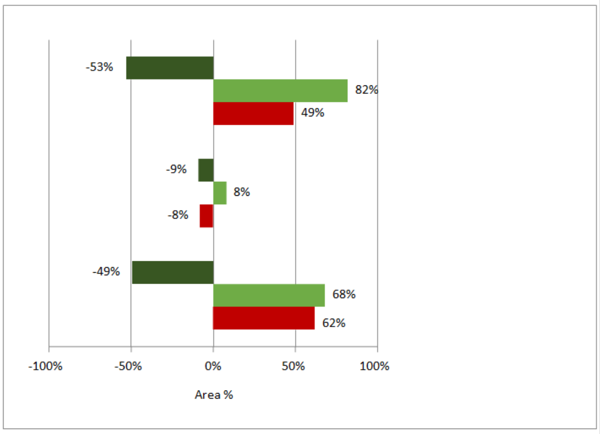

Figure 9: Relative change of vegetation coverage (percentage/year). **Note:** (■) Dense; (■) Vegetation light; (■) Vegetation

Table 3: Relative change (%), where positive values specify increasing and negative values specify decreasing trends.

NDVI types	Area/Year			Relative changes (2017 to 2021) %		
	2017 (ha)	2019 (ha)	2021 (ha)	2017- 2019	2019- 2021	2017- 2021
No Vegetation	7603	12311	11322	+62%	-8%	+49%
Light Vegetation	16477	27776	30095	+68%	+8%	+82%
Dense Vegetation	33408	17400	15830	-49%	-9%	-53%

Abbreviation: ha: Hectare

Analysis of the Land Surface Temperature (LST)

Using the calibration of spectral radiance and emissivity correction of remote sensing, land surface temperature was calculated from the thermal band of the satellite image. The header file (metadata) downloaded with the satellite images that had all of the essential information to compute LST. Moreover, the maximum, minimum and mean land surface temperature of four land features has been calculated in 2017, 2019 and 2021. It should be mentioned that the LST has been calculated in different year in different days. Land Surface Temperature can be changed with the pattern and density of Land Use and Land Cover area (LULC) (Table 4).

Visual interpretation of LST in Ukhia and Teknaf sub districts

The changes of land surface temperature with the changes of land use land cover have been illustrated in Figure 10. It has been found from the Figure 10 that most of the area of Ukhia and Teknaf experiences low LST in 2017 and even it is lower than 20°C in most of the places. In somewhere of Ukhia and Teknaf area, LST has also found more than 20°C. Now comparing with 2021 it reveals that the higher LST area with the LULC map, it has been found that earth filled, sand areas or bare land have the highest LST (point out as A and B in Figure 10).

From the observation of LULC and LST maps of 2017 to 2019 it has been found that the mean LST in 2019 is higher than 2017 as in 2017 vegetation cover was 64% and in 2019 it has been declined to 54%. In 2019 vegetation decreasing rate is of about 10% also water body decreasing rate is 38% but settlement increased very rapidly, which causes the overall increase in LST. The differences of LST between years 2017-2019 can be represented in Table 4, where the mean LST of year 2019 is higher than 2017. In this duration, decreasing rate of water body and vegetation is about 38% and 16% respectively, which causes the increasing rate of LST of the total area. Again in 2021 we can see the surface temperature is slightly degrading due to the decreasing of settlement and increasing of vegetation it is about 37% and 3% respectively. So it can be said, the increasing pattern of these LST and LULC map indicates that the Land Use and Land Cover area (LULC) changing is one of the main causes of LST changes (Figure 10).

Accuracy assessment

The raw satellite images were used as a reference for the categorization of accuracy assessment. Following a stratified random sampling approach, the complete process was carried out by comparing the reference images with the classified images with certain random locations. The detail results of the accuracy assessment are shown, the user accuracy varies from 75% to 91.67% and producer accuracy varies from 78.57% to 91.67%. The result reveals of 2017, overall classification accuracy was 88% and Kappa statistics was 85%. In 2019 and 2021, overall classification accuracy calculates 90% and 93% where kappa co-efficient 88% and 92% respectively. The accuracies of the classified images were higher because of the availability of high resolution images. The analyzed land cover maps were validated against the remote sensing images captured by Google earth and USGS in different random locations of the study area (Table 5).

Table 4: Derived Minimum, maximum and mean LST of the study area over the year.

