Ilkogretim Online - Elementary Education Online, 2021; Vol 20 (Issue 2): pp. 3512-3524
http://ilkogretim-online.org
doi: 10.17051/ilkonline.2021.02.366

Change Detection Analysis In Land Use Land Cover In Majuli, Assam

Suman Das* , Deep Narayan Pandey**

* Assistant Professor, Department of Geography, Shaheed Bhagat Singh Evening College, University of Delhi, Delhi. Email - sumangeo@hotmail.com

** Assistant Professor, Special Centre for Disaster Research, Jawaharlal Nehru University, Delhi.

Correspoding Author: Deep Narayan Pandey (email. deepudai@gmail.com)

Abstract:
The largest river island in the world, located on the Brahmaputra River course through the high countries of Assam, a state in the upper east piece of India. On a specific note, Majuliisland faces natural disasters like flooding and riverbank erosion. The Brahmaputra waterway has overflowed the island for generations, but since the 1950's earthquake that struck Assam's Valley of the Brahmaputra, riverbank erosion has become a problem for the area and its Majuli peoples.Enormous measure of water and residue conveyed by the streamresults in continuous shifting of course. This river island faces massive erosion due to repeated channel movement. As a result, Majulishrunk to one-third of its original area (Sahay & Roy., 2016). This study assesses the land-use land cover changes inMajuli and the impact of spatial changes at the local level. To obtain this, we used multi-temporal remote sensing data for LANDSAT ETM 2010 and LANDSAT ETM 2020 obtained from the United States Geological Survey (USGS) and the primary data collected through fieldwork. The detection of land use change in Majuli for one decade was analysed by supervised classification, where seven land-use classes have been identified and analysed using Eradas Imagine software. The result shows changes in the agricultural land and forested area as well as built-up areas all over Majuli.

1. Introduction

Land-use and land-cover (LULC) change have become a fundamental and essential component in current strategies for monitoring environmental changes and managing natural resources (Rawat. et. al., 2013, Kumar. et. Al., 2014). Therefore, the knowledge of spatial land cover information is essential for the proper management, planning and monitoring of natural resources (Zhu, 1997). For example, LULC is the desired input for many agricultural, geological, hydrological and ecological models.

Also, any natural hazard study, such as landslide hazard zonation highly depends on the availability of accurate and up-to-date land cover information (Saha et al.,2005;). Land use and land cover change make Majuli more vulnerable to river bank erosion. After reviewing the existing conditions, this paper attempts to detect land use and land cover changes in the Majuli district of Assam. Due to the synoptic view, map-like format and repetitive coverage, satellite remote sensing imagery is a viable source of gathering quality land cover information at local, regional and global scales (Csaplovics, 1998; Foody, 2002).

The Brahmaputra River descends from a height of 2,450 m above mean sea level in the Himalayas to 135 m in Pasighat, the Indian state of Arunachal Pradesh, within a stretch of two kilometres (Sahay & Roy., 2016). As soon as the Brahmaputra reaches the plains, it is adjoined by the Dibang River in the north and the Lohit River in the south. However, the river does not have a well-developed drainage profile, like the rivers of peninsular India, and therefore, continuously changes its course. The Brahmaputra plains of Assam are one of the most flood-prone areas of the world. At the peak time of flooding, the Brahmaputra River became 18 to 20 km wide at the town of Dibrugarh, resulting in displacements of 2 to 3 million people every year (Hazarika, 2005). On average, floods affect more than 12 per cent of the total geographical area of the state every year (Goyari 2005; Sahay & Roy., 2016).

The Brahmaputra River in India has become an extensively braided river with numerous channels spinning around numerous midchannel and lateral sandbars, which are locally known as "chars" (Goswami 2008) or "chapooris" in Majuli. The Brahmaputra also ranks second after the Hwang Ho, or Yellow River, of China in terms of river sediment load. The heavy sediment load of the river Brahmaputra along with a near-flat gradient of 0.1 m/km near the city of Guwahati— makes the Brahmaputra highly vulnerable to flooding. Besides this, the Brahmaputra basin receives an annual average rainfall of 230 cm, which makes the flooding situation more vulnerable.

