The Jahangirnagar Review: Part II: Social Science, Vol. 47, No. 1, 2023
ISSN : 1682-7422, ©Jahangirnagar University

Predicting spatio-temporal dynamics of LULC change for 2030 using multi-spectral temporal satellite imageries of Hatiya Island, Bangladesh

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Abstract: Anthropogenic and natural factors like population growth, urbanization, industrialization, transportation and communication, climate change, erosion, and deposition all contribute to changes in Land Use and Land Cover (LULC). However, it is increasingly essential to understand how land use and land cover have changed in order to manage and monitor development processes, particularly land use planning. As of late, a region's LULC change heavily relies on geographic information systems (GIS) and remote sensing for purposes of monitoring, assessing, and long-term planning. The study is concerned with the detection of LULC change of Hatiya Island and predicting the spatiotemporal dynamics of the changes using GIS and RS techniques. Therefore, Landsat TM and Landsat OLI satellite images of three distinct years 2010, 2015, and 2020 were analyzed using the maximum likelihood classification technique (MLC). The result reveals that most noticeable LULC changes among the major classes is the gradual depletion of agricultural lands and the transformation of waterbodies into built-up areas in the southern and northern part especially. In accordance with the study, between the years 2010 and 2020, built-up area, homestead vegetation, and mud flat or intertidal area increased by 6.06%, 9.98%, and 13.39%, respectively, whereas water bodies, vegetation cover, agriculture, and bare land decreased by 7.97%, 4.76%, 8.82%, and 24.70%, respectively. Hereafter, CA-Markov chain model was applied to predict the LULC of Hatiya for 2030 considering the current and previous trends of the dynamics of LULC. *Kappa* coefficient analysis was conducted to measure error matrix along with user's accuracy, producers' accuracy and overall accuracy whereas value of Cohen's kappa was calculated 82.07%, 83.65% and 82.36% in the years of 2010, 2015 and 2020 accordingly.

Keywords: LULC; Spatio-temporal dynamics; MLC; Cellular automata; Markov chain; and *kappa* coefficient.

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1. Introduction

Bangladesh is a land of diverse topographic features including rivers, hills, and huge floodplains. Island is one of the most unique and significant land features of the country. Among a number of islands, Hatiya is one of the offshore ones which lies in the lower Meghna estuary and undergoes severe geomorphological and demographic transformation every year (Ghosh et al., 2015). As Hatiya lies in the confluence zone of three prominent river systems Padma-Meghna-Jamuna, therefore a great amount of erosion and accretion occurs at different parts of the Island (Kumar and Ghosh, 2012). Remote sensing data examined that in recent years major erosion has occurred in the northern, the north-western and north-eastern parts of the island; whereas accretion has occurred in the southern part and south-eastern parts of the island. Both natural and anthropogenic actions have made the region highly vulnerable in terms of LULC change (Mahmood, 2018).

Land Use and Land Cover (LULC) change is a dynamic process of altering the distribution of land and its uses over time. Most of the time the term land use and land cover are used interchangeably (Yesuph and Dagnew, 2019). Land use refers to how people use the landscape environment for socio-economic activities like farming, business, housing, and recreational purposes, on the other hand, land cover refers to the actual physical landscapes of the earth’s surface, such as vegetation cover, soil, water bodies, marshy land, forestry, etc. (Rahman and Rahman, 2021). It is indispensable for understanding the dynamics of change, simulating and evaluating its consequences on human beings and the environment to know the changing pattern of LULC in an area (Chen. et.al. 2003). Furthermore, the management of natural resources and the observation of environmental changes heavily rely on LULC changing patterns (Zubair et al., 2006). The detection of (LULC) change is a scientific process of identifying various features which have changed within the passage of time (Alqurashi and Kumar, 2013).

Moreover, prediction of LULC aids researchers, planners, environmentalists, and economists to monitor land degradation, urban expansion, and shifting of agricultural (Adnani et al., 2019). Multi-temporal satellite imageries and Geographic information system (GIS) assist to estimate land use and land cover change along with chronological sequences (Hamad et al., 2018). Furthermore, CA-Markov chain model is a computer-based simulation system that helps to predict future LULC change by using the previous state of changing matrix with the advancement of Remote sensing (RS) and Geographic Information System (Tahsin et al. 2021). The physics-based hypotheses of Markov chain analysis indicate that if the previous LULC) changing trend is known, it is possible to calculate the likelihood that a system will be in a particular state at a given time (Hua, 2017).

