Research article

Ecology Journal

ISSN (Print): 2708-6356, ISSN (Online): 2708-6364, Website: journal.esbangladesh.org
Ecol. J. (2021) 3 (2) : 185-192

ASSESSING LAND USE LAND COVER CHANGE USING REMOTE SENSING: A CASE STUDY FROM GAZIPUR DISTRICT OF BANGLADESH

Tahmina Afroz[1*], Md. Giashuddin Miah[2], Hasan Muhammad Abdullah[2] and Muhammad Shahadat Hossain Siddiquee[3]

[1]Department of Agroforestry and Environmental Science, Sylhet Agricultural University, Sylhet, Bangladesh. [2]Department of Agroforestry and Environment, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur 1706, Bangladesh. [3]Department of Agricultural Extension, Dhaka, Bangladesh.

***Correspondence e-mail:** tahmina.smriti@gmail.com

Received: 12 October 2021, Revised: 26 October 2021, Accepted: 30 October 2021

ABSTRACT

Land use land cover change (LULCC) is a major concern now-a-days. Conserving forests and other ecosystems is one of the 17 Global Goals for Sustainable Development. Gazipur district dominating sal forest area in Bangladesh is experiencing extensive LULCC in last few decades. Objective of this study is to quantify the area of land use land cover change over the years. Landsat images of the year 1990, 2001, 2010 and 2019 of Gazipur district were collected for study. Analysis of images from 1990 to 2019, revealed that built-up and homestead were increased drastically. During 1990-2001, 2001-2010 and 2010-2019, built-up increased by 107.51%, 97.21% and 129.18 %, and homestead increased by 42.74%, 39.10% and 12.82%, respectively. Both the forest and crop/fallow lands were decreased where crop/fallow decreased by 2.82%, 13.75% and 11.15% and forest decreased by 40.10%, 13.25% and 14.56%, respectively, in last three decades. Crop/fallow lands were reduced due to conversion of crop/fallow lands to homestead (42909.03 ha) and built-up (5611.23 ha), whereas, forest was shrinking due to conversion of forest to crop/fallow (9091.98 ha) and homestead (9186.12 ha) during 1990 to 2019.

Keywords: LULCC, land conversion, landsat, remote sensing

Introduction

Monitoring land use and land cover change (LULCC) is an important part of evaluating landscape dynamics at different spatiotemporal scales. Land use and land cover change (LULC) analysis helps with environmental monitoring as well as the direction of current and future land use planning (Rahman *et al*. 2017). LULC must be considered in policymaking and a sustainable development approach (Wang *et al*. 2018). Changes in land use/land cover (LULC) have hydrological consequences, which can aid not only in water resource management planning (Gashaw *et al*. 2018), but also in estimating regional economic development (Chen *et al*. 2020). Agricultural growth, tree cutting, overgrazing, and settlement are the main causes of land use changes. LULC changes are also influenced by population increase, policy and institutional changes, poverty, and other factors (Hailu *et al*. 2020). The conversion of mid-latitude natural forests to crops and pastures has resulted in an increase in the frequency of hot, dry summers from once every decade to every 2–3 years, owing to the effects of land use and land cover change (Findell and colleagues 2017). Agricultural development and other related land use changes drove worldwide emissions from 1961 to 2017, with Latin America, Southeast Asia, and Sub-Saharan Africa at the forefront. Despite the fact that land use emissions are small or nonexistent in some areas, overall CO_2-equivalent land-use emissions per capita remain close to 0.5 ton per capita (Hong *et al*. 2021).

According to Xu *et al*. 2020, urban household dynamics, population increase, distance to cities and major highways, and precipitation dynamics, especially in Bangladesh's southwest region, are the causes of LULC. The Earth was covered with 60 million square kilometers of forest before the rise of human civilizations (Waring and Running 2007). Deforestation has reduced the size of the world's forests to less than 40 million square kilometers (The State of the World's Forests 2018). Bangladesh is vulnerable as a result of the loss of forest and agricultural land. The overall forest area of Bangladesh is 2.6 million hectares, accounting for about 17.4% of the country's total land area (IUCN and BFD 2016). However, in Bangladesh, forest degradation is caused by overexploitation, conversion of forest area for agriculture, fire, and grazing, among other

things (Sadath and Rahman 2016). Wetlands and forests are being converted to cropland and other uses, while agricultural land is diminishing at a rate of around 1.3% per year (IUCN and BFD 2016).

