Publisher homepage: www.universepg.com, ISSN: 2707-4668 (Online) & 2707-465X (Print)
https://doi.org/10.34104/ajssls.023.02460252
Asian Journal of Social Sciences and Legal Studies
Journal homepage: www.universepg.com/journal/ajssls

# Land Use and Land Cover Change Detection of Teknaf Upazila Due to Rohingya Crisis by Using GIS, and RS Techniques

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## ABSTRACT

Bangladesh is in a terrible condition due to forced migration of Rohingya refugees from Myanmar to Bangladesh. Study focused on mapping and estimating changes in Teknaf Upazila's land use and land cover (LULC) between the years of 2010 and 2022. For the purpose of conducting this study, both primary and secondary data have been collected. The study found that the growing population has created unexpected and uncontrolled changes in LULC. It was found that between the years of 2010 and 2022, there was a drop in forest (1.68 SKM), vegetation (10.99 SKM), and bare soil (10.71 SKM). It was found that residences (22.96 SKM) and water bodies (42 SKM) increased during the course of these twelve years. Unplanned construction of refugee camps, political unrest, consumption of wood from surrounding forest, and the large influx of Rohingya refugees into the area are main causes for rising built-up area and drastic reduction of vegetation. As a result, the Rohingya population put pressure on Teknaf's established natural surroundings and land cover.

**Keywords:** Rohingya crisis, Refugee, Land use, Land cover, LULC, Teknaf upazila, GIS, and RS.

## INTRODUCTION:

The world community is paying attention to the Rohingya refugee problem. Because of their fear of religious and ethnic persecution, millions of people from neighboring Myanmar State were fleeing into Bangladesh (BBC, 2018; Chowdhury *et al.*, 2022). Military restrictions on the Rohingyas occurred in 1978, 1991-1992, 2012, 2015, and 2016-2017. Since 1978, Bangladesh has been dealing with challenges related to refugees; At that time almost 200,000 again in 1991-92 approximately 250,000 migrants reached and accommodated in the Kutupalong, Balukhali, Nayapara, Teknaf, Ukhiya and Leda and this number increased to 624000 by November 7, 2017 (Hossain *et al.,* 2018; Labib *et al.*, 2018).

The government of Myanmar does not offer citizenship to the Rohingya they were even left out of the 2014 census (BBC, 2018). As a result, Bangladesh is the becoming the main destination for the Rohingya refugees. There were about 20 refugee camps where the Rohingya people were housed (Moslehuddin *et al.,* 2018). After the Rohingya crisis the growing population had a negative impact on LULC, which

resulted in LULC changes that were unexpected and unregulated (Sakamoto *et al.,* 2021).

The biophysical elements (soil, water, and vegetation) and the physical elements that make up the earth's surface are referred to as land cover (Rawat & Kumar, 2015; Junjie, 2008). Based on the need for a certain service, people and other living things alter the land in different ways, which is referred to as land use. Due to the high population growth rate in tropical regions, land use patterns there change more quickly than in other regions (Junjie, 2008). LULC change has grown to be a significant contributor to global change because of its linkages to the climate, biological processes, and biogeochemical cycles (Islam and Hassan, 2011). A district's LULC status reflects the natural and socioeconomic features of that area and how they are used over time and space (AbdelRahman *et al.,* 2019; Siddeqa *et al*., 2023).

Bangladesh's economy and resources are heavily burdened by the growing number of the Rohingya people (Hossain, 2018). Refugees from Rohingya are posing four different security threats to Bangladesh (Ahmed, 2010). Additionally, it has had a significant impact on the loss of biodiversity, global warming, and a rise in the frequency of natural disasters like flooding (Prenzel, 2004; Seto *et al.,* 2002). The government has authorized clearing the forest in Kutupalong, Balukhali, and other nearby places to make room for Rohingyas (Labib *et al.,* 2018). Following the inflow of Rohingya refugees in the years 1991-1992, Cox's Bazar's forest department recorded the damage of natural resources worth Tk 13.5 crore (Hossain, 2018). During that period, illegal actions in Cox's Bazar and Bandarban were also perpetrated by the Rohingya refugees (Uddin, 2015). Both qualitative and quantitative changes in land cover have been effectively tracked with the aid of remote sensing (Collins & Woodcock, 1996; Rawat & Kumar, 2015). The goal of the study is to create maps showing the changes in land use and land cover in Teknaf Upazila from 2010 to 2022. Additionally, it aims to assess how much of such changes are attributable to the Rohingya crisis so that it can be helpful for further research on this issue.