The purpose of this study is to map the Hatiya Island's land use and land cover at distinct periods in order to identify the changes that occurred last 10 years. The study also aimed to predict the spatiotemporal dynamics of LULC change of Hatiya island of Bangladesh for 2030 using multi-temporal satellite imageries where CA-Markov automata chain model helped to predict the feasible changes of LULC for the year 2030. There are two specific objectives were set to attain the aim of the study. These are i) map the chronological changes in land use land cover from 2010 to 2020 using multi-temporal satellite imageries of Hatiya Island, Bangladesh; and, ii) predict the dynamics of LULC changes of Hatiya Island for 2030 using satellite imageries and the CA-Markov chain model.

2. Methodology

2.1 Selection of the study area

The study area determines the boundary of the research and the depth of the work. Considering environmental sensibilities, economic opportunities, and development strategies, Hatiya Island of Bangladesh is picked up as the area of study. Hatiya Island is located in the southern part of Bangladesh. Geographically it is located between 22º03´N to 22º25´N Latitude and 90º 58´E to 91º12´E Longitude. Hatiya Island is a part of Hatiya Upazila of Noakhali district of Bangladesh. The island is located in the northern Bay of Bengal at Meghna River's mouth. It is bordered by the Meghna River and Noakhali in the North, Bay of Bengal in the south, Monpura and Tajumuddin Thana to the west, and Sandwip of Chittagong district in the east (Ghosh et al., 2015). The approximate elevation of the island is about 2.5 meters from the mean sea level. Total area of the island is around 46,000 hectares or 480 square kilometers.

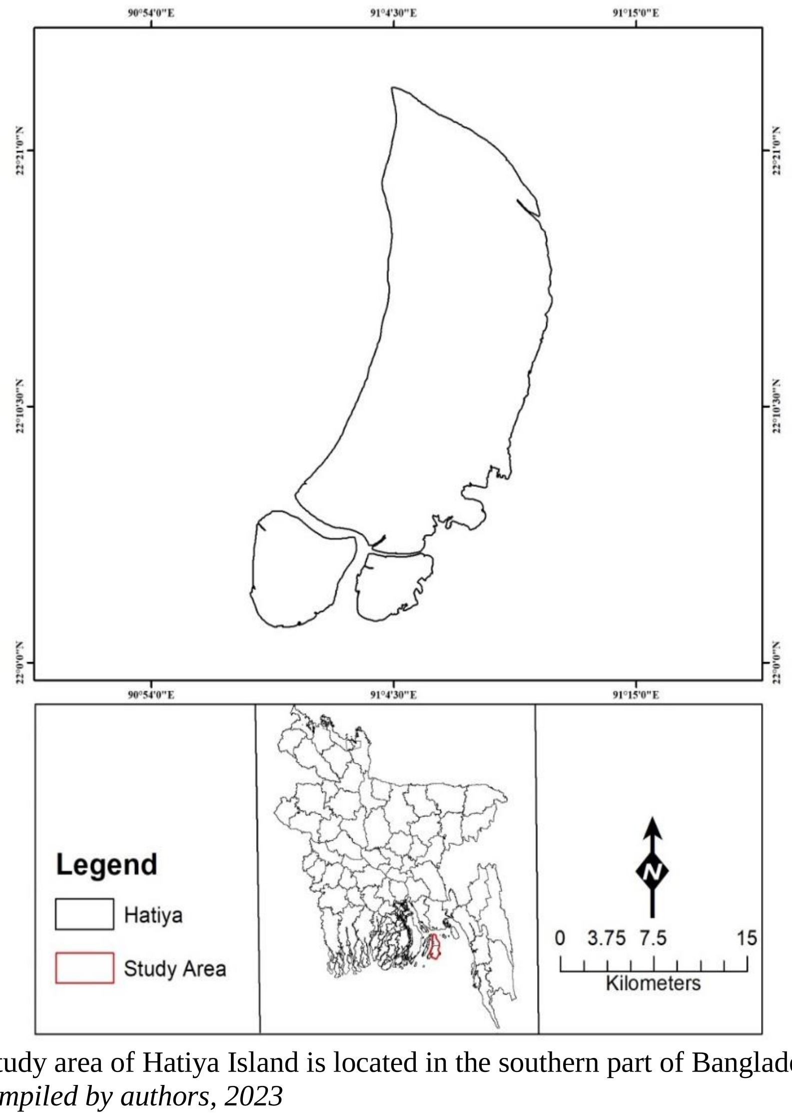

Figure 1. Study area of Hatiya Island is located in the southern part of Bangladesh, 2023
Source: Compiled by authors, 2023

The economy and livelihood of the island's people mainly depend on agricultural practices and fishing activities. The LULC change as well as coastline shifting is prevalent in Hatiya due to excessive Human intervention, coastal morphological behavior, and regular tides. According to IPCC (2014) Hatiya Island is marked as "key societal hotspots of coastal vulnerability."