El-Zeiny *et al*. (2017) mentioned remote sensing and GIS approaches might be used to examine LULC as well as the relationship between LULC and economic activity. The most widely utilized data for detecting and measuring land cover changes is satellite imagery, such as Landsat data (Williams *et al*. 2006). Even though remote sensing and GIS have various limitations, such as cloudiness contamination, it is difficult to obtain same-season LULC maps using existing remote sensing images (Lu *et al*. 2019). The relationship between LST and NDVI, NDBI within each LULC type is not necessarily linear because it varies between LULC types and is affected by geographic location and season (Tran *et al*. 2017). Otherwise, Bangladesh's high-level landscape variability and lack of high-quality remotely sensed data is a major hindrance to effectively categorizing LULC (Abdullah *et al*. 2019).

As Gazipur is renowned for sal forest area and as it is near the adjacent of capital of Bangladesh, monitoring of LULC is important. Considering this importance, the study was undertaken to monitor the land use land cover change in Gazipur district from 1990 to 2019, and to quantify the land conversion among the different classes in Gazipur district.

Materials and Methods

Study area: Study area covers entire Gazipur district having 5 upazillas namely Gazipur sadar, Kaliakair, Kapasia, Sreepur and Kaliganj. Gazipur District (area 1741.53 sq km) is under Dhaka division located in between 23°53' and 24°21' north latitudes and in between 90°09' and 92°39' east longitudes (Figure 1).

Data collection and LULC classification: For analysis of 29 years Land Use Land Cover Change of Gazipur district, four Landsat satellite images (1990, 2001, 2010, 2019) were downloaded from United States Geological Survey (USGS) website (earthexplorer.usgs.gov) through ordering ESPA. Table 1 represents the characteristics of Landsat data. Gazipur shape file has been chosen as an area of interest (AOI) where all satellite images were clipped by Q GIS. Multiband images were done through

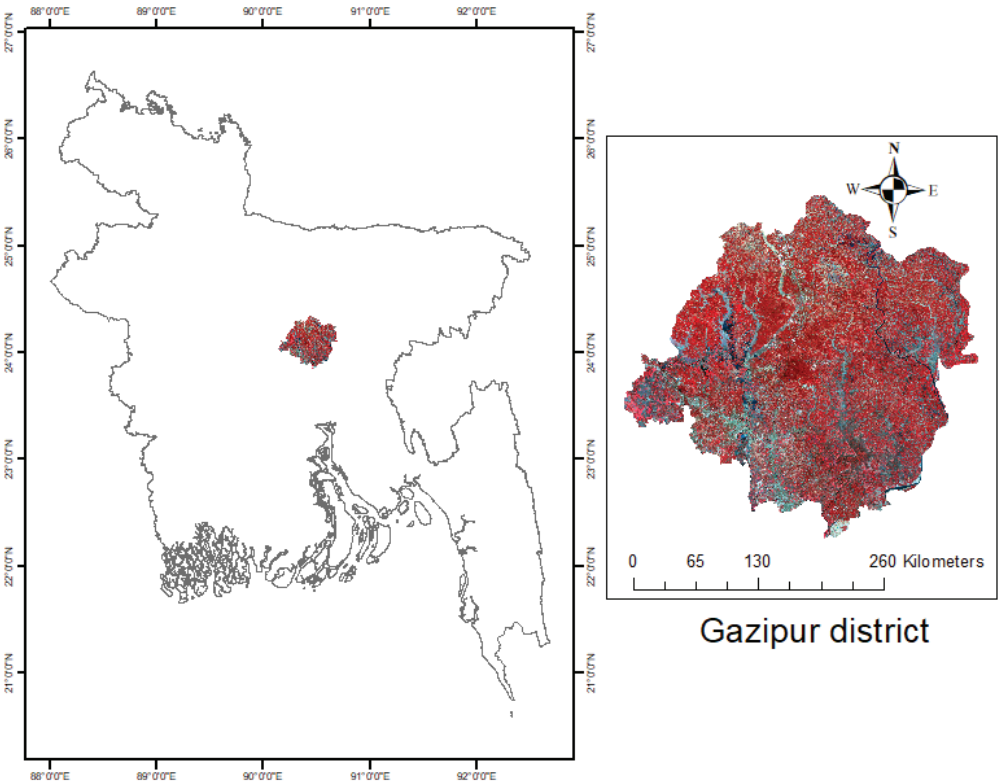


Figure 1. The study area of Gazipur district.

