Monitoring dynamic land-use change in rural–urban transition: a case study from Hathazari Upazila, Bangladesh

Mohammad Muzammal Hossain Bhuiyan a, Kamrul Islam b, Kazi Nazrul Islam a, and Mohammed Jashimuddin a, c

*Institute of Forestry and Environmental Sciences, University of Chittagong, Chittagong, Bangladesh; bDepartment of Systems Innovation, Graduate School of Engineering, The University of Tokyo, Tokyo, Japan; cDepartment of Forestry, The Papua New Guinea University of Technology, Lae, Papua New Guinea

ABSTRACT
This study evaluates land-use/cover change (LULCC) and urban expansion in Hathazari Upazila, Chittagong, between 1977 and 2017 using satellite images. Spatial and temporal dynamics of LULCC was quantified using three Landsat images, a supervised classification algorithm, and the post-classification change detection technique through geographic information system. The overall supervised classification accuracy of the Landsat-derived land-use/cover maps ranged from 74% to 91%. The analysis revealed substantial growth of settlement (146%) and agricultural land (124%) in Hathazari Upazila, Chittagong, over the study period which resulted in significant decrease in the area of water bodies (68.9%), homestead (54.4%), and hill forest (43.3%). The research quantified the patterns of LULCC for the last 40 years for Hathazari Upazila, Chittagong, that might contribute to both development of sustainable urban land-use planning decisions and probable growth patterns.

1. Introduction
The physical cover observed on the surface of the earth is termed as the “land cover” whereas the anthropogenic utilization of the land is referred to as “land use.” However, these two terms are often used synonymously (Islam, Rahman, & Jashimuddin, 2018; Rai, Zhang, Paudel, Li, & Khanal, 2017). The monitoring of land-use and land-cover change (LULCC) could provide valuable information which is essential for city planning (Ahmed & Ahmed, 2012). However, due to increase of human population, people from the rural area migrate toward the city for numerous reasons (e.g., searching for work, better life, improved amenities, etc.) (Padmanaban et al., 2017). This trend is evident in most parts of the world which in turns changes the pattern of land use (Güler, Yomralioğlu, & Reis, 2007; Hasan, Deng, Li, & Chen, 2017; Liu & Yang, 2015). The LULCC is a dynamic process. Therefore, extensive and continuous research needs are sought for to find the causes along with its implications in different spatiotemporal scales (López, Bocco, Mendoza, & Duhau, 2001; Mondal, Sharma, Garg, & Kappas, 2016).

Due to the advancement and data availability, researchers are now using remote sensing (RS) technology and geographic information system (GIS) to monitor land-use change (Islam, Jashimuddin, Nath, & Nath, 2016; Rahman, Jashimuddin, Islam, & Nath, 2016). Spatial extent and temporal change of land cover can be analyzed extensively by the remotely sensed data (Dou & Chen, 2017; Hassan & Nazem, 2016). This spatial trend is studied through the technique called “change detection” which is the spectral characteristics of the vegetation or other cover types in a particular location that change/persist over times (Hoffer, 1978; Singh, 1989).

There remains a few landscape which has not been modified by human interventions. The natural setting is being altered by the actions of the human being (López et al., 2001). This anthropogenic influence on the land cover is a recent environmental concern as it could affect the integrity of total ecosystem. LULCC is so pervasive that it is regarded as the key driver of environmental change (Islam, Rahman et al., 2018). The change in land-use pattern has direct implications at regional, local, and even global scales. Starting from the last century till now, humans have evolved greatly with skills and capacities to take the control of the earth. The result of this action leads to the overwhelming alterations of the global environment. The widespread change in land use has already transformed a major part of the earth (Islam, Jashimuddin, Nath, & Nath, 2018).

Population is a major factor which alters the land cover through diversified anthropogenic activities. In recent times, RS data are providing immense help to monitor LULCC pattern. The technique of RS has been extensively applied in various researches in Bangladesh and rest of the world for land-use studies. Land-cover change of Chittagong city was analyzed by Hassan and...
Nazem (2016) and Islam and Chowdhury (2014) using RS and GIS. LULCC in greater Dhaka was studied using RS (Ahmed & Ahmed, 2012; Dewan & Yamaguchi, 2009a). On the other hand, Brink and Eva (2009) had monitored 25 years of land-cover change in Africa in their research.