2.2 Data sources

To ensure the quality of a research, it is crucial to focus on the source of data, reliability and technique of acquisition (Ngoy et al., 2021). Therefore, data was acquired from various sources such as primary and secondary in a sophisticated way (Akdeniz et al., 2022). The significant data needed for the study were basically acquired from field survey which includes questionnaires (sample size was 385 whereas the margin of error and confidence level are 5% and 95% respectively:), local people perceptions and FGDs (each groups consists 7 to 8 persons with almost same male and female ratio) whereas Landsat images were used as a secondary data source (Leta et al., 2021). Using supervised classification technique seven major classes of LULC were identified. The major classes were waterbodies, built up areas, vegetation cover, agriculture, mud flat or intertidal areas, homestead vegetation, and bare land (Roy and Farzana, 2015).

2.3 Data Acquisition

Satellite images of Landsat-5 TM and Landsat-8 OLI of three different years 2010, 2015, and 2020 were used in this study. Images were downloaded from the USGS Earth observation website (Table 2.1). The images were collected in a cold-dry period (from October to November) to avoid the effect of cloud cover. Considering the cloud cover and clearness, satellite data was acquired of these seasons which are more dependable to monitor Land use and land cover change of the island (Dewan and Yamaguchi, 2009).

Table 1. Properties of obtained Satellite Images from USGS in different years of Hatiya island, Bangladesh

Satellite Sensor	Acquisition Year	Acquisition Date	Resolution	Path and Row	Cloud cover
Landsat-5 TM	2010	11/10/2010	30 Meter	136/45	≤5%
Landsat-8 OLI	2015	16/10/2015	30 Meter	136/45	0%
Landsat-8 OLI	2020	05/11/2020	30 Meter	136/45	0%

Source: Compiled by authors, 2023

2.4 Image Classification

The satellite images were classified using the technique of supervised classification. Ground truth data were acquired for the classification of image (Leta et al., 2021). The statistical properties of the pixels gathered for each class selected by the user were taken into consideration while classifying images using the supervised classification technique. For assessing land use change, the maximum likelihood classification (MLC) technique was applied (Akdeniz et al., 2022).

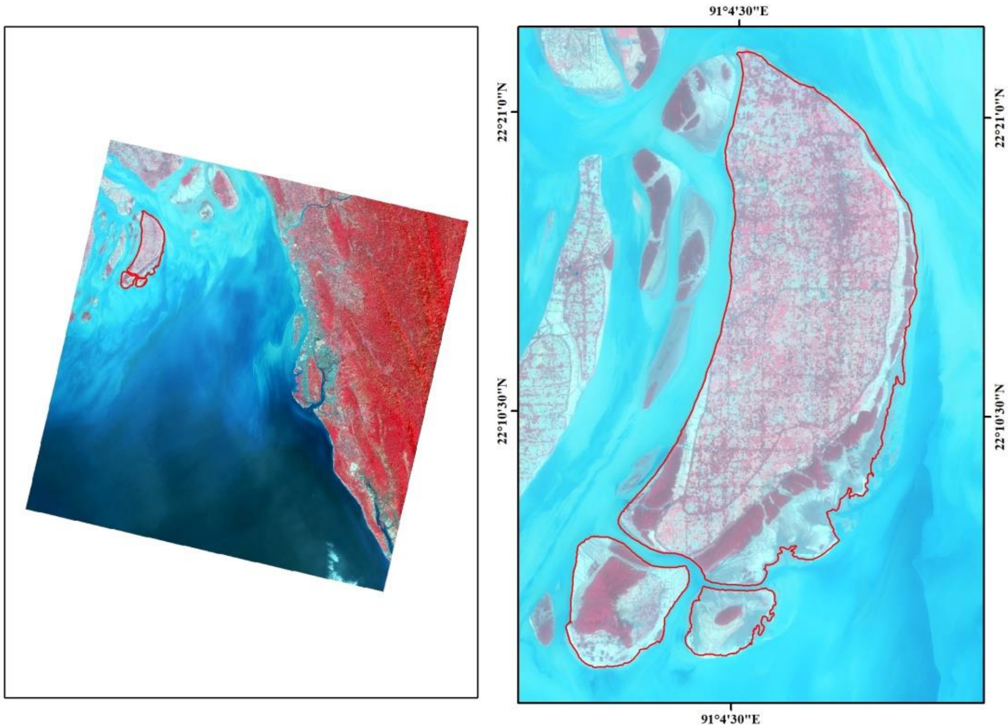

Figure 2. Multi-spectral time series imageries from USGS of Hatiya Island from 2010 to 2020