layer stacking in QGIS. False color composite image and training shape file were done through QGIS. ArcGIS 10.5 software mainly used for cross tabulation and mapping. Repeated training samples were taken in supervised classification for accurate classification. In case of image selection, winter season image was collected because cloud free image was available at that time. To produce LULC map, supervised classification (semi-automated) was used for classification of spectral images. LULC classified into 5 classes namely built-up, crop/fallow, homestead, forest and water (Table 2). Crop and fallow were considered under the same class because many crop lands were remained fallow for few time (crop either harvested or going to be ready for seed sowing) but those are actually crop land. A detailed framework of study has been presented in flow chart (Figure 2)

Accuracy assessment: According to the classification accuracy results, for the years 1990, 2001, 2010 and 2019, the overall classification accuracy were 95, 92, 97 and 94, and overall kappa statistics were 92, 90, 93 and 91, respectively (Table 3). These estimates indicate that the classification accuracies were of substantial agreement. This level of agreement is acceptable for classification of land use land cover changes.

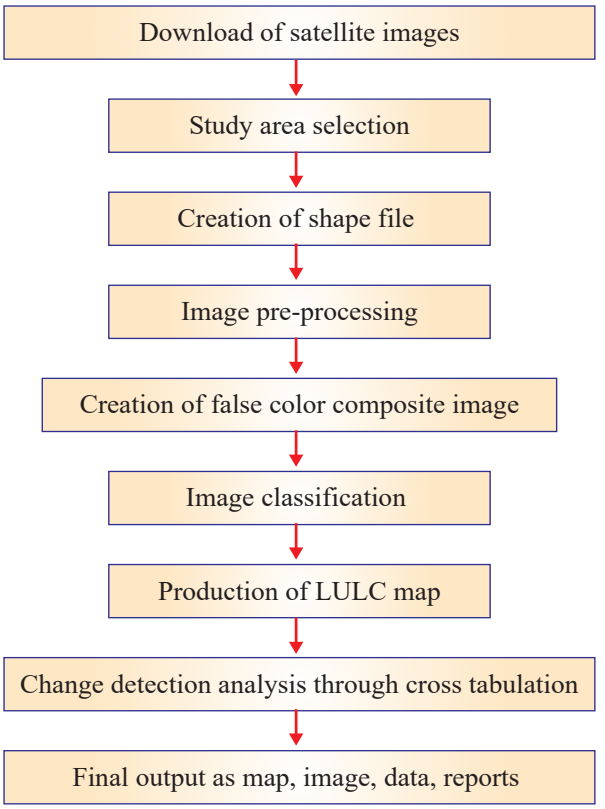


Figure 2. Flow chart of methodology.

Results and Discussion

Classified Land use land cover map for the different year (1990, 2001, 2010 and 2019) of Gazipur district shown in Figure 3 with five LULC classes in the study area namely built-up, crop/fallow, homestead, forest and water. False color composite was done in every images of 1990, 2001, 2010, 2019 year (Figure 4). After performing supervised classification in the images, the land use land cover change was easily detected.

The area of built up increased over time (Figure. 5) obviously for increasing population. Analysis of 29 years

Table 1. Characteristics of satellite images

Sensor	Path/Row	Image acquisition date	Resolution
Landsat 4-5 TM	137/43	7-Jan-90	30m
Landsat 4-5 TM	137/43	21-Jan-01	30m
Landsat 4-5 TM	137/43	30-Jan-10	30m
Landsat 8 OLI	137/43	23-Jan-19	30m

Table 2. Land use land cover classification scheme

Land use/cover types	Description
Built-up	Industrial, residential, transportation, road, urban, commercial
Crop/fallow	Agriculture area, crop fields, vegetable lands, fallow lands
Homestead	Home consists of tree, pond/crop field
Forest	Mainly sal forest and others
Water	River, permanent water, lakes, pond, River

Table 3. Accuracy assessment for the classified images

Reference year	Classified image	Overall classification accuracy (%)	Overall kappa statistic
1990	Landsat 4-5 TM	95	92
2001	Landsat 4-5 TM	92	90
2010	Landsat 4-5 TM	97	93
2019	Landsat 8 OLI	94	91

it was found that in recent decade (from 2010 to 2019) built-up area expanded vigorously by 129.18% followed by 107.51% and 97.21% than other decades (from 1990 to 2001 and from 2001 to 2010) (Table 4). Where many crop and fallow land converted to built-up specially the lower and upper zone of the image. Shapla *et al*. 2015 identified urban area increased from 1% to 3% in Gazipur district by analyzing of the year 2001, 2005 and 2009. Our study gives additional information that before 20th century built up was also increased i.e. 107.51% between 1990 to 2001.