The Chittagong district located at the southeastern corner of Bangladesh is important due to its position. It is one of the most important hubs for commercial and economic activities of the country. The whole district is administratively divided into 15 Upazila (sub-district) (MoL, 2011). Hathazari Upazila is one of them that came into existence in 1929. The total area of the Upazila is roughly 251 km². The Halda River is a major river of this region which is famous worldwide as a natural breeding ground of carps. However, the growth trend of Chittagong district on the northeastern and on the southern side is practically not possible because of the presence of Bay of Bengal (Islam & Chowdhury, 2014). Since the Hathazari Upazila is located in the northeastern side of the Chittagong city corporation, Geographers suggest that the importance of Hathazari Upazila will increase day by day (MoL, 2011).

A few attempts have been made by the government to produce the upazila zonal land-use map under a pilot project of the Ministry of Land (MoL, 2011), but this provides only the present land-use distribution of the areas. Considering these facts, this study has been conducted to monitor the land use and land cover of Hathazari Upazila from 1977 to 2017 using the freely available multi-temporal satellite imageries. The outcome of this research may help the government organizations and natural resources management authority by providing information of the spatiotemporal pattern of land-use change of the area. Therefore, this study aims to (1) to classify the land use of the study area in different temporal periods and (2) to analyze how the land use of the study area changed over the period of time.

2. Methods

2.1. Study area

The study was conducted in Hathazari Upazila of Chittagong district. Hathazari Upazila is located between 22°37ʹ57.97ʺ and 22°24ʹ7.78ʺ north latitude and 91°42ʹ23.03ʺ and 91°52ʹ39.62ʺ east longitude (Figure 1). Hathazari is bounded by Fatikchhari Upazila in the northeast, Raozan Upazila in the east, Chittagong City Corporation in the south, and Sitakunda Upazila in the west (MoL, 2011).

2.2. Satellite data collection and image processing

Satellite imagery viz. Landsat-8 OLI-TIRS (Operational Land Imager-Thermal Infrared Sensor), Landsat-5 TM

Figure 1. Map of the study area.
(Thematic Mapper), and Landsat-2 MSS (Multispectral Scanner) were collected from USGS (United States Geological Survey) database for the time period of 2017, 1997, and 1977, respectively. The resolution of different spectral band varies depending on the nature of the satellite mission. However, in general, the spatial resolution of Landsat-8 and Landsat-5 is 30 m whereas for Landsat-2, it is 60 m, respectively. Cloud and unwanted shade free imagery were set as the criteria during image selection. The reason behind this is that the imagery having cloud could substantially reduce the accuracy of the classification. The details of the collected imageries are provided in Table 1.

Another criterion for image selection was the choice of specific season. In order to reduce the effect of seasonal variation, winter season was preferred. In Bangladesh, winter is mostly cloud free compared to other seasons (e.g., monsoon period from May to August).

The collected imageries need to be processed further to classify the different land use of the study area. Supervised classification was used in this regard. In order to perform this operation, ERDAS Imagine 2014 software was used. The layer stacking option from this software was used to convert the RGB bands (5, 4, 3 for Landsat-8 and 4, 3, 2 for both Landsat-5 and Landsat-2) into a single layer. From the layer file, Hathazari Upazila was clipped by using subset tool and shape file of Hathazari Upazila. Vector layer of Hathazari Upazila was collected from the WFP (World Food Programme) website (https://geonode.wfp.org).

### 2.3. LULCC detection

The base map of the study area was prepared by using satellite imageries and shape file of Bangladesh administrative area which was obtained from WFP website (https://geonode.wfp.org). ERDAS Imagine 2014 and ArcGIS 10.2.2 software were used to prepare land-use category map and image interpretation. Latitude and longitude of specific land-use category were searched for and recorded by conducting a field survey in the study area. A total of six major land-use categories were identified and considered for this research based on the knowledge from the field. The latitude and longitude of a specific area were collected from a wider area. This helps to trace the category without further complexities. These data were used in the later stage to identify different land-use categories from the image and the process was followed for all the six classes. The recorded land-use data were used to identify the pixel color tone of 2017 image while training the dataset. At least 10 latitude–longitude points were considered in this case to verify the pixel color tone. After finding the specific cell of a certain land use, polygons were drawn from the classifier. For each land-use class, nearly 30 polygons were drawn to train the software. These data were saved as a signature file and used later. This whole process was done for all the land-use classes and studied imageries.