In 1950, the Brahmaputra valley was hit by an earthquake of 8.6 magnitude that raised the northeast section of the Brahmaputra valley by 3 to 4 meters and caused severe flooding in parts of Assam. Since after the earthquake, land along with the riverbank has been eroding at an increasing rate. During the 1920s, in Assam theBrahmaputra river occupied an area of 4,000 square kilometres but in 2008 its spread increased over more than 6,000 square kilometres (WRD 2008). Repeated change of courses by the Brahmaputra and the Luhit rivers resulted into loss of almost one-third to two-thirds of the earlier geographical area extent of the island. It came about into close to half of the all-out cadastral towns of Majuli i.e.107 out of 210 have been somewhat or entirely lowered in the stream. As per the data provided by the local administration, from 1960 to July 2014, around10,139 families have been moved, and a lot more are living as displaced people in camps.To look at all these changes in land use practices both at local and regional levels, satellite imagery helps as an imperative tool. Change Detection involves the application of multi-temporal satellite data to analyse it quantitatively and visualize the temporal variations. It is a principal tool to demonstrate the changes in land use, deforestation, disaster mapping, urban sprawl, change in the ecosystem, etc. (Das & Roy., 2019). In the present study, multi-temporal satellite images of LANDSAT ETM 2010 and LANDSAT ETM 2020 have been used to map the changing pattern of LULC in Majuli.

2. Materials and methods

2.1 Study Area

Majuli is one of the most populated stream islands on the planet, home to 167,304 people and covering an area of about 584 square kilometres (Census of India 2011). It is made up of aoutlet from the Brahmaputra, named asLuhit or locally called 'KherkuttiXuti', moves towards the north and covers a distance of about 100 km as a tributary stream, and finally drops into the Brahmaputra river near Golaghat district. Administratively, Majuli (Fig. 1) is categorized into 3 divisions locally called 'mauzas', namely, Salmora in the east, Kamalabari in the centre and Ahatguri in the west. Each of these mauzas are divided into panchayats. Finally, the panchayat is divided into individual villages.

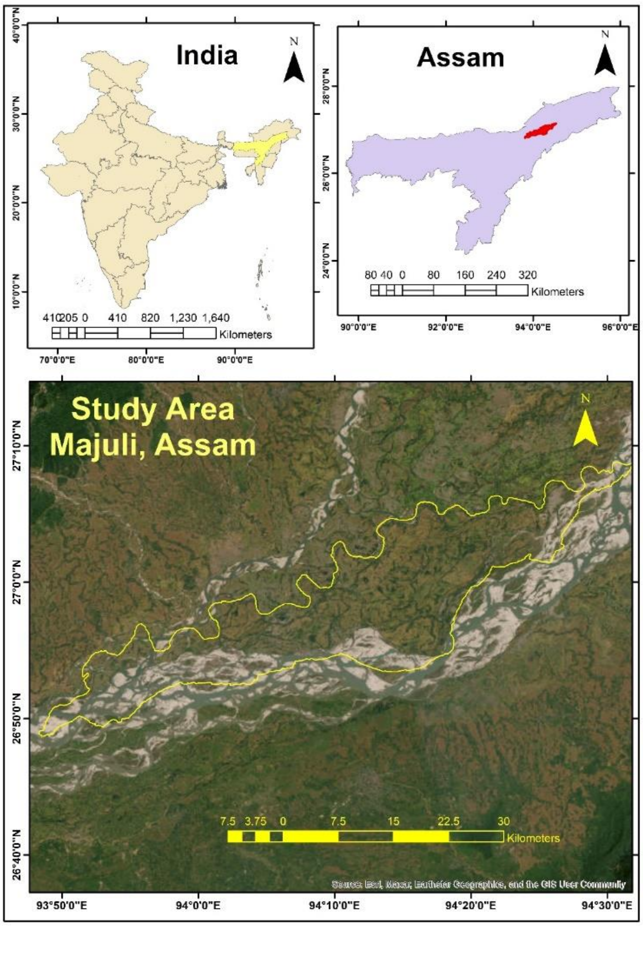


Figure 1: Location of Majuli, the background is based on Google Earth Imagery.

2.2 DataBase:

The present study used Landsat images of 2010 and 2020 (ETM+) collected from the website of Global Land Cover Facilities (GLCF). The LANDSAT (ETM+) multispectral image having 30 m spatial resolution, was used as the primary data to produce using the LULC map (Fig. 2). Whereas the Google Earth image, along with Toposheet, has been used for the generation of training and testing data sets. Detailed description of the data is given in Table 1.