Figure. 6 represents the decreasing trend of cop land/ fallow land in the study area. There was a huge change in crop/fallow land in from 1990 to 2019 and it was reduced

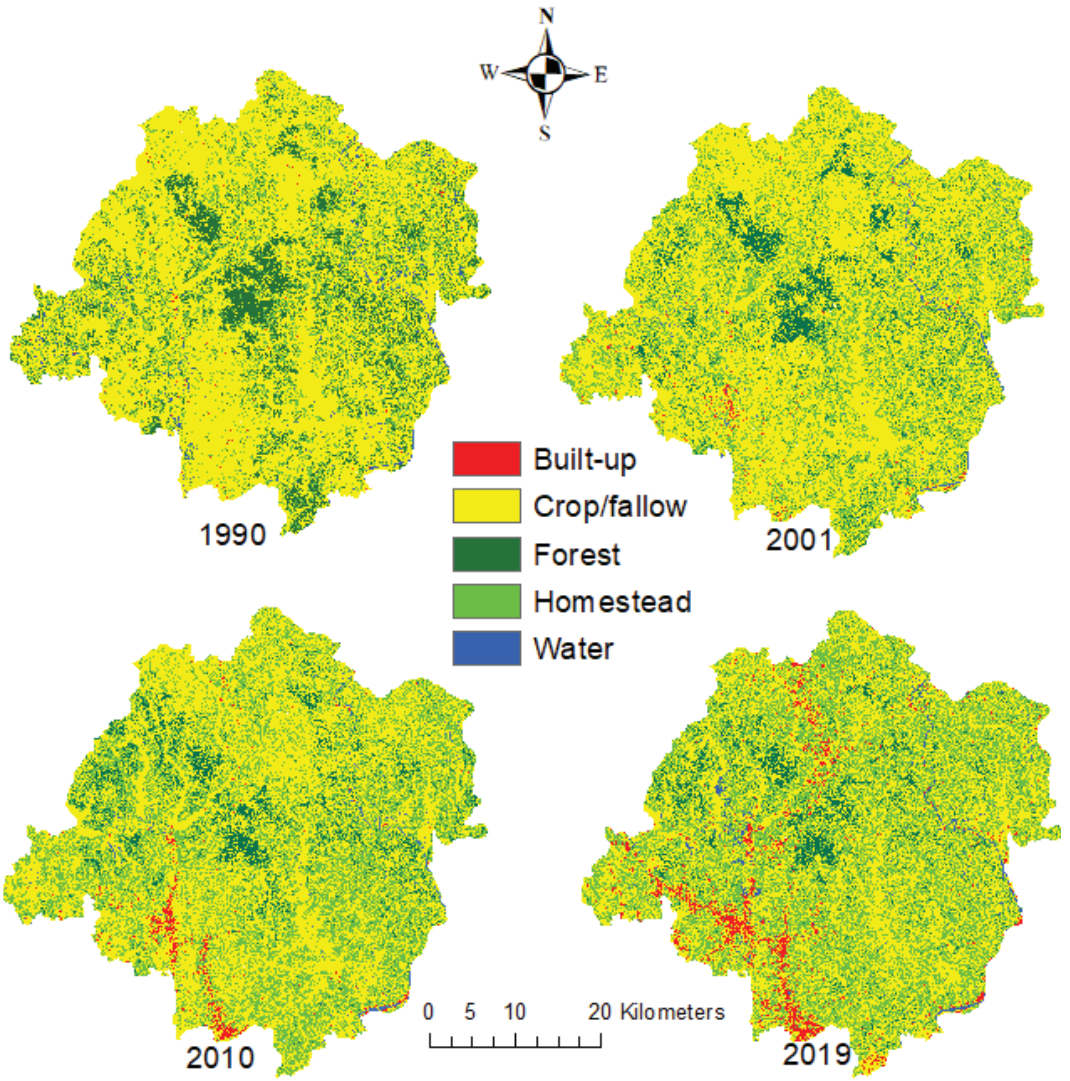


Figure 3. Classification of images for showing Land use land cover change in 1990, 2001, 2010, 2019