Source: Compiled by authors; using USGS Satellite imageries, 2023

The MLC method is based on the idea that the determined classes should have equal probability curves, and that the pixels should be categorized into the class with the highest probability (Leta et al., 2021). Reference data were obtained from Google earth for classifying the images of 2010, 2015, and 2020 (Wang et al., 2020). ERDAS Imagine 2015 and ArcGIS 10.6 software were used to accomplish the classification technique. Training samples were taken from the composite image and Google earth for distinct land use/ land cover classes. For image classification, verification, and validation the training Samples were used.

Table 2. Description of Land Use/ Land Cover (LULC) classes of Hatiya Island, Bangladesh.

LULC Class	LULC Features of the class
Waterbodies	Source of water including rivers, ponds and lakes.
Built up areas	Built-up areas include residential areas, commercial and industrial buildings, transport networks, and mixed urban areas.
Vegetation cover	Herbivorous plant communities including grasses and forbs. Afforestation of salt-tolerant mangrove plants and trees. Shrub lands and semi-natural vegetation: deciduous, coniferous, and mixed forest, palms, orchards, herbs, climbers, gardens, etc.

LULC Class	LULC Features of the class
Mud flats or intertidal areas	Zone to tidal flats which are submerged during high tide. The soil type is very clayey and moisturized.
Agriculture	Lands are under cultivation which is either in single cropping or multiple cropping.
Homestead vegetation	Residence of the people of rural, semi-urban, and urban areas with homestead vegetation.
Bare land	Land of exposed soil or barren soil which is in no use currently.

Source: made by authors; using USGS Satellite imageries, 2023

2.5 CA-Markov model for LULC change prediction

Considering the homogenous land use and land cover categories and same sequential thematic raster images are input into the IDRISI Selva software, where it is presented as a .txt file and used to simulate spatiotemporal changes for future developments using a Markov Chain model (Sabree Ali et al., 2020). In this study, the probability of changing each LULC category to another form through a transition probability matrix for Markov for the periods between 2010 and 2020 is examined (Eastman, 2012). The CA-Markov model for the targeted year 2030 was validated by assuming two targeted years 2010 and 2020. The Markov process creates a transition probability matrix of LULC change beginning from the time one to time two to forecast the future state of a system based on the previous state. It demonstrates the type of changes and serves as the foundation for predicting future growth (Adegbola and Adewumi, 2021). This transition from one state to another is explained by transformation probability explained below as:

$$P=P_{ij}=\begin{vmatrix} P_{11} & P_{12} \ldots\ldots & P_{1n} \\ P_{21} & P_{22} \ldots\ldots & P_{2n} \\ P_{31} & P_{32} \ldots\ldots & P_{3n} \\ P_{41} & P_{42} \ldots\ldots & P_{4n} \end{vmatrix} \quad (1)$$

Here, P represents probability from one state to another state and equation- (1) Must meet the following two other conditions.

$$\sum_{j=i}^{n} P_{ij} = 1 \quad (2)$$

$$0 \leq Pij \leq 1 \quad (3)$$

Obtaining a primary matrix and transition probability matrix (P_{ij}) is a major step in Markov model. Hence, the Markov forecast model is expressed as stated in equation 4.

$$P_n = P(n-1).p_{ij}(0)P_{ij}^{\ n} \quad (4)$$

Here, P_n represent the state probability and $P_{(0)}$ represents primary matrix (Adegbola & Adewumi, 2021).

2.6 Data verification and accuracy assessment

In this study, for the verification of data cross-validation method was applied (Hussain et al., 2022). The checkpoints of the reference data were used to make cross-validation in google earth pro software. An effective and appealing source of positional data, google earth pro is highly utilized for research and initial investigations with enough precision (Mishra et al., 2020). An error matrix was measured from the samples evaluated in google Earth pro software. After that the producer's accuracy, user's accuracy, overall accuracy, and *Kappa* coefficient were calculated from the error matrix table. (Yesuph and Dagnew, 2019). The formula of Cohen's kappa coefficient (Hua, 2017): $K = \frac{PO - Pe}{1 - Pe}$,

Where, *K*= Kappa Coefficient; *PO*= relative observed agreement among raters; and *Pe*= the hypothetical probability of chance agreement.