Representative	LST		
	Maximum	Minimum	Mean
12 February, 2017	24	16	20
28 February, 2019	27	16	21.5
17February, 2021	25	16	20.8

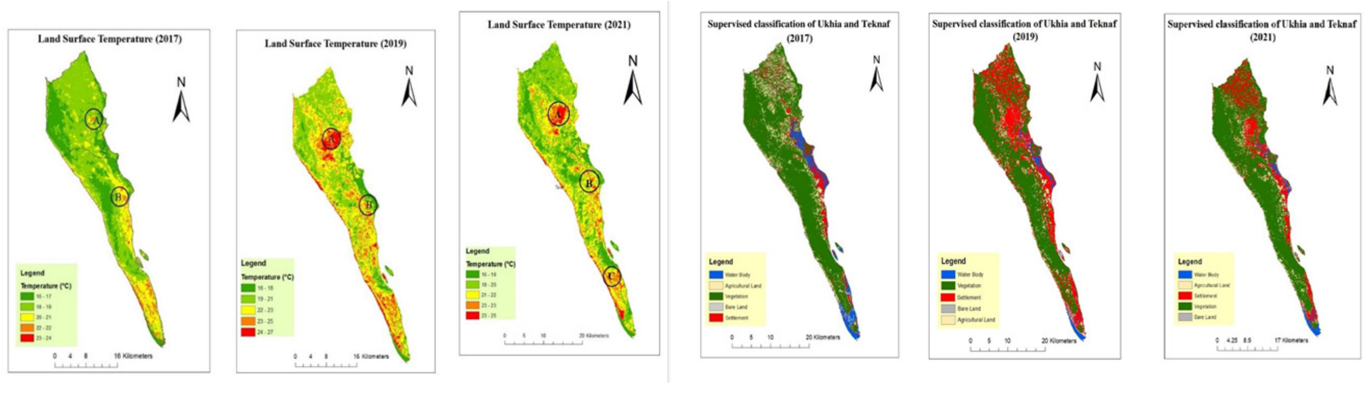

Figure 10: Visual Interpretation of LST with respect to LULC area transition (2017, 2019 and 2021).

Table 5: Accuracy Assessment.

Year	User Accuracy (%)					Producer Accuracy (%)					Overall Accuracy (%)	Kappa Co-efficient (%)
	Water (%)	Settlement (%)	Bare Land (%)	Vegetation (%)	Agricultural land (%)	Water (%)	Settle ment (%)	Bare Land (%)	Vege tation (%)	Agricultural land (%)		
2017	91.67	75	100	83.33	91.67	100	100	83.33	85.71	78.57	88	85
2019	100	83.33	91.67	83.33	91.67	92.3	83.33	91.16	83.33	91.16	90	88
2021	100	91.67	100	83.33	91.67	100	91.67	91.67	83.33	91.67	93	92

CONCLUSION

The study had used the classification method to detect the environmental change as well as land use and land cover changes and land surface temperature in the Ukhia and Teknaf sub district through the integration of GIS and Remote sensing techniques in between 2017 to 2021. However, few limitations may influence the outcome of the study; To begin with, cloud cover can produce errors in satellite data, and seasonal variations can alter the amount of water bodies and vegetation. Second, during the training sample, some of the research area's settlements were classified as vegetation cover because they were hidden in plant cover, which could affect the pixel value for prediction outcomes. Finally, the agricultural land use category was combined with barren and open terrain, and the area was counted as a single agricultural land use pattern. Though there are some confines of this study, the methodology and outcomes can be measured as a suitable one for deciding better management and long-term planning for land use of ongoing crisis. Different methods indicate the remarkable change of various land use categories over the last 5 years. As vegetation cover was the dominant feature of the study area, NDVI analysis was executed to delineate the change in various time frames which revealed the decreasing trend of dense vegetation at an alarming rate. Moreover, post-classification change detection methods showed a significant decline in vegetation cover of about 35114.733% ha in 2017 to 2019. Increasing settlements and agricultural land denote that somehow the local people, national and international or organizations were built up temporary or permanent settlements nearby refugee camps which also may put pressure on biodiversity as a partial. However, in camp areas, lots of service communities are needed for helping a vast number of Rohingya refugees. Again, due to the change of vegetation and increase of settlement surface temperature is decreasing. The density of the built-up area increased in 2019, from the year 2017. That's why, the LST increases greatly in present year which indicating gradual rise of surface temperature regarding temporal basis. Instead of causing a negative effect from fast refugee influxes and settlements, this large loss in vegetation cannot be a natural event in any regard. Despite the fact that the enormous refugee inflow was an inevitable humanitarian crisis in those circumstances, active efforts must be done to mitigate the long-term environmental and ecosystem damage. In such cases, objective assessment of environmental changes using GIS and remote sensing technology can provide vital information that can assist policymakers in more sustainably implementing programs.

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