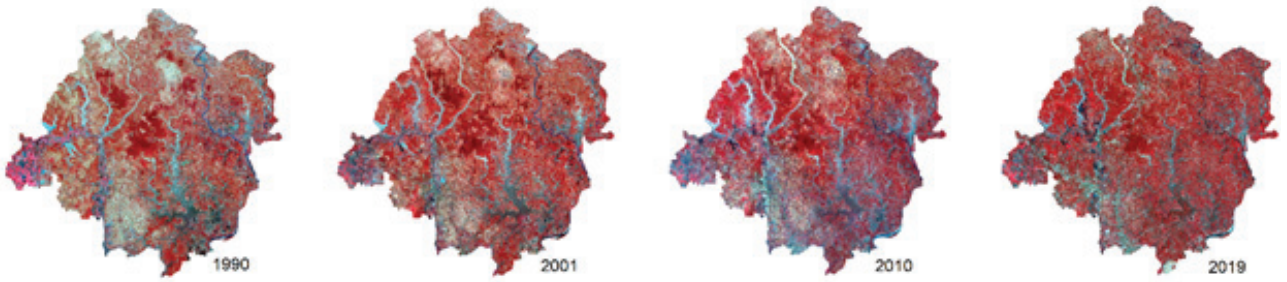


Figure 4. False color composite image of Gazipur (1990, 2001, 2010, 2019)

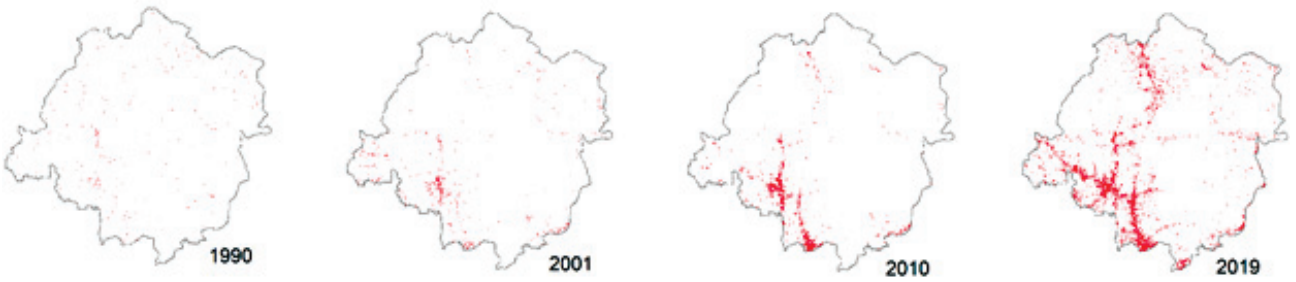


Figure 5. Thematic map showing change of built-up over the year in Gazipur (1990, 2001, 2010, 2019)

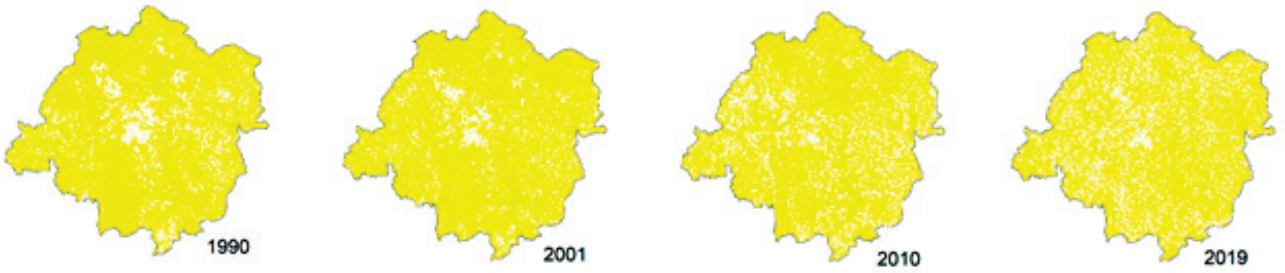


Figure 6. Thematic map showing change of crop/fallow over the year in Gazipur (1990, 2001, 2010, 2019)

by 2.82%, 13.75% and 11.15%, respectively in last three decades in the study area (Table 4). Like as Gazipur district agricultural land was also decreased in Tangail mentioned by the author Mamun *et al*. (2018).

Sal forest is the dominating forest in Gazipur but this forest was decreasing from last 29 years (Figure 7). Forest shrank by 40.10%, 13.25% and 14.56%, respectively in last three decades (Table 4). Deforestation was highest during 1990 to 2001 but after that it was decreased because many afforestation programme started to halting cut down of forest. Forest of Gazipur district was decreasing match the findings of Yesmin *et al*. (2014) who conducted a research in a part of Gazipur district (Mirzapur Union) mentioned that forest cover was decreased by 20.29 % because population pressure becomes double enhancing the deforestation of Sal (*Shorea robusta*).