3. Results and discussions

3.1 LULCC from 2010 to 2020

Integrated approaches like GIS and RS are used to detect LULC changes to carry vital information of the study area. However, analysis of satellite imagery delineates that in the year 2010 agricultural land, homestead vegetation, built up area and mud flat or intertidal areas consisted 22,016.57, 10,314.26, 1,242.33 and 6,343.19 hectors respectively. Following the demonstration of satellite image of 2020, remarkable changes (LULC) has happened within the last 10 years. In the year 2020, agriculture was recorded 20,075.43 hectors, homestead vegetation 11,343.52 hectors, built up area 1,317.56 hectors and mud flat or intertidal area was calculated 7,192.33 hectors.

Table 3. Temporal distribution of LULC class in hectors along with percentages of the Hatiya Island, Bangladesh.

Category of LULC	Year 2010		Year 2015		Year 2020	
	Area (Hectares)	Area (%)	Area (Hectares)	Area (%)	Area (Hectares)	Area (%)
Water bodies	685.66	1.47	878.15	1.91	740.31	1.59
Built up Areas	1,242.33	2.66	1,263.87	2.75	1,317.56	2.84
Vegetation Cover	5,817.48	12.47	4,986.59	10.86	5,540.28	11.95
Mud Flat or Intertidal Areas	6,343.19	13.59	7,033.42	15.31	7,192.33	15.31
Homestead Vegetation	10,314.26	22.10	10,692.86	23.28	11,343.52	24.45
Bare Land	249.60	0.53	237.21	0.52	187.96	0.40
Agriculture	22,016.57	47.18	20,842.8	45.37	20,075.43	43.27
Total	**46,669.09**		**45,935**		**46,397.4**	

Source: made by authors, 2023; using USGS Satellite imageries

Hatiya island lies in the estuary of lower Meghna river which is also the agglomeration zone of three mighty river system (Kumar and Ghosh, 2012). Therefore active force from river discharge hits the northern part of the island and results continuous erosion. On the other hand regular tides, coastal morphology and anthropogenic activities also impact the erosion process (Kabir et al., 2020) of the island. Besides dominant erosion in the northern and north-eastern part of the island, remarkable accretion has noticed in the southern and south-eastern part of the island. Due to enormous amount of accretion mud flat or intertidal areas have increased whereas mangrove plantation and built up areas also developed (Ghosh et al., 2015). Active erosion and accretion has also impacted cultural factors of LULC change in Hatiya.

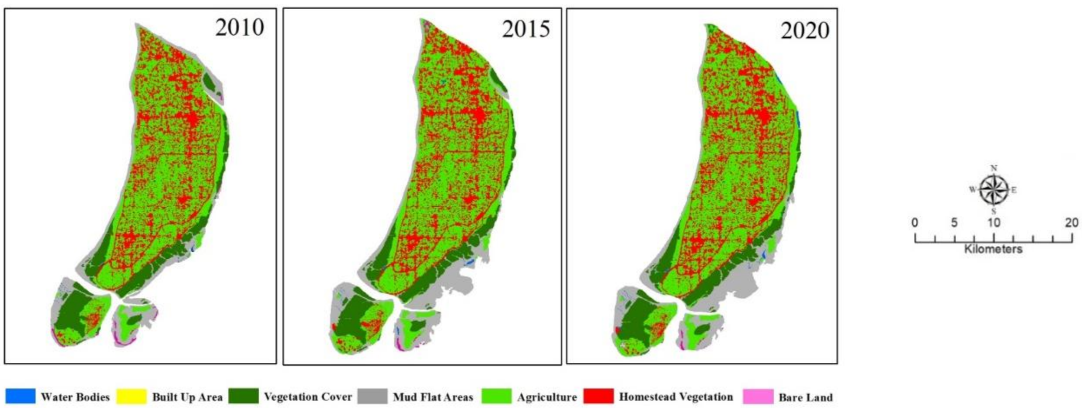

Figure 3. Land use and land cover changes using multi-spectral time series imageries from USGS of Hatiya Island from 2010 to 2020
Source: Compiled by authors, 2023; using USGS Satellite imageries

Table 4. Analysis of Land use and land cover change in Hatiya Island from 2010 to 2020, Bangladesh