## METHODOLOGY:

### Study Area

The Cox's bazar district's Teknaf upazila is located in Bangladesh's most southern region (Moslehuddin *et al.,* 2018). Its coordination is the 20.8667°N-20.52°N and 92.3000°E-92.18°E **Fig. 1**. Its total land area is 11,615 hectares (Imtiaz, 2018). It has many tourists' spot.

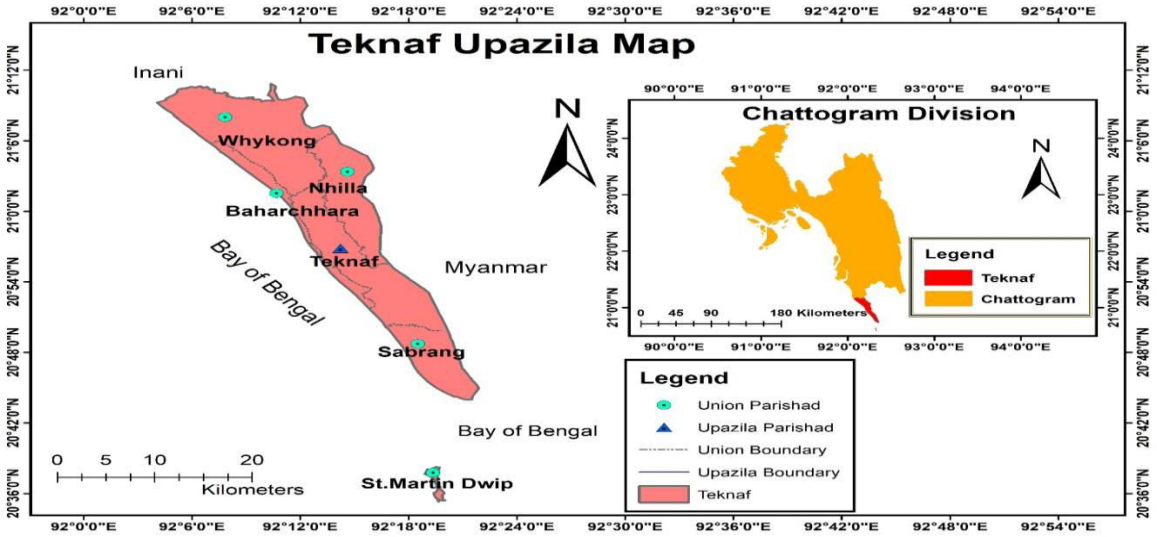


**Fig. 1:** Area of Study.

### Data Procurement

The study completed based on primary (Household survey, KII) and secondary data which are gathered from different journals, articles, websites, newspapers, other published and unpublished reports on Rohingya crisis. To fulfill the objectives one Landsat Thrmatic Mapper 4-5 (TM) C1 level 1 and one Landset 8 OLI/TIRS C1 level 1 are used. The characteristics of collected satellite image are shown in **Table 1**. The United States Geological Survey (USGS) website was used to access the image data (Alam *et al*., 2022; USGS, 2018).

**Table 1:** Characteristics of satellite image.

| Acquisition date | Satellite (sensor) | Path | Raw |
|---|---|---|---|
| 16-01-2010 | Landset 4-5 | 135 | 46 |
| 23-01-2010 | Landset 4-5 | 136 | 45 |
| 08-11-2022 | Landset 8 | 136 | 45 |
| 09-11-2022 | Landset 8 | 135 | 46 |

### Image Classification and Validation

The study utilized ArcGIS Software for the various tasks, including the digitizing, demonstrating, and evaluating vector layers. To eliminate data flaws and abnormalities, preprocessed Landsat TM image from 2010 and 2022 were used. For map preparation, a supervised classification approach was employed. The raw images had seven and eleven bands, which were combined using composite bands in ArcMap. Mosaic to new raster in ArcMap was used to create a single, accurate aerial representation of the study area. The Extract by Mask tool was applied to focus on the desired location. To classify the images, the Image Classification tool was utilized with different band combinations: (2, 4, 7), (3, 4, 5), (3, 5, 7), and (4, 5, 6). Area calculation was performed using the formula: [Counted pixels] * (pixel size)^2 / 10^6. The Land Use Land Cover (LULC) data for the two images for 2010 and 2022 were obtained after the images were processed. The data are then compared to determine the outcomes.