Homestead consists of trees, home, crops etc. In the study area, the number of homesteads was in increasing trend from 1990 to 2019 shown in Figure 8. Homestead was increased by 39.10% between 2001-2010 and 12.82% in 2010 -2019, respectively, (Table 4). This result is similar with Shapla *et al*. (2015) and our study reveals additional information that homestead was also increased by 42.74% between 1990-2001.

In the study area, river, pond, the temporary watered area, permanent watered area etc. were in this water class. So, the change of watered area may vary from year to year as because of drainage problem, temporal stagnation of

water etc. shown in Figure 9. In 1990, total watered area was 2049.97 ha followed by 1272.91 ha in 2001, 1158.43 ha in 2010 and 2028.73 ha in 2019, respectively, (Table 4). Through analyzing LANDSAT TM images of 1989 and 2009 water bodies was decreased by 6.25 % at Mirzapur Union of Gazipur District of Bangladesh (Yesmin *et al*. 2014).

Table 4 depicts among the different classes, forest and crop/fallow were in decreasing trend in every decade. In 1990, the area of forest was 23855.30 ha followed by 14288.40 ha in 2001, 12394.62 ha in 2010 and 10590.57 ha in 2019, respectively. Crop/fallow was also decreased and it occupied 124779.0 ha in 1990, 121259.5 ha in 2001, 104590.90 ha in 2010 and 92928.8 ha in 2019, respectively. Area of homestead was more than double in recent year (67393.8 ha) than the year of 1990 (30086.40 ha). The increasement of built-up area was also vigorous and rate of increasement was more than nine folds in 2019 (8763.05 ha) than 1990 (934.34 ha). The area of water was varied in different year.

During 1990 to 2019, persistent area of forest and crop/fallow was 5203.44 ha and 71835.48 ha. Whereas maximum forest land converted to homestead (9186.12 ha) and crop/fallow (9091.98 ha) area. Crop/fallow was decreased also whereas maximum crop/fallow was converted to homestead (42909.03 ha) and built-up (5611.23 ha) followed by forest and water. The persistent area of homestead and built up was 14979.6 ha and 72.99 ha, respectively. Homestead was increased by conversion of maximum area of crop/fallow (42909.03 ha) and forest (9186.12 ha) to homestead. Rather than, built-up increased by conversion of crop/fallow (5611.23 ha)

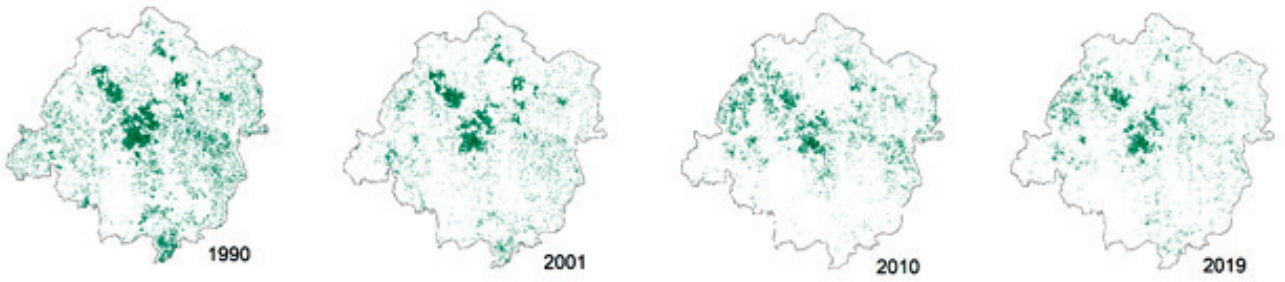


Figure 7. Thematic map showing change of forest over the year in Gazipur (1990, 2001, 2010, 2019).

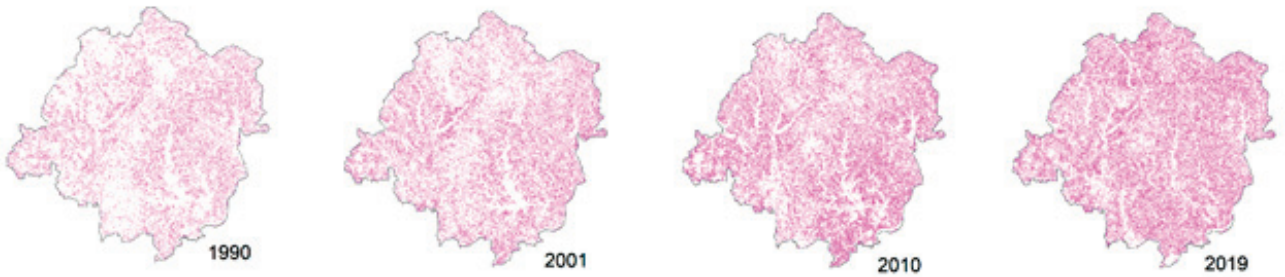


Figure 8. Thematic map showing change of homestead over the year in Gazipur (1990, 2001, 2010, 2019).