The signature file was used to classify the satellite imageries. Maximum likelihood estimation (MLE) algorithm was used to classify the imageries as it can perform well among the others. Following equations were used to assess the change, percentage of change, and annual rate of change:

\[
\text{Land use change} = \frac{\text{magnitude of the new year} - \text{magnitude of the previous year}}{\text{Base Year}}
\]

\[
\text{Change(%) } = \frac{\text{Magnitude of Change} \times 100}{\text{Base Year}}
\]

\[
\text{Annual Rate of Change} = \frac{\text{Final year} - \text{Initial Year}}{\text{No. of Years}}
\]

### 2.4. Accuracy assessment

ERDAS Imagine 2014 was used for accuracy assessment of all the classified imageries (i.e., 1977, 1997, and 2017). Random points were generated by the classifier for all the classified imageries. These points were considered as the reference values whereas correctly identified points by the users were considered as the classified values. Both the reference and classified data were then used to prepare the error matrix and kappa statistics following the methodology of Islam, Jashimuddin et al. (2018).

| Satellite | Sensor | Path/Row | Date of acquisition | Spatial resolution (m) | Spectral bands (µm) | Data sources |
|-----------|--------|----------|---------------------|------------------------|---------------------|--------------|
| Landsat 8 | OLI-TIRS | 136/44 | 27–02–17 | 30 | B2 (blue): 0.45–0.51 <br> B3 (green): 0.53–0.59 <br> B4 (red): 0.64–0.67 <br> B5 (NIR): 0.80–0.88 | US Geological Survey |
| Landsat 5 | TM | 146/44 | 19–01–97 | 30 | B1 (blue): 0.45–0.52 <br> B2 (green): 0.52–0.60 <br> B3 (red): 0.63–0.69 <br> B4 (NIR): 0.76–0.80 <br> B5 (green): 0.60–0.70 | |
| Landsat 2 | MSS | 146/44 | 02–01–77 | 60 | B4 (blue): 0.50–0.60 <br> B5 (green): 0.60–0.70 <br> B6 (red): 0.70–0.80 <br> B7 (NIR): 0.80–1.10 | |

Table 1. Detailed information about satellite images.
Overall accuracy of the supervised classification was also calculated from the error matrix using the following equations:

$$K^\wedge = \frac{P_o - P_c}{1 - P_c}$$  \hspace{1cm} (4)

$$P_o = \sum_{i=1}^{r} P_{ii}$$  \hspace{1cm} (5)

$$P_c = \sum_{j=1}^{c} (P_{1j} * P_{2j})$$  \hspace{1cm} (6)

Here, 
- $r$ is the number of rows in the error matrix,
- $P_{ii}$ is the proportion of pixels in row “$i$” and column “$i$,”
- $P_{1i}$ is the proportion of the marginal total of row “$i$,” and
- $P_{2i}$ is the proportion of the marginal total of column “$i$.”

3. Results

3.1. Land-use change assessment in Hathazari Upazila from 1977 to 2017

From the field survey, six major land uses were found. These were categorized as follows: (a) agriculture, (b) barren land, (c) hill forest, (d) homestead, (e) settlement, and (f) water body. The result of land-use mapping of Hathazari Upazila would provide information on spatiotemporal distribution of land-use changes over the past 40 years. The land-use maps produced from satellite imageries are shown in Figures 2-4. The spatiotemporal distribution of various land-use categories for the year 2017, 1997, and 1977 and the changes are provided in Tables 2 and 3. After image classification, map layouts were prepared on 1:129,550 scale (Figures 2-4).

3.2. Land-use pattern of Hathazari Upazila in 1977

The land-use pattern identified (six classes) for the year 1977 is presented in Table 2. From the identified land-use categories, it was found that hill forest (8704.08 ha, 34.74% of total land area) was the dominant land use during 1977. The remaining land uses were homestead forest (6821.28 ha, 22.22%), agriculture (3864.96 ha, 15.43%), water body (2571.12 ha, 10.26%), settlement (1781.28 ha, 7.11%), and barren land (1313.28 ha, 5.24%) (Table 2).

The southwestern and northwestern part of the study area was dominated by the hill forest. On the other hand, agricultural land was found to be sporadically distributed in the northeastern and southeastern part of the area. Since population at that time was much lower than the present, settlement was also scattered that covered nearly 1781 ha (Figure 2).

3.3. Land-use pattern of Hathazari Upazila in 1997

The 1997 image classification results revealed that the highest category was agriculture (7594.65 ha, 30.30% of total land area). Other land uses were homestead forest (5746.95 ha, 22.93%), settlement (5206.23 ha, 20.77%), hill forest (4168.17 ha, 16.63%), barren land (1519.92 ha, 6.06%), and water body (825.39 ha, 3.29%) (Table 2).