LULC Category	Changes in area (Ha.)			Changes in area (%)		
	2010 to 2015	**2015 to 2020**	**2010 to 2020**	**2010 to 2015**	**2015 to 2020**	**2010 to 2020**
Water bodies	+192.49	-137.84	+54.65	+28.07	-15.6	-7.97
Built up Areas	+21.54	+53.69	+75.23	+1.73	+4.25	+6.06
Vegetation Cover	-830.89	+553.69	-277.2	-14.28	+11.10	-4.76
Mud Flat or Intertidal Areas	+690.23	+158.91	+849.14	+10.88	+2.26	+13.39
Homestead Vegetation	+378.6	+650.66	+1029.26	+3.67	+6.09	+9.98
Bare Land	-12.39	-49.25	-61.64	-4.96	-20.76	-24.70
Agriculture	-1173.71	-767.43	-1941.14	-5.33	-3.96	-8.82

***Note: (+) sign represents the increasing rate and (-) sign represents decrease rate
Source: Compiled by authors, 2023; using USGS Satellite imageries

The present study shows that both physical and cultural dynamics has influenced the LULC change of Hatiya (Kumar and Ghosh, 2012). Here, natural processes like erosion, transportation and deposition of earth materials and socio-economic factors including rapid population growth, heavy industrialization and land shifting have impacted the LULC change. Analysis of multi-temporal satellite imageries shows that erosion was dominant in northern part and deposition was found in both southern and south-eastern part of the island (Mahmood, 2018). During the interval of 2010 to 2020 overall decreases of water bodies, vegetation cover agriculture and vegetation cover were estimated.

3.2 Dynamics of LULC change of Hatiya Island

Dynamics of land use and land cover change of Hatiya includes physical, cultural, economic and political factors mainly. The effectiveness of the dynamics is unequal in different parts of the island. For instance urbanization and settlement is growing rapidly in the central and southern parts whereas mangrove plantation and agricultural boom is noticed in the southern and south-eastern part of the island. Hatiya is an area of overpopulation and the rate of population growth is also high. According to the census of 1991 the population of Hatiya was estimated 295,501 which increased in 2001 and 2011 largely.

Table 5. Population of Hatiya in different censuses of Bangladesh.

Population Census (Year)	Number of Population	Male	Female
Census 1991	2,95,501	150705	144796
Census 2001	3,41,176	174640	166536
Census 2011	4,52,463	2,23,853	2,28,610

Source: National Encyclopedia of Bangladesh, 2023

The growth of population has had a great impact on LULC change of Hatiya. Within the years 1991 to 2011 there was growth of 1,56,962 which is approximately 53% more than 1991. According to the housing census 2011 the annual growth of population was 2.8% in Hatiya. The growth of population needed more food and housing. To fulfill the necessity of Housing and other economic activities lands covered by vegetation/Agriculture/ water bodies are altered to Homestead vegetation or built up areas (Mdemu et al., 2016).

Urbanization is also ascertained as one of the most influential anthropogenic process which has caused loss of arable lands, decline of water bodies, abatement of natural vegetation and destruction of habitats (Clarin et al., 2021). Increased economic productivity, employment prospects and an increase in tourism triggered the expansion of urban area (Kumar & Ghosh, 2012). Along with Urbanization, Infrastructural improvement (construction, Road networks, Electrification) recorded as key stipulations of development. A large number of Mega projects have been implemented in Hatiya which have impacted the (LULC) change of the island directly or indirectly. Among a number of projects “Hatiya Island solar and wind power generation system” impacted LULC alteration. As a result 12 families lost their housing and arable lands encompassing 24,969 square meters. On the other hand, due to 15 megawatt heavy fuel oil-based power plant project 23 families and total 127 people lost their cultivable lands (Hoque et al., 2020).

Tourism is one of the fast growing industries of the country. Besides other ecotourism sites Hatiya is recognized as one of the most potential region. Last few years due to rigorous demand the tourism sites of Hatiya have expanded significantly. Among a number of sites Nijhum Dwip, Rahmat Bazar Ghat, Sunflower Sea Beach, Island

Development Agency Park, Shipboard, and Domar Chor have been evolved as tourist zones. In demand of road network, infrastructures, and different amenities for tourism, agriculture lands, bare soils and vegetated areas were altered (Lodge & Nujhum, n.d.). To protect Bangladesh's coastal residents from cyclones and storm surges, mangroves have been planted along the island's coastline. Some of the mangroves have been cleared for development during the last several years. It has been estimated that losses of 1,024 hectares of mangrove forest, from 1989 and 2018, 395 ha were replanted. Net forest cover change in the 2000s was 425 ha. The drivers or dynamics can be shown in order according to their activeness and significance which is shown below in the significance triangle (Figure 4).