Table 1: Remote sensing and other data Characteristics used in the study.

Year	**Data Type**	**Data Sources**	**Date of Acquisition**
2010 Pre-Period	LANDSAT (ETM+), Global Land Cover Facilities	United State Geological Survey (USGS)	13th October 2010
2014 Post Period	LANDSAT (ETM+), Global Land Cover Facilities	United State Geological Survey (USGS)	10th September 2020
2007	Topographic maps	Survey of India,	----------
2019	Field data on land use/land cover	Ground truth collected during the study	October 2019.

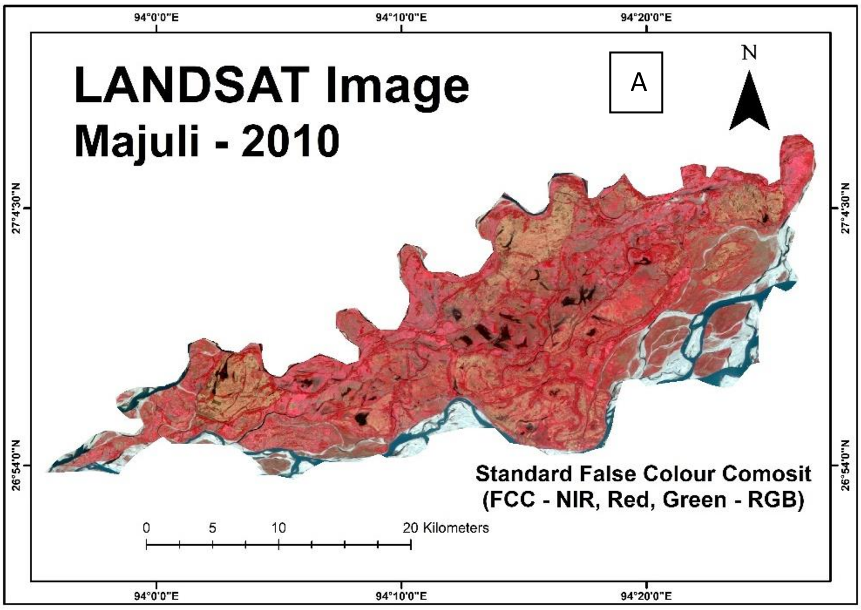
The preparation of reference data for the classification of the images was ably assisted by field surveys conducted during October 2019, which reflect the almost similar atmospheric and environmental conditions throughout the study area. Due to the inadequate road network and inaccessible due to the huge width of the mighty Brahmaputra River, the land cover was collected along the roads which were accessible and freight availability during the field surveys.

2.3 Methodology:

Image classification was done using various tools provided in GIS platform, which includes image mosaic, subset to Aoi, image classification, accuracy assessment and Change Detection. Arc GIS, and ERDAS Imagine software were used for processing of images. The processing steps are briefly described below.

2.3.1 **Pre-processing of satellite image**

The LANDSAT (ETM+) multispectral image (figure 2) was downloaded from the USGS portal. The boundary of Majuli was prepared using the command of Arc-GIS. The spectral data of the LANDSAT (ETM+) satellite were stacked and mosaic. Then the layer stacking of three bands for both time periods images was done, i.e. Green band, Red band, NIR band, for ease of understanding Green, Red, and NIR bandswere numbered as 1, 2, 3, sequentially. Therefore, the boundary of Majuli is used for sub-setting the spectral imagery. Finally, the layout map of classified images has been prepared using Arc-GIS.