Table 4. Change of LULC in Gazipur district

Class	Area (ha)				Change (%)		
	1990	2001	2010	2019	'90-'01	'01-'10	'10-'19
Forest	23855.30	14288.40	12394.62	10590.57	-40.10	-13.25	-14.56
Water	2049.96	1272.91	1158.43	2028.73	-37.91	-8.99	75.13
Homestead	30086.40	42945.30	59737.41	67393.80	42.74	39.10	12.82
Built-up	934.34	1938.87	3823.63	8763.05	107.51	97.21	129.18
Crop/fallow	124779.00	121259.50	104590.90	92928.85	-2.82	-13.75	-11.15

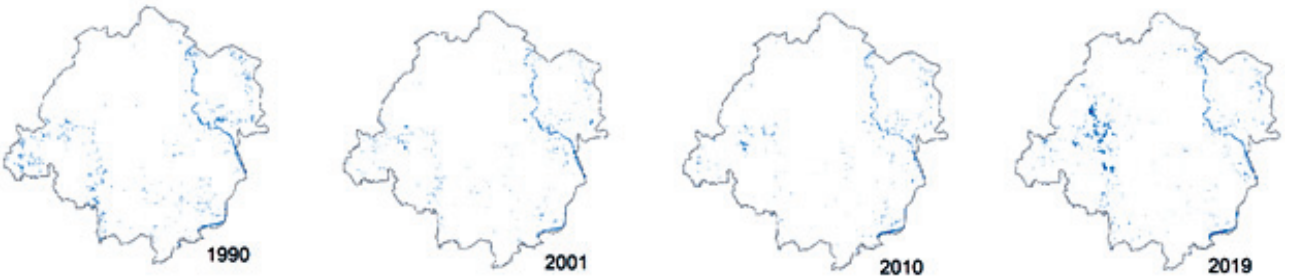


Figure 9. Thematic map showing change of water over the year in Gazipur (1990, 2001, 2010, 2019)

followed by others (Figure 10). Abdullah *et al.* (2019) also found that forest areas, particularly those dominated by the threatened sal tree (*Shorea robusta*), were converted into other land-use classes.

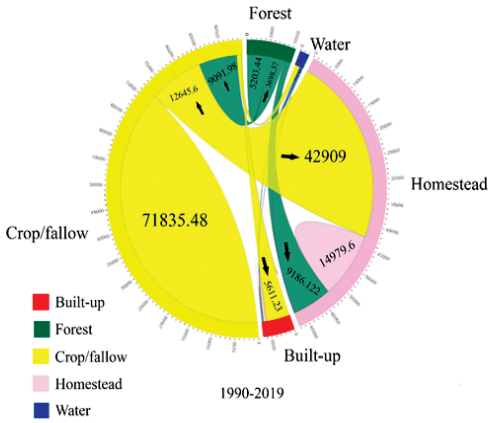


Figure 10. Land use land conversion among different LULC classes in Gazipur district

Conclusion

Extensive land use land cover change was observed in the study area. Both the built-up and homestead area were increased, whereas, built-up increased by 107.51%, 97.21% and 129.18 % and homestead increased by 42.74%, 39.10% and 12.82% during 1990-2001, 2001-2010 and 2010-2019. On the other hand, at the same time, crop/fallow lands were decreased by 2.82%, 13.75% and 11.15% and forest decreased by 40.10%, 13.25% and 14.56%, respectively. Between 1990 to 2019, maximum crop/fallow converted to homestead and built-up. Besides, maximum forest land converted to homestead and crop/fallow lands. Such a decline in forest coverage is concerning for preserving ecological balance, especially in the context of the country's ever-increasing population. This finding is helpful for policy making and halt deforestation in future.

References

Abdullah AYM, Masrur A, Adnan MSG, Baky M, Al A, Hassan QK and Dewan A. 2019. Spatio-temporal patterns of land use/land cover change in the heterogeneous coastal region of Bangladesh between 1990 and 2017. Remote Sensing, *11*: 790.

Abdullah HM, Islam I, Miah MG and Ahmed Z. 2019. Quantifying the spatiotemporal patterns of forest degradation in a fragmented, rapidly urbanizing landscape: a case study of Gazipur, Bangladesh. Remote Sensing Applications: Society and Environment, *13*: 457-465.