Compared to the previous time period, the land uses of the study area changed drastically. While settlement started to grow very fast, people explored more for expanding the agriculture. This is quite noticeable from the land-use map. Agricultural expansion occurred in exchange of losing both the hill and homestead forest in Hathazari (Figure 3).

3.4. Land-use pattern of Hathazari Upazila in 2017

Due to high population growth rate (1.40%) and high population density (1753 per sq. km) (BBS, 2013), the land-use pattern of Hathazari Upazila significantly changed between 1997 and 2017. It is noticed that agriculture land use is still dominant in the area (8670.98 ha, 34.6%). Other land uses are hill forest (4933.28 ha, 19.69%, which increased slightly compared to 1997), barren land (3157.02 ha, 12.6%, which increased significantly compared to 1997), homestead forest (3112.9 ha, 12.42%), and water body (798.95 ha, 3.19%) (Table 2). From the 2017 image analysis, it was noticed that settlement (4387.3 ha, 17.51%) decreased. During field visit and image analysis, it was observed that people preferred to live sporadically before, but at present they are moving toward urban areas and tried to form a clustered habitat (Figure 4). That is why, in spite of increasing population, settlement area is still less than 1997.

3.5. Relative changes in land use in Hathazari Upazila from 1977 to 2017

The relative land-use changes of Hathazari Upazila were evaluated based on Tables 2 and 3. Trends of land-use changes from 1977 to 1997 showed some negative changes; but land-use changes pattern from 1997 to 2017 showed comparatively better trend than 1977–1997 time period. About 765.11 ha of hill forest increased from 1997 to 2017 and 818.93 ha of settlement decreased due to habitat pattern change. But overall land-use changes from 1977 to 2017 showed negative change. It is evident that hill forest, homestead forest, and water body decreased whereas settlement, barren land, and agriculture land increased (Table 3 and Figure 5).

About 8704.04 ha land was covered by hill forest during 1977 which started to decrease in the subsequent years and reached 4933.28 ha. Roughly, 3770 ha of the hill
forest had been destroyed with an annual rate of change of 94 ha. On the other hand, the percentage change of agriculture, settlement, and barren land in the studied time frame was +124%, +146%, and +140%, respectively. This is indeed a matter of serious concern (Tables 2 and 3).

3.6. Supervised classification accuracy and kappa ($K^*$) statistics

The accuracy assessment result for the supervised classification of the imageries is presented in Table 4. The corresponding error matrix that was used to calculate the accuracy was provided in Tables A1–A3. The highest accuracy was found for 2017 supervised classification (90.24%) and the lowest for 1977 (74.47%) (Table 4). Kappa statistics is a widely used measure to evaluate the agreement between classified and reference data. Having a kappa value of (0.81–1.00) indicates almost perfect/perfect match between the referenced and classified data (Landis & Koch, 1977; van Vliet, Bregt, & Hagen-Zanker, 2011; Yang & Lo, 2002). The kappa statistics for 2017 image classification shows a value of 0.8703 which signifies almost perfect/perfect match between the reference and classified (Table 4). The kappa statistics and the overall accuracy of the supervised classification were satisfactory.

3.7. Cross-classification between 1997 and 2017 imageries

The cross-classification was done through overlapping two supervised images. Due to nature of spatial development of the land use, the classified images of 1997 and 2017 were overlapped to observe the land-use shift in this time. By cross-
classification between 1997 and 2017 classified images, the study shows that agriculture and barren land increased remarkably and if this trend goes on, it may rise in the future. Water body and hill forest are the main sources for expanding agricultural land whereas agricultural land, hill, and homestead forest are also converted to barren land by this time period. It is evident that water body and homestead forest have reduced a lot.

From 1997 to 2017, nearly 2317.97 ha of the land remained in hill forest category. However, the conversion from hill forest to agriculture (1121.85 ha) outweighed the other classes. This trend was also similar for the conversion of homestead forest to agriculture (1278.9 ha) (Table 5). The agricultural expansion shifted from the close proximity of the available river water source (e.g., Halda River) in 1997 to the central, northwestern margin of Hathazari Upazila (Figure 6).