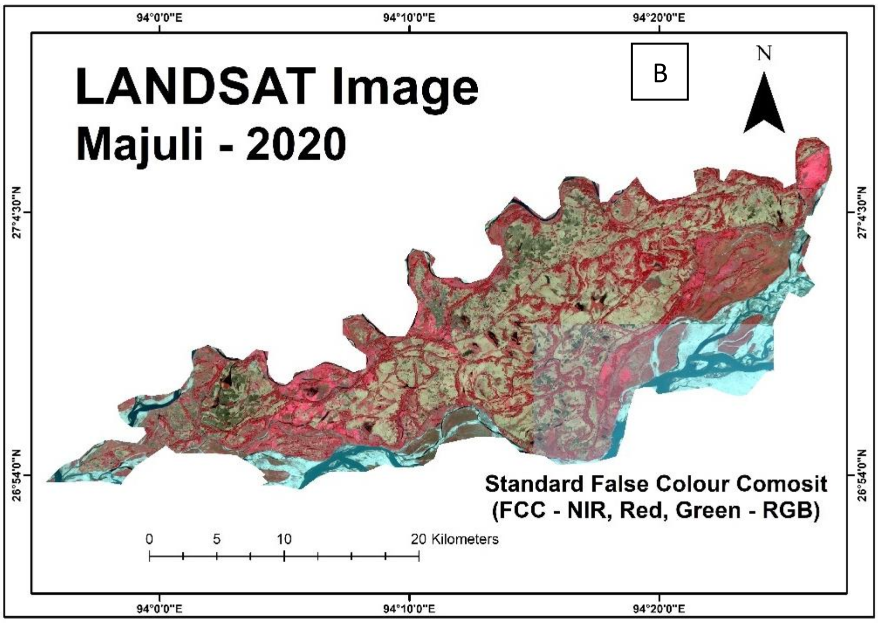


Figure 2: The Standard FCC NIR band, Red band and Green band in 2010(a) & 2010(b) of Majuli.

2.3.2 Image Classification

In this study, supervised classification of the Maximum Likelihood method has been used in Erdas Imagine. In remote sensing supervised classification is broadly being used which depends on information on information to be ordered. "These methods are often central to the image analysis process since these concerns the direct transformation from pixel counts to thematic map" (Wilkinson, 2000). The strategy for distinguishing obscure items utilizing the phantom information created from preparing information given by the investigatoris known as supervised classification. The task of obscure pixels to pre-laid out bunches is the result of the recognizable proof interaction.

When distributional data assumptions are met, MLC has been shown to be the most reliable and widely used classifier. This classifier is based on the decision process that assigns pixels with uncertain class membership to classes where such membership is most likely to occur (Foody et al., 1992). In this study, MLC has been used here to produce seven land cover classes i.e. Water Body, Vegetation, Build-up, Agricultural Land, Fallow Land, Barren Land and Sand Bar using band combinations of NIR band, Red band and Green band.

2.3.3 Preparation of training dataset

If statistical predictions are to be trusted in supervised classification, the percentage of the training data set is equally crucial. The training data must be representative of the location of the land cover classes being studied because the success of a classification rests heavily on their quality. The minimum training set size is typically advised to be 10–30 times the number of wavebands per class being used for classification (Mather, 1999; Piper, 1992). More user input is required when using supervised classification methods, particularly when gathering training data. In this study, the training data set consisted of about 1.52% in 2010 and 1.49% in 2020 of the total pixels in the LANDSAT (ETM+) image. The quantity of preparing tests for each LULC class were picked in relation to the area covered by the particular classes on the ground. The High spatial resolution Google Earth picture and geological guide were utilized as reference information (ground truth) to depict the preparation pixels on the LANDSAT (ETM+) image. To avoid confusion in identifying the classes, verification is done through the Google earth Image and, if accessed, then in the field.

2.3.4 Accuracy assessment and Field Observation

An irregular example of the testing pixels is picked for the sorted picture, and their class is contrasted and the reference information or ground truthing to survey the precision of the characterization.The selection of an acceptable sampling strategy and the calculation of an adequate sample size for testing data are crucial decisions in determining classification accuracy (Arora and Agarwal, 2002). In this study, information from Google earth Image, together with Toposheet and field visits, was used as reference data to generate a testing data set. A stratified random sampling method was applied for the generation of the testing pixel. For accuracy assessment, a sum of 200 testing pixels were picked, which is significantly more than the sample size of 100 to 150 pixels for each classsuggested by Congalton (1991).