### Accuracy Measurement

By contrasting the classified image with the ground truth data, a confusion matrix was created to assess the precision of the supervised classification. The confusion matrix provides the information on the number of correctly and incorrectly classified pixels for each land cover class. Subsequently, the Kappa coefficient was calculated using the formula:

Kappa = (Overall Accuracy - Random Accuracy) / (1 - Random Accuracy) (Rwanga & Ndambuki, 2017)

## RESULTS AND DISCUSSION:

### Maps depicting the 2010 and 2022 changes in land use and land cover

Natural forces, seasonal fluctuations, shifting agri-cultural patterns, and other factors frequently change how land is used (Kirui *et al.,* 2013). Land cover changes has many socio-economic impacts, it affects the agriculture, economy and ecosystem. Five kinds of land cover, including barren soil, vegetation, settlement, water bodies, and forest area, were detected and interpreted in a categorized image of the land cover from 2010 (**Fig. 2**) and 2022 (**Fig. 3**). The results found after the analysis of multi-temporal satellite image shown in **Table 2** below.

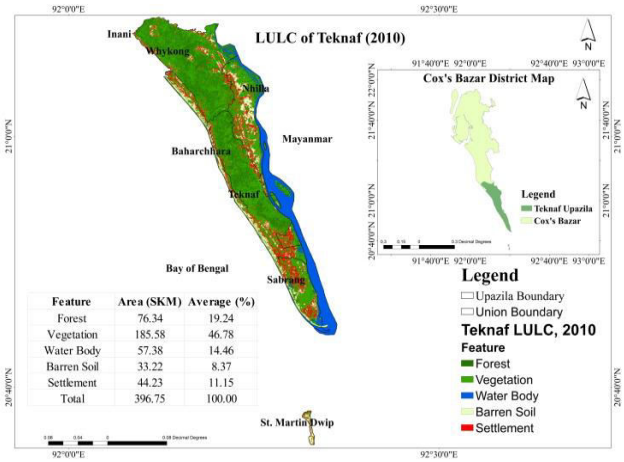


**Fig. 2:** LULC status in 2010.

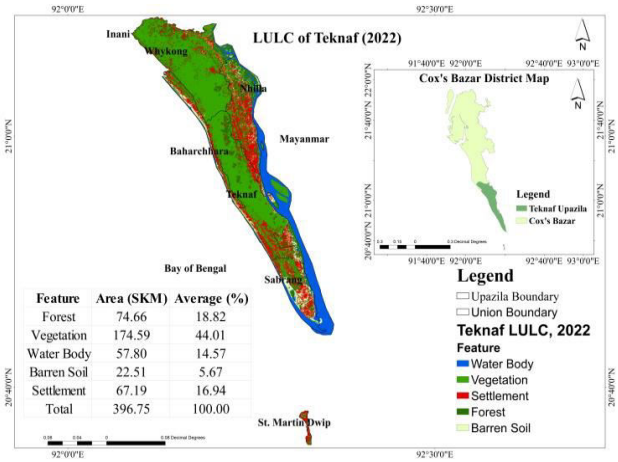


**Fig. 3:** LULC status in 2022.

### Detection of Land Use/Land Cover Change between 2010 and 2022

**Table 2:** LULC change between 2010-2022.

| Feature | 2010 | | 2022 | | Change from 2010 to 2022 |
|---|---|---|---|---|---|
| | Area (SKM) | Average (%) | Area (SKM) | Average (%) | Area (SKM) |
| Forest | 76.34 | 19.24 | 74.66 | 18.82 | -1.68 |

| | | | | | |
|---|---|---|---|---|---|
| Vegetation | 185.58 | 46.78 | 174.59 | 44.01 | -10.99 |
| Water Body | 57.38 | 14.46 | 57.80 | 14.57 | 0.42 |
| Barren Soil | 33.22 | 8.37 | 22.51 | 5.67 | -10.71 |
| Settlement | 44.23 | 11.15 | 67.19 | 16.94 | 22.96 |
| Total | 396.75 | 100.00 | 396.75 | 100.00 | |

**Change in Forest and Vegetation between 2010 and 2022**

In 2010 **Fig. 2** about 76.34 Square Km land was occupied as forest which was declined to 74.66 Square Km in the year of 2022 **Fig. 3**. The forest area decreased by 1.68 Square Km over these 12 years **Fig. 4**. Similar research on Dhaka, Khulna, and Rajshahi city discovered that the open spaces and vegetation converted into building areas (Billah & Rahman, 2004; Islam & Hassan, 2011; Mamun *et al*., 2013). Research found that 572 hectares of land typically cleared each year to set up refugee camp (Uddin, 2015). Expanding built-up land, especially in places with a high density of refugees, is the main driver of deforestation. The study found that in 2010 **Fig. 2** 185.58 Square Km land was occupied as vegetation which was declined to 174.59 Square Km in the year of 2022 **Fig. 3**.