4. Discussion

This research reveals the LULCC pattern of Hathazari Upazila. The study area is important due to its geographical location. It shares the boundary with the Chittagong city while acting as the route of entrance to Chittagong Hill Tracts. The city centers of the study area (Hathazari municipality) have all the required characteristics for urbanization. People are shifting to the city centers from the rural areas and urban area is expanding eventually.

The major land use of the study area during 1977 was the hill forest. This pattern is similar to other
Table 2. Land-use distribution of Hathazari Upazila from 1977 to 2017.

| Land-use class | Land-use (A) in 1977 | Land-use (B) in 1997 | Land-use (C) in 2017 |
|----------------|----------------------|----------------------|----------------------|
|                | Area (ha) 1977 | % of land | Area (ha) 1997 | % of land | Area (ha) 2017 | % of land |
| Agriculture    | 3864.96       | 15.43     | 7594.65       | 30.30     | 8670.98       | 34.60     |
| Barren land    | 1313.28       | 5.24      | 1519.92       | 6.06      | 3157.02       | 12.59     |
| Hill forest    | 8704.08       | 34.74     | 4168.17       | 16.63     | 4933.28       | 19.69     |
| Homestead      | 6821.28       | 27.22     | 5746.95       | 22.93     | 3112.85       | 12.42     |
| Settlement     | 1781.28       | 7.11      | 5206.23       | 20.77     | 4387.3        | 17.51     |
| Water body     | 2571.12       | 10.26     | 825.39        | 3.29      | 798.95        | 3.19      |
| Total          | 25,056        | 100       | 25,056        | 100       | 25,056        | 100       |

Table 3. Assessment of land-use change in Hathazari Upazila based on time frame data (1977–2017).

| Land-use category | Land-use change (B – A): 1977–1997 | Land-use change (C – B): 1997–2017 | Land-use change (C – A): 1977–2017 |
|-------------------|-------------------------------------|-------------------------------------|-------------------------------------|
|                   | Changed area 1977–1997 (ha) | Change % | Annual rate of change (ha) | Changed area 1997–2017 (ha) | Change % | Annual rate of change (ha) | Changed area 1977–2017 (ha) | Change % | Annual rate of change (ha) |
| Agriculture        | +3729.69       | +96.5    | +186.48        | +1076.33      | +14.17   | +53.81          | +4806.02       | +124    | +120            |
| Barren land        | +206.64        | +15.73   | +10.33         | +1637.1       | +107.71  | +81.86          | +1843.74       | +140    | +46.1           |
| Hill forest        | –4535.91       | –52.11   | –226.8         | +765.11       | +18.36   | +38.26          | –3773.8        | –43.3   | –94.3           |
| Homestead          | –1074.33       | –15.75   | –53.72         | –2634.1       | –45.83   | –131.71         | –3708.43       | –54.4   | –92.7           |
| Settlement         | +3424.95       | +192.27  | +171.25        | –818.93       | –15.73   | –40.95          | +2606.02       | +146    | +65.2           |
| Water body         | –1745.73       | –67.89   | –87.29         | –2643.86      | –3.20    | –1.32           | –1772.17       | –68.9   | –44.3           |
part of the country where forestland remains a major one. The reason is simple, the population at that time was much lower than that of present time. However, population growth posed tremendous impact on the land-use system, which ultimately changed the pattern and also evident from other studies (e.g., Ahmed & Ahmed, 2012; Dewan & Yamaguchi, 2009a, 2009b). A lot of forestland was being converted to agricultural land and settlement throughout the country (Hassan, 2017).

The cities in the developing countries are growing very fast (Roy, 2009). Although the major cities of the country are growing fast, the trend of urbanization also accelerates the transition of once suburban area to a major urban hub. Considering the socioeconomic perspectives, it could bear positive influences on the societal system. But recent studies suggest that urbanization also poses serious threat to the whole environmental systems (Ahmed, Hasan, & Maniruzzaman, 2014; Byomkesh, Nakagoshi, & Dewan, 2012; Roy, 2009). Sustainable urban planning in this regard could be a possible solution that might address the challenge of growing urban cities. The concept of integrated land-use planning is also suggested by other researchers as a relevant technique (Roy, 2009).