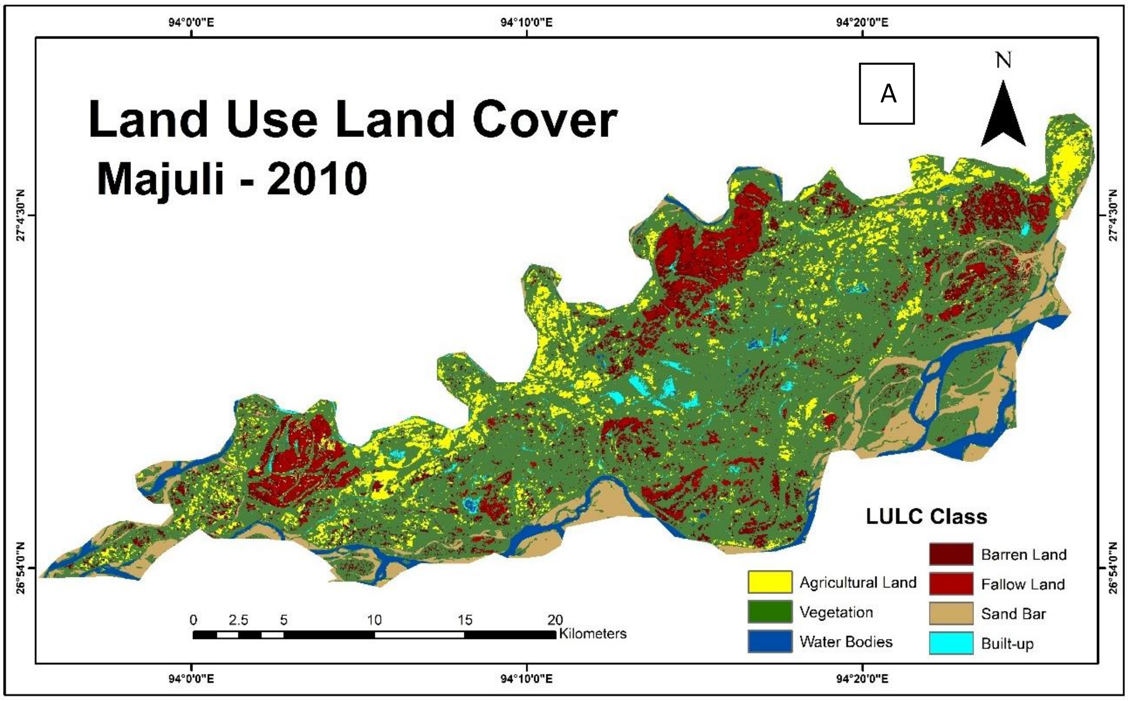
2.3.5 LULC change detection

Change Detection operation allows for two continuous raster images as input (Jensen, 1996). In the last few decades, many change detection methods have been developed viz; image differencing, post-classification change matrix, comparison technique and principal component analysis (Lu et al., 2004, Mishra et al., 2019). The change detection matrix illustrates the important information about the changes between LULC classes. Therefore, the change detection of the classified image between 2010 and 2020 was performed using change matrix tool in Eradas Imagine.

3. Result and Discussion

3.1 Image Classification:

In the visual comparison between 2010 and 2020 classified images (fig. 3 a & b) show that there is a profound change between various LULC classes on Majuli, which may be due to the expansion of the build-up areas as well as river flooding and erosion.