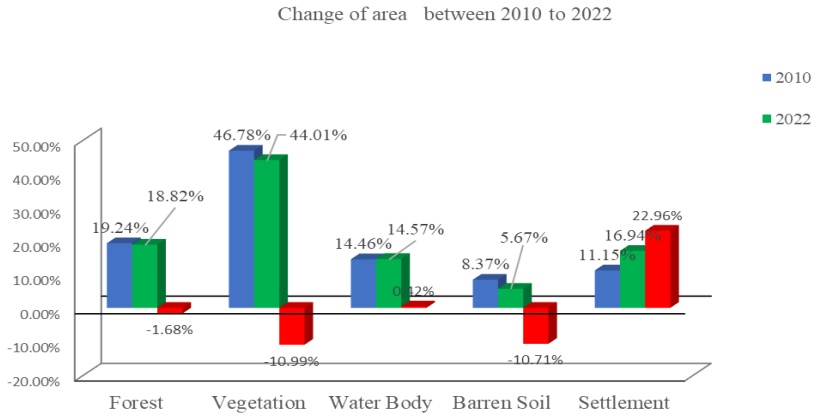


**Fig. 4:** Area change in percentage between 2010 and 2022.

The vegetation area dropped by 44.01% of the overall land area throughout the course of these 12 years (**Table 2**). According to the earlier research, between 1980 and 2020, the Rohingya refugee problem in the Ukhia Upazila caused an increase in agricultural land of around 14.34 sq km and a decline in the green space of 42.93 sq km (Quader, 2019). Different humanitarian organization provides different relief materials but it is not an easy matter to provide the firewood for the huge number of Rohingya. As a result, they (78%) rely on the forest for firewood which is responsible for significant decline in vegetation. The creation of refugee camps is also responsible for the vegetation deterioration (Rahman *et al.,* 2018; Hasnat and Ahmed, 2023).

**Settlement and Barren Soil Vary Between 2010 and 2022**

In 2010, 33.22 square kilometers of the land were considered to be barren soil (**Fig. 2**), but by 2022, that number had decreased to the 22.51 square kilometers (**Fig. 3**). According to the study, the overall area of built-up land increased from 44.23 square kilometers in the 2010 (**Fig. 2**) to 67.19 square kilometers in 2022 (**Fig. 3**). According to Sakamoto *et al.* (2021) Teknaf's built-up area had increased by 6825 ha by May 2021 compared to the years 2015-17. According to this research, unplanned construction, political unrest, poor policies, and the large influx of Rohingya refugees into the area are main causes for rising built-up land.

**Change in Water Bodies between 2010 and 2022**

The large number of the Rohingya population significantly putting stress on the long-standing natural surroundings and land cover of Tecnaf Upazila. It is important to record the changes the Rohingya colony has made. **Fig. 2** shows that the total area covered by water bodies in 2010 was 57.38 square kilometers, and that **Fig. 3** climbed to 57.80 square kilometers in 2022). Thus, between 2010 and 2022, water bodies grown by 0.42 square kilometers (**Fig. 4**). Several studies conducted on Dhaka, Khulna, Chittagong and Rajshahi city found that low land and water bodies have been converted into reclaimed built-up lands (Mamun *et al*., 2013; Quader, 2019; Ali *et al.,* 2022).

**Accuracy Measurement**

The confusion matrix of classified image of 2010 revealed different accuracy levels (**Table 3**) for the five land cover the classes. Class C_109 achieved perfect accuracy (1.00), indicating a precise classify-cation. Class C_35 exhibited high accuracy (0.94), with only a few misclassifications. Similarly, class C_108 achieved a satisfactory accuracy level (0.93). However, classes C_1 and C_110 showed slightly lower the accuracy (1.00 and 0.91, respectively), indicating a few misclassifications within these categories.