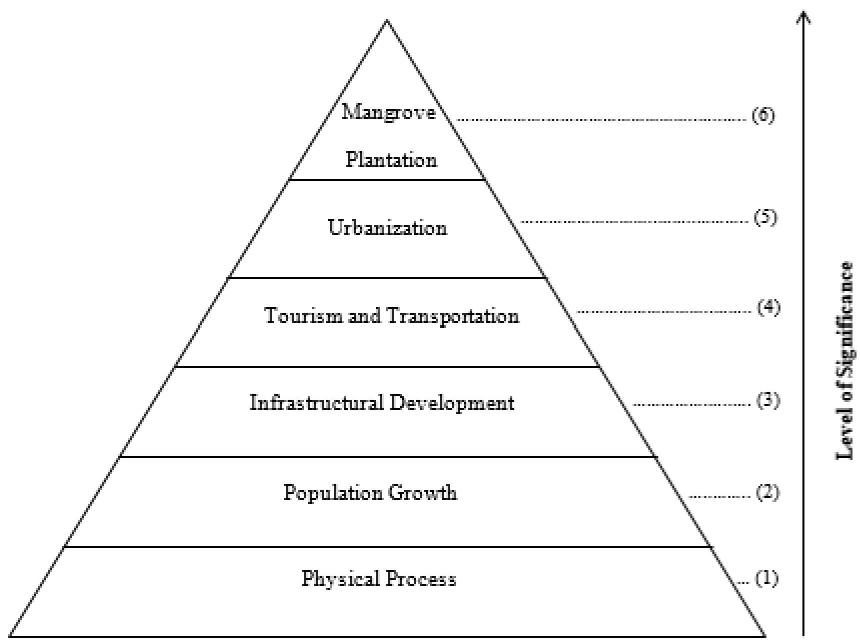

Figure 4. Dynamics of Land Use and Land Cover (LULC) changes of Hatiya island, Bangladesh, 2023
Source: Compiled by authors, 2023; using local people perceptions acquired from questionnaire suyvey, 2022.

3.3 Predicting LULC changes for 2030 using CA-Markov chain model

Scenario 1: Prediction of LULCC for 2010 to 2030

Using classified LULC maps of 2010 and 2030, CA-Markov chain model examined the gains and losses experienced by various classes of Hatiya island. Using probability matrix of different multispectral imageries, prediction of LULC for 2030 is developed. In the first scenario, from 2010 to 2030, the LULC undergoes a significant transformation during a time of rapid urbanization and economic growth. The predicted figure 5 (A and B) using equation 1 to 4 provides that waterbodies will be decreased by 5.32%

encompassing an area of 36.48 hector; vegetation cover will be decreased by 8.47% with an area of 492.70 hectors and agriculture land is prone to be reduced by 6.35% covering an area of 1398.05 hector. The prediction probability also indicates that built up area, homestead vegetation and mud flat or intertidal area will be increased by 14.46%, 7.58% and 1.59% respectively containing an area of 179.64, 781.82 and 100.85 hectors respectively.

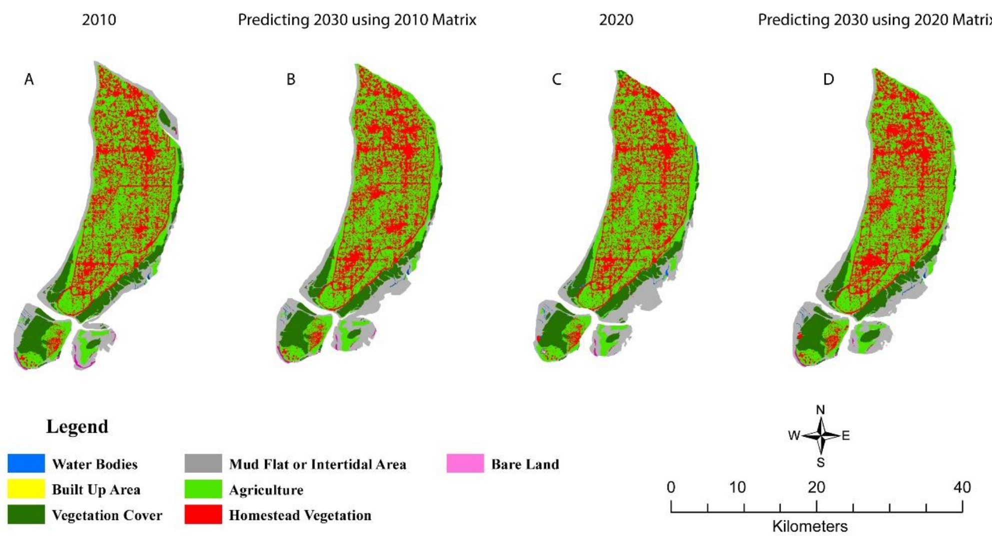

Figure 5. Predicting of Land Use and Land Cover (LULC) changes of Hatiya Island, Bangladesh, 2030 using different matrix.
Source: Compiled by authors, 2023; using CA-Markov chain model