Remotely sensed imageries have a great potential to monitor dynamic land-use change and been widely used by researchers throughout the world (Ahmed et al., 2014; Islam, Jashimuddin, et al., 2018; Islam, Rahman, et al., 2018). Among the available classification algorithm, MLE is often used due to its less complexity and better accuracy. The accuracy of the supervised classification in this research was in the range between 74% and 90% which is quite satisfactory. However, most of the land-use change studies conducted in Bangladesh focused on either large cities (Hassan, 2017; Hassan & Nazem, 2016) or

| Overall classification accuracy | Overall kappa statistics |
|---------------------------------|--------------------------|
| 1977                            | 1997                     | 2017 |
| 74.47%                          | 79.17%                   | 90.24% |
| 0.6548                          | 0.7274                   | 0.8703 |

Table 4. Classification accuracy and kappa statistics of supervised classification of 1977, 1997, and 2017 imageries of Hathazari Upazila.

Table 5. Interconversion of land uses from 1997 to 2017.

Table 5. Interconversion of land uses from 1997 to 2017.
5. Conclusion

Bangladesh is gradually transitioning toward industrialization. The trend of economic growth is on the rise. On the other hand, population of the country is still increasing rapidly. All these factors are fueling up the process of urbanization. The urban land-use system is a complex and dynamic one. Monitoring such dynamic land use is essential for sustainable urban development and planning. RS and GIS are widely used tools for land-use change assessment. The findings from this research suggest that agriculture land is increasing fast in the area whereas hill forest is disappearing gradually. One important pattern of land-use change in the area is the formation of urban cluster. This pattern of urban cluster formation may face serious environmental problems which is already going on in major cities of the country (e.g., Dhaka, Chittagong, Khulna). In this regard, integrated land-use planning could be adopted to reduce the severity of such problems. This research may contribute in this case while addressing the information gap.

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

Kamrul Islam http://orcid.org/0000-0003-3443-9030
Kazi Nazrul Islam http://orcid.org/0000-0003-0222-5900
Mohammed Jashimuddin http://orcid.org/0000-0002-7556-042X

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### Appendices

#### Table A1. Error matrix showing accuracy of 1977 supervised classification of land uses of Hathazari Upazila.

| Error matrix       | Reference data |
|--------------------|----------------|
|                     | Hill forest    | Barren land | Homestead forest | Settlement | Agriculture | Water body | Row total |
| Classified data     | 12             | 0           | 1               | 0          | 2           | 1          | 16        |
| Barren land         | 0              | 0           | 1               | 0          | 0           | 0          | 1         |
| Homestead forest    | 0              | 0           | 3               | 0          | 4           | 0          | 7         |
| Settlement          | 0              | 0           | 0               | 1          | 0           | 0          | 1         |
| Agriculture         | 0              | 0           | 1               | 0          | 12          | 2          | 15        |
| Water body          | 0              | 0           | 0               | 0          | 0           | 7          | 7         |
| Column total        | 12             | 0           | 6               | 1          | 18          | 10         | 47        |

#### Table A2. Error matrix showing accuracy of 1997 supervised classification of land uses of Hathazari Upazila.

| Error matrix       | Reference data |
|--------------------|----------------|
|                     | Water body | Settlement | Hill forest | Homestead | Agriculture | Barren land | Row total |
| Classified data     | 1          | 0          | 0           | 0         | 0           | 0          | 1         |
| Settlement          | 0          | 6          | 0           | 0         | 1           | 0          | 7         |
| Hill forest         | 0          | 0          | 9           | 3         | 0           | 0          | 12        |
| Homestead forest    | 0          | 0          | 5           | 10        | 1           | 0          | 16        |
| Agriculture         | 0          | 0          | 0           | 0         | 10          | 0          | 10        |
| Barren land         | 0          | 0          | 0           | 0         | 0           | 2          | 2         |
| Column total        | 1          | 6          | 14          | 13        | 12          | 2          | 48        |

#### Table A3. Error matrix showing accuracy of 2017 supervised classification of land uses of Hathazari Upazila.

| Error matrix       | Reference data |
|--------------------|----------------|
|                     | Water body | Agriculture | Hill forest | Settlement | Barren land | Homestead | Row total |
| Classified data     | 2          | 0           | 0           | 0          | 0           | 0         | 2         |
| Agriculture         | 0          | 14          | 0           | 1          | 1           | 0         | 16        |
| Hill forest         | 0          | 0           | 4           | 0          | 0           | 0         | 4         |
| Settlement          | 0          | 0           | 0           | 10         | 1           | 0         | 11        |
| Barren land         | 0          | 0           | 0           | 0          | 6           | 0         | 6         |
| Homestead forest    | 1          | 0           | 0           | 0          | 0           | 1         | 2         |
| Column total        | 3          | 14          | 4           | 11         | 8           | 1         | 41        |