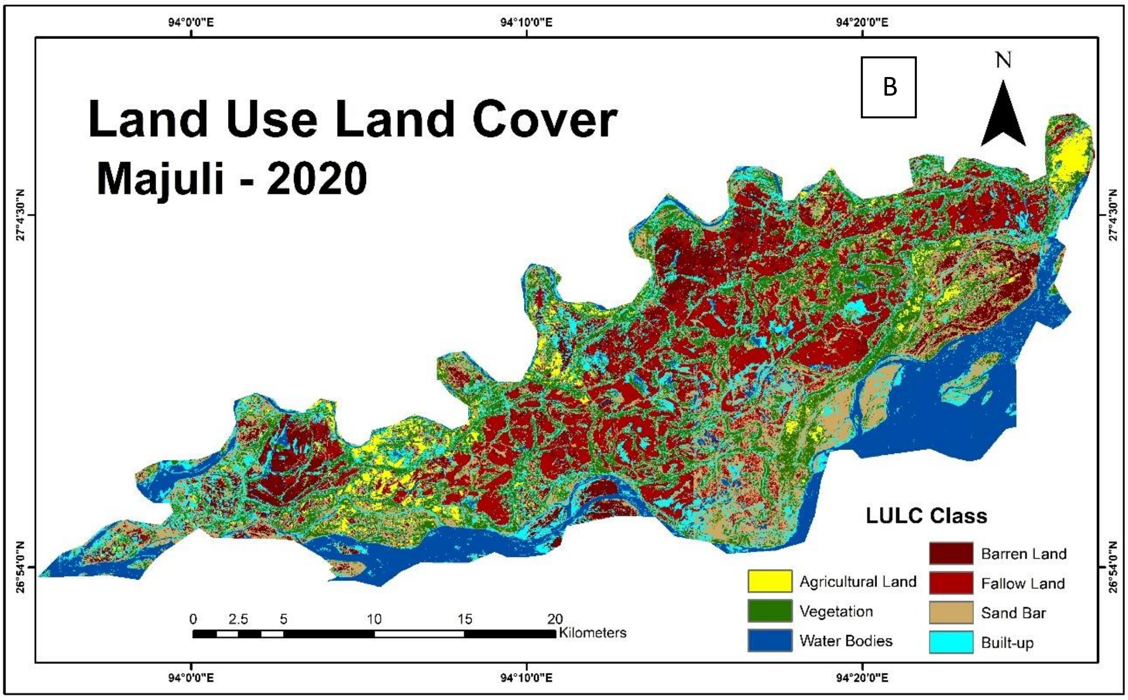


Figure 3: The LULC classification of Majuli in 2010(a) & 2020(b).

Table 2 indicates the areas changed in an area with their corresponding percentages between various LULC classes during the pre and post-period images, respectively. The results of the study duration between 2010 and 2020 indicate that major changes occurred between vegetation and built-up, where dense vegetation decreased to 17.66% from 55.45% whereas built-up increased from 1.04% to 14.58%. The post-period image of Majuli also reflects that agricultural land was reduced to 3.38% from 8.83% and resulted in an increase in fallow land to 21.40% from 9.38% during 2020 and 2010 respectively. Another major change was observed in the Barren land and Sand Bar classes. Barren land and sand bar have both increased from 8.07% and 13.19% to 11.95% and 15.64% respectively in the years 2010 and 2020 respectively.

Table 2: LULC of Majuli in 2010 and 2020.

Class	2010 (Pre period)	2020 (Post Period)
	Area (in %)	Area (in %)
water	4.05	15.39
Build-up	1.04	14.58
Agriculture Land	8.83	3.38
Fallow Land	9.38	21.40
Barren Land	8.07	11.95
Vegetation	55.45	17.66
Sand Bar	13.19	15.64
Total	100.00	100.00

3.2 Accuracy Assessment:

The overall accuracy of the classified image is 87.04% and 86.53% in the years 2010 and 2020, respectively, whereas the Kappa coefficient is 0.8529 and 0.8492 in the years 2010 and 2020, respectively. The producers and users' accuracy of the 2010 classified images ranges from 73% to 92.85% and 71.29% to 97.12%, whereas in 2020 it ranges from 71.83% to 94.28% and 78.91% to 97.76% respectively. The higher accuracy percentage is achieved for those classes whose pixels are distinct and the same class pixels are mixed-up.

3.3 Change Detection

The output result of the cross-tabulation change matrix for the change in percentage between different LULC classes in comparison with the total area of each LULC class from 2010 and 2020 is shown in Table 3. The values highlighted in bold letters indicate no change in LULC in corresponding categories for the duration of the study.

The result indicates vegetation experienced the highest conversion. During the field visit it was observed that the vegetation also included the grass land. The majority of the vegetation part (6.11%) is followed by a sand bar (5.04%), then converted into water body. The changes are observed in the field due to the wetland found in the region. During the Monson season, varying from July to September or October, the land is submerged by and after reducing the water level, it becomes either a sand bar or covered by grass. That's one of the reasons for fluctuations in vegetation class.

Table 3: LULC change Matrix between 2010 and 2020 as observed between Various LULC classes in Majuli.

		2010 (Data in %)							
	LULC Class	**Water Body**	**Build-up**	**Agricultural Land**	**Fallow Land**	**Barren Land**	**Vegetation**	**Sand Bar**	**Total**
2020 (Data in %)	**Water Body**	**3.17**	0.21	0.21	0.20	0.44	6.11	5.04	15.39
	Build-up	0.49	**0.29**	1.06	0.32	0.79	10.42	1.21	14.58
	Agricultural Land	0.00	0.01	**1.78**	0.04	0.15	1.39	0.00	3.38
	Fallow Land	0.01	0.01	1.26	**2.08**	2.75	10.26	5.04	21.40
	Barren Land	0.13	0.03	0.85	1.96	**2.18**	5.93	0.86	11.95
	Vegetation	0.08	0.29	1.76	4.10	0.32	**10.95**	0.17	17.66
	Sand Bar	0.17	0.20	1.91	0.67	1.44	10.39	**0.86**	15.64
	Total	4.05	1.04	8.83	9.38	8.07	55.45	13.19	100.00