Scenario 2: Prediction of LULCC for 2020 to 2030

In the second scenario for the year 2020 to 2030, using equation 1 to 4, the predicted figure 5 (C and D) describes that waterbodies will be decreased by 6.28% covering an area of 46.49 hectors; vegetation cover will be decreased by 7.81% covering an area of 432.70 hector and agricultural land by 5.37% covering an area of 1078.05 hector. Besides depletion of waterbodies, vegetation cover and agriculture, build up area, homestead vegetation and mud flat intertidal areas will be increased by 12.87%, 6.43% and 2.21% respectively encompassing an area of 169.60, 729.39 and 157.56 hectors.

4. Accuracy Assessment using Kappa Statistics

This could be happened because of the quality of satellite imageries where the accuracy got reduced due to errors in sampling. Moreover, a reduction in picture spatial resolution leads spectral mixing across several categories, which affected the samples of various land cover types. However, the overall accuracy of all the categorized satellite imageries were greater than 82.06%%. The range 81%-99% (Kumar and Ghosh, 2012) meet almost perfect agreement according to Cohen's interpretation approach, which strongly suggests the acceptance of the classified outcomes.

Table 6. Error matrix for 2010, 2015 and 2020 Landsat image, Hatiya Island, Bangladesh

LULC Category	2010 (Landsat 5TM)		2015 (Landsat 8 OLI)		2020 (Landsat 8 OLI)	
	Producer's Accuracy	User's Accuracy	Producer's Accuracy	User's Accuracy	Producer's Accuracy	User's Accuracy
Water bodies	83.05%	82.61%	86.57%	84.47%	81.07%	82.37%
Built up Areas	80.32%	81.57%	78.92%	86.69%	80.38%	79.57%
Vegetation Cover	82.74%	84.14%	81.24%	81.15%	78.84%	83.49%
Mud Flat or Intertidal Areas	80.33%	83.38%	86.58%	80.43%	82.35%	84.44%
Homestead Vegetation	83.91%	80.84%	801.76%	84.73%	85.16%	81.92%
Bare Land	86.22%	81.62%	85.85%	77.28%	85.32%	83.04%
Agriculture	79.54%	82.48%	83.64%	88.48%	84.87%	81.54%
Overall Accuracy	82.33%		83.34%		82.45%	
Overall Kappa	82.07%		83.65%		82.36%	

Source: Made by authors, 2023; using sample size of each features collected through googole earth and GPS survey.

The table 6. reveals the result which are obtained from the classified map of Landsat 5 TM and 8 OLI images where a total of 3,182 pixels were randomly selected for *2010,2015 and 2020* and checked using Google Earth images and local knowledge of the area. From the data table 6, an overall accuracy for 2010,2015 and 2020 are respectively 82.33%, 83.34%,82.45% and kappa coefficient are obtained 82.07%,83.65%, 82.36% .

5. Conclusion and Recommendations

Results recommends that significant changes in land cover happened during the study period in Hatiya Island. Both natural actions and human intervene played vital role to bring significant changes of LULC of Hatiya Island. According to research, the island's northern, north-eastern, and southern regions had experienced greatest amount of land alterations, where significant morphological change had taken place as a result of the island's rapid population growth and accelerated urbanization. During the study period waterbodies, vegetation cover, agriculture and bare soil classes had decreased by 7.97%, 4.76% 8.82%, and 24.70%, respectively. Despite the overall loss of such features built up area, homestead vegetation and mud flat of intertidal area rose by 6.06%, 9.98% and 13.39% respectively. Among the LULC classes Agriculture and vegetation cover are mostly vulnerable of reduction as CA-Markov model suggests that within the year 2030 they can be reduced by 5.37% and 7.82% correspondingly. The study has shown that homestead vegetation cover has also augmented to facilitate growing population and their settlement. Road network and communication system also consume arable lands and natural resources. Although bare land comprises a little portion of the LULC but they have also altered to arable lands or housing purposes. Therefore, the outcome of the study suggests that migrated population, urban planning, and mega projects should consider the LULC change to mitigate the land feature degradation.

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