**Table 3:** Accuracy Test Confusion Matrix for Classified Image of 2010.

| Class Value | C_1 | C_35 | C_108 | C_109 | C_110 | Total | U_Accuracy | Kappa |
|---|---|---|---|---|---|---|---|---|
| C_1 (Forest) | 17.00 | 0.00 | 0.00 | 0.00 | 0.00 | 17.00 | 1.00 | 0.00 |
| C_35 (Vegetation) | 2.00 | 46.00 | 0.00 | 0.00 | 1.00 | 49.00 | 0.94 | 0.00 |
| C_108 (Water Body) | 1.00 | 0.00 | 13.00 | 0.00 | 0.00 | 14.00 | 0.93 | 0.00 |
| C_109 (Barren Soil) | 0.00 | 0.00 | 0.00 | 9.00 | 0.00 | 9.00 | 1.00 | 0.00 |
| C_110 (Settlement) | 0.00 | 0.00 | 1.00 | 0.00 | 10.00 | 11.00 | 0.91 | 0.00 |
| Total | 20.00 | 46.00 | 14.00 | 9.00 | 11.00 | 100.00 | 0.00 | 0.00 |
| P_Accuracy | 0.85 | 1.00 | 0.93 | 1.00 | 0.91 | 0.00 | 0.95 | 0.00 |
| Kappa | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.93** |

The total Kappa coefficient for the supervised classification was determined to be 0.93, indicating that there was a considerable amount of the agreement between the classified image and the reference data. This suggests a reliable and consistent classification outcome, surpassing chance agreement. The confusion matrix of classified image of 2022 revealed varying classification accuracies for different land covers classes **Table 4**. Land covers class C_242 achieved perfect accuracy (1.00) due to consistent and error-free classification. However, some classes, such as the C_51 and C_53, exhibited slightly lower accuracy (0.86 and 0.91, respectively), indicating misclassifications. There was a significant amount of arrangement between the classified image and the reference data, as indicated by the total Kappa coefficient for the supervised classification, which was found to be 0.91. The classification performed reasonably well because there seemed to be more agreement between the classified and reference data than could have been expected by chance.

**Table 4:** Accuracy Test Confusion Matrix for Classified Image of 2022.

| Class Value | C_1 | C_51 | C_53 | C_176 | C_242 | Total | U_Accuracy | Kappa |
|---|---|---|---|---|---|---|---|---|
| C_1 (Settlement) | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 1.00 | 0.00 |
| C_51 (Water Body) | 1.00 | 12.00 | 1.00 | 0.00 | 0.00 | 14.00 | 0.86 | 0.00 |
| C_53 (Forest) | 1.00 | 0.00 | 21.00 | 1.00 | 0.00 | 23.00 | 0.91 | 0.00 |
| C_176 (Vegetation) | 0.00 | 3.00 | 0.00 | 35.00 | 0.00 | 38.00 | 0.92 | 0.00 |
| C_242 (Barren Soil) | 0.00 | 0.00 | 0.00 | 0.00 | 5.00 | 5.00 | 1.00 | 0.00 |
| Total | 22.00 | 15.00 | 22.00 | 36.00 | 5.00 | 100.00 | 0.00 | 0.00 |
| P_Accuracy | 0.91 | 0.80 | 0.95 | 0.97 | 1.00 | 0.00 | 0.93 | 0.00 |
| Kappa | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.91 |

## CONCLUSION:

Millions of people from Myanmar State were fleeing in the south coasts of the Bangladesh, because of persecution. The Government of Bangladesh has triggered wide response to deliver basic assistance and medical services to Rohingya refugees. But this increasing number of people imposed giant socio-economic impact on the study area. The huge number of Rohingya burned huge amount of fire-wood for cooking every day. The forest area decreased by 1.68 Square Km between 2010 and 2022. There was a 22.96 Square Km growth in the built-up area. The enormous influx of Rohingya refugees into the area was the primary driver of the rise of built-up area. We are aware that the forest plays the most significant role in the preserving an area's natural equilibrium. As Teknaf's forest acreage has shrunk, it is losing important ecosystem services like food, shelter, fuel, well-being, and the livelihood, which would harm the region's overall economic system. So, the concerned authority should come forward & take immediate actions to solve the Rohingya issues which in turn will impose positive impact on LULC.

**ACKNOWLEDGEMENT:**
We are extremely thankful to all those who directly and the indirectly helped us in the completion of the research work.

**CONFLICTS OF INTEREST:**
The author(s) declared that they had no potential conflicts of interest with regard to research, authorship, and publication of this paper.

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**Citation:** Siddeqa M, Islam MT, Hasan MF, Islam R, and Rasheduzzaman M. (2023). Land use and land cover change detection of Teknaf upazila due to rohingya crisis by using GIS, and RS techniques. *Asian J. Soc. Sci. Leg. Stud.*, **5**(6), 246-252. https://doi.org/10.34104/ajssls.023.02460252