Another major change observed in built-up the area increased from 1.04% to 14.58%, near about 10.42% of the vegetation converted into build-up. From the study it was observed that the growth in build-up area occurred in the central part of the island, which builds that people are moving towards centre because of riverbank erosion and flooding by Brahmaputra at the periphery of the island. Agricultural land was reduced by 5.45% and fallow land increased by 12.02% between 2010 and 2020 (Fig. 4), which is another major concern. Interviewing with the local people revealed that, due to flooding every year, people are least interested in agricultural practices and moving towards alternate livelihoods. The slight changes are observed between Barren land and sand bar where net changes observed at 3.38% and 2.45% respectively.

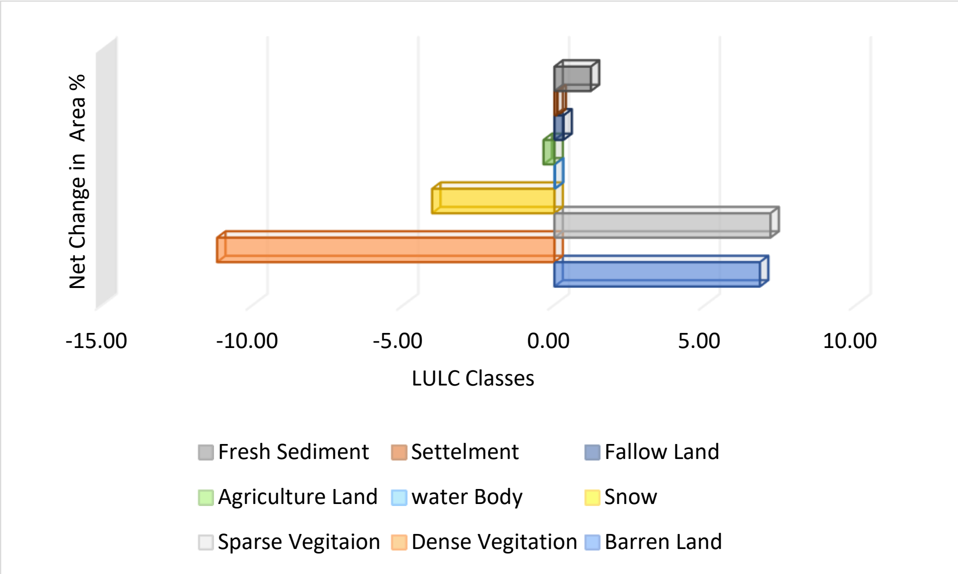


Figure 4: Net Changes in LULC classes of Majuli from 2010 & 2020.

Figure 5: Freight Transport (A) &NimatiGhat (B), Wet Land (C)& Squatter Settlement of Kuccha House (D),Handicraft Industry (E & F) of Majuli, Assam.

4. Conclusion

This study assessed the changes in LULC patterns in the Majuli of Assam using LANDSAT (ETM+) data from 2010 to 2020. For centuries, the Brahmaputra River has been shaping the economy and culture of Assam. The Brahmaputra can be rewarded as the lifeline of Assam. However, this life-giving river is also a precursor of disaster. Remote sensing image classification has proven to be a useful technique for extracting and monitoring LULC, thus helping in proper management and planning to achieve sustainable development. By comparing the changes in the land use pattern of Majuli, it's evident that the Brahmaputra has influenced the land use pattern in Majuli. The increased area of the sand bar also indicates the high level of riverbank erosion and sediment load on the Brahmaputra. One of the major notable points in this study is reducing the pattern of vegetation cover which, further leads to erosion. High-resolution satellite data is required to identify the grassland and vegetation cover more accurately, which is a major barrier to this study. The major significant changes in vegetation cover need immediate attention as Majuli is highly fragile to riverbank erosion. Another important change in land use is reducing agricultural land. Agriculture, which is the primary economic activity of the island, has been disrupted because of land loss by river erosion and flooding. The built-up area, which is also significantly increased in the central part of the island, is a major concern for administrators and planners. Finally, the changes in the land use pattern of the Majuli need to be monitored carefully as they may alter the geography, economy and culture of the Majuli.