Chen C, He X, Liu Z, Sun W, Dong H and Chu Y. 2020. Analysis of regional economic development based on land use and land cover change information derived from Landsat imagery. Scientific Reports, *10*: 1-16.

El-Zeiny AM and Effat HA. 2017. Environmental monitoring of spatiotemporal change in land use/land cover and its impact on land surface temperature in El-Fayoum governorate, Egypt. Remote Sensing Applications: Society and Environment, *8*: 266-277.

Findell KL, Berg A, Gentine P, Krasting JP, Lintner BR, Malyshev S and Shevliakova E. 2017. The impact of anthropogenic land use and land cover change on regional climate extremes. Nature Communications, *8*: 1-10.

Gashaw T, Tulu T, Argaw M and Worqlul AW. 2018. Modeling the hydrological impacts of land use/land cover changes in the Andassa watershed, Blue Nile Basin, Ethiopia. Science of the Total Environment, *619*: 1394-1408.

Guo F, Lenoir J and Bonebrake, TC. 2018. Land-use change interacts with climate to determine elevational species redistribution. Nature Communications, *9*: 1-7.

Hailu A, Mammo S and Kidane M. 2020. Dynamics of land use, land cover change trend and its drivers in Jimma Geneti District, Western Ethiopia. Land Use Policy, *99*: 105011.

Hong C, Burney JA, Pongratz J, Nabel JE, Mueller ND, Jackson RB and Davis SJ. 2021. Global and regional drivers of land-use emissions in 1961-2017. Nature, *589*: 554-561.

IUCN and BFD. 2016. Bangladesh National Conservation Strategy, Part II: Sectoral Profile. BFD, Ministry of Environment and Forests, Government of the People's Republic of Bangladesh, and IUCN, Bangladesh Country Office, Dhaka, Bangladesh.

Lu Y, Wu P, Ma X and Li X. 2019. Detection and prediction of land use/land cover change using spatiotemporal data fusion and the Cellular Automata–Markov model. Environmental Monitoring and Assessment, *191*: 68.

Mamun SA, Runa HA, Hoque MMM, Sheikh S and Arif RH. 2018. Assessment of spatio-Temporal changes of land use in Tangail municipality using GIS. Journal of Environmental Science and Natural Resources, *11*: 245-252.

Pang SE, De Alban JDT and Webb EL. 2021. Effects of climate change and land cover on the distributions of a critical tree family in the Philippines. Scientific Reports, *11*: 1-13.

Rahman MTU, Tabassum F, Rasheduzzaman M, Saba H, Sarkar L, Ferdous J and Islam AZ. 2017. Temporal dynamics of land use/land cover change and its prediction using CA-ANN model for southwestern coastal Bangladesh. Environmental Monitoring and Assessment, *189*: 1-18.

Sadath MN and Rahman S. 2016. Forest in crisis: 2 decades of media discourse analysis of Bangladesh print media. Forest Policy and Economics, *68*: 16-21.

Shapla T, Park J, Hongo C and Kuze H. 2015. Agricultural land cover change in Gazipur, Bangladesh, in relation to local economy studied using Landsat images. Advances in Remote Sensing, *4*: 214.

The State of the World's Forests 2018. Forest Pathways to Sustainable Development, Food and Agriculture Organization of the United Nations Rome.

Tran DX, Pla F, Latorre-Carmona P, Myint SW, Caetano M and Kieu. 2017. Characterizing the relationship between land use land cover change and land surface temperature. ISPRS Journal of Photogrammetry and Remote Sensing, *124*: 119-132.

Wang C, Wang Y, Wang R and Zheng P. 2018. Modeling and evaluating land-use/land-cover change for urban planning and sustainability: a case study of Dongying city, China. Journal of Cleaner Production, *172*: 1529-1534.

Waring RH and Running SW. 2007. Forest Ecosystems: Analysis at Multiple Scales. Academic Press.

Williams DL, d Goward S, Arvidson T. 2006. Landsat: yesterday, today and tomorrow. Photogrammetric Engineering and Remote Sensing, *72*: 1171.

Xu X, Shrestha S, Gilani H, Gumma MK, Siddiqui BN and Jain AK. 2020. Dynamics and drivers of land use and land cover changes in Bangladesh. Regional Environmental Change, *20*: 1-11.

Yesmin R, Mohiuddin ASM, Uddin MJ and Shahid MA. 2014. Land use and land cover change detection at Mirzapur union of Gazipur District of Bangladesh using remote sensing and GIS technology. Earth and Environmental Science, *20*: 012055.