References:

1. Arora, M K and Agarwal, K. 2002. A program for sampling design for image classification accuracy assessment. Photogrammetry Journal of Finland, 18(l), 33-43.
2. Congalton, R G. 1991. A review of assessing the accuracy of classifications of remotely sensed data. Remote Sensing of Environment, 3 7, 3 5-47.
3. Census of India 2011. District Census Handbook of Jorhat District. Retrieved from (http://www.censusindia.gov.in/2011census/dchb/1813_PART_B_DCHB_JORHAT.pdf), (http://www.censusindia.gov.in/2011census/dchb/1813_PART_B_DCHB_JORHAT.pdf).
4. Das, S and Roy, N. 2019. Land Use/Land Cover Mapping and Change Detection Using Satellite Data – A Case Study Of Guwahati City, Assam. Global Journal For Research Analysis, 10 (8), 121-123.
5. Csaplovics, E. 1998. High-Resolution space imagery for regional environmental monitoring — status quo and future trends. International Archives of Photogrammetry and Remote Sensing, 32(7), 211-216.
6. Foody, G M, Campbell, N A, Trodd, N M and Wood, T F. 1992.Derivation and applications of probabilistic measures of class membership from maximum likelihood classification, Photogrammetric engineering and remote sensing 58: 1335-1343.
7. Goyard, P. (2005). Flood damages and sustainability of agriculture in Assam. Economic and Political Weekly, 2723-2729.
8. Goswami, D. 2008. Managing the Wealth and Woes of the River Brahmaputra. Retrieved from http://www.indianfolklore.org/journals/index.php/Ish/article/download/449/51423
9. Hazarika, S. (2005). The Brahmaputra: muse, metaphor, source of life. India International Centre Quarterly, 32(2/3), 243-252.
10. Jensen, J R. 1986. Introductory Digital Image Processing: A Remote Sensing Perspective (New Jersey: Prentice-Hall).
11. Kumari, M., Das, A., Sharma, R. and Saikia, S., 2014. Change detection analysis using multi-temporal satellite data of Boba reserve forest, Assam and Arunachal Pradesh. International Journal of Geomatics and Geosciences, 4(3), pp.517-525.
12. Lu, D., Mausel, P., Brondizio, E., Moran, E., 2004. Change detection techniques. Int. J. Remote Sens. 25 (12), 2365–2401.

13. Mather, P. M., 1999, Computer Processing of Remotely-Sensed Images: An Introduction. Second Edition, Chichester: John Wiley and Sons.
14. Mishra, P.K., Rai, A. and Rai, S.C., 2019. Land use and land cover change detection using geospatial techniques in the Sikkim Himalaya, India. The Egyptian Journal of Remote Sensing and Space Science.
15. Piper, J., 1992, Variability and bias in experimentally measured classifier error rates. Pattern Recognition Letters, 13, 685-692.
16. Rawat, J.S., Biswas, V. and Kumar, M., 2013. Changes in land use/cover using geospatial techniques: A case study of Ramnagar town area, district Nainital, Uttarakhand, India. The Egyptian Journal of Remote Sensing and Space Science, 16(1), pp.111-117.
17. Saha, A K, Gupta, R P and Arora, M K. 2002. GIS-based Landslide Hazard Zonation in the Bhagirathi (Ganga) Valley, Himalayas. International Journal of Remote Sensing, 23(2), 357-369.
18. Saha A. K., Arora M. K., Csaplovics E., Gupta R. P., 2005, Land Cover Classification Using IRS LISS III Image and DEM in a Rugged Terrain: A Case Study in Himalayas, Geocarto International, 20 (2): 39-46.
19. Sahay, A., & Roy, N. (2017). Shrinking space and expanding population: socioeconomic impacts of Majuli's changing geography. Focus on Geography, 60-2.
20. WRD [Water Resources Department]. 2008. North Eastern Integrated Flood and Riverbank Erosion Management Project: Feasibility Study (PPTA, Phase II). Unpublished report of Water Resources Department.
21. Wilkinson, G. G., 2000. Processing and classification of satellite images. Encyclopaedia of Analytical Chemistry, Edited by R. A. Meyers. John Wiley and sons, 8679-8693.
22. Zhu, A X. 1997. Measuring uncertainty in-class assignment for natural resource maps under fuzzy logic. Photogrammetric Engineering and Remote Sensing, 63 (10), 1195-1202.