The Dhaka University Journal of Earth and Environmental Sciences, Vol. 8, 2019

Md. Sofi Ullah[1*]
Tarulata Shapla[2]
Md. Amran Hossain[1]
Md. Hasibul Hasan[1]

Delineating Agricultural Landuse Change using Geospatial Techniques and Markov Model in the Tarakanda Upazila of Mymensingh, Bangladesh and Future Prediction

Manuscript Received: 12 May 2019
Accepted: 30 October 2019

[1]Department of Geography and Environment, University of Dhaka, Dhaka 1000, Bangladesh

[2]Department of Agroforestry and Environmental Science, Sher-e-Bangla Agricultural University, Dhaka 1207, Bangladesh

**Corresponding author*
Email: sofiullah.geoenv@du.ac.bd

Abstract: *The study aims at detecting agricultural landuse change and its prediction by using the Markov model in Tarakanda Upazila of Mymensingh District during 1989-2018 which is one of the most fish farming dominated areas of Bangladesh. Therefore, agricultural landuse is converted to the fish farming sector as well as other sectors. In such a situation the study intends at identifying agricultural landuse shifting to various sectors from 1989 to 2018 and predicting it for the year of 2026 as a future vector of the Markov model. The study was conducted using multispectral data from Landsat imageries. The imageries for the years of 1989, 2000, 2010 and 2018 were collected from Landsat 4-5TM and Landsat 8 OLI-TRIS. Maximum likelihood classification and supervised classification were applied to detect landcovers of the study area. The study showed that in 1989, there was 58.55% of agricultural land, but it stood at 46.65% in 2018. About 11.9% of agricultural land has also decreased during 1989-2018. Therefore, yearly about 0.4% of agricultural land has decreased from 1989 to 2018. The predicted data shows that about 2.96% of agricultural land will be decreased from 2018-2026, hence, about 0.37% of agricultural land will be decreased in the near future in the study area. As a fish farming dominated area, the water body of the Tarakanda Upazila has increased by about 0.18% per year, similarly, other sectors have decreased at 0.21 percent per year. Therefore the landuse change dynamics should be considered seriously for future planning.*

Keywords: *Geospatial, Supervised classification, Unsupervised classification, Maximum likelihood classification, Markov probability matrix*

Introduction

Landuse/landcover change is crucial for further discernment of changing landscape during a certain time; it is also a widely used technique, mostly by natural development and man-made activities (Ruiz-Luna and Berlanga-Robles, 2003; Turner and Ruscher, 2004). Agricultural land shifting and changing landuse patterns can be caused due to several reasons which can result in landcover changes; the landcover change can affect diversity, water/solar radiation budget etc. that all together, affect the climate (Riebsame et al., 1994). The major causes of increasing land use and landcover change include high economic and population growth, urban development and climatic impact (Uddin and Gurung, 2010).

Remote Sensing (RS) and Geographical Information System (GIS) have been used together to enlarge the selection of agricultural and urban areas in a particular region (Selcuk et al., 2003); remotely sensed data can provide an efficient and affordable way to analyze landcover changes (Kachhwala,1985) in combination with GIS, it can acquire a better way to analyze and improve data (Chilar, 2000). Also, remote-sensing is widely used to update LULC maps/mapping (Lo and Choi, 2004).

Satellite data are useful to detect landuse and landcover change (Yuan et al., 2005; Brondizio et al., 1994). The approach of satellite imagery with a high spatial resolution and advanced image processing with GIS has made observing and creating landuse-landcover (LULC) patterns more conductive. The Landsat-TM has been representing a constant record of the earth's surface from the last three decades (https://glovis.usgs.gov, 2014). Agricultural crops have a higher reflectance of the spectral signature. Pertinent to this condition, multispectral remote sensing plays an important role as a tool for monitoring and estimating agricultural landuse and cover because it can provide earlier information than conventional landuse mapping methods.

Rahman (2011), prepared a country report for Bangladesh where it is stated that climate is an important factor in agriculture and climate change has greatly influenced agricultural production and agriculture pattern change. As one of the ancient activities, agriculture is a common source of employment for the rural parts of Bangladesh and also plays a key role in its socio-economic development. The country's progress in terms of economy is also dependent on its progress towards agriculture which is characterized by paddy cultivated in most areas. Furthermore, agricultural land is composed of cropped land, current fallow and lastly, culturable waste on which, the rate of changing agricultural to non-agricultural land is 1% for every year (Planning Commission, 2009) which is a risk factor for crop production in total and food security in Bangladesh perspective (Rahman and Hasan, 2003).

Food security caused by currently talked about issues related to climate change is affecting people in Bangladesh since it is prone to climatic risks. Recently, there has been an international argument about land sharing (the combination of ecological and economic goals on the same area) against land saving (dividing lands committed to protecting comprehensive agriculture) (Perfecto and Vandermeer 2010; Phalan et al., 2011). The cultivation shifting with different activities are broadly known to be inconsistent with biological diversity (Kramer et al., 1997; Struhsaker, 1998; Terborgh, 1999). If complex landuse patterns are maintained, performances of landscapes and the diversity of livelihoods can be built upon in order to upgrade rural communities (Wilson, 2010).

Being densely populated, Bangladesh contains only 12.5 decimals/capita of cultivated land (BBS, 2011). However, the landcover is constantly changing and agricultural land is decreasing due to infrastructure, homestead and anthropological demands where available agricultural land has been abstaining at 1%/year for the last 30~40 years (Planning Commission, 2009). Issues that are related to landuse/landcover include drainage, change in forest cover, degradation of soil in croplands etc. (Lambin et al., 2003). In terms of urban growth, for 2001 to 2011, Bangladesh was ranked 4th and had a rate of 4.8% for 2000 to 2011 (Hasan et al., 2013) where one of the important issues of food security is caused by the increasing population and abstaining rate of agricultural land per capita.

Bangladesh is also a rural country because of the fertile soil that is best for growing different crops throughout a year (BBS, 2015) and also has the potential for agricultural practices; approximately 60% of the land is also present for cultivation. Farmers have opted for intensive and distinct agricultural techniques including high-yield crop diversity because of the reduction of agricultural land. It is observed that in 2006, the cropping intensity elevated by 4% (Rahman, 2010) also, areas with cropland increased at 0.28% per annum from 1980 to 2000 (Jaim and Begum, 2003) lastly, from 1988-2004, the annual agricultural land changed to cropland areas by 5% (Rahman et al., 2009). As per the previous researches, agricultural land has been changed into urban areas throughout recent decades (Hasan et al., 2013; Quasem, 2011; Uddin et al., 2014). In Bangladesh, the urban areas have increased by 23.6% to 28.4% from 2000 until 2011 (FAO, 2014) where, the urban area in Dhaka Division elevated drastically throughout this time. Based on the Markov chain model, the general increase of urban land is 46%~58% from 2009 to 2019 (Dewan, and Yamaguchi, 2009) and 26% for 2020 until 2050 and also, for 2008 till 2020 a change of vegetation to cultivation land change of 38% in Dhaka was detected (Islam and Ahmed, 2011).

Due to the severe shortage of land and lack of technological advancement, the farmers are encouraged to follow the integrated way of farming for each category of land (Haque, 1994b). It is stated that food insecurity is related to the level of income of households (WFP, 2006) however, 40% of the rural population have a poor land status (FAO, 2000). Additionally, almost 60% of farmers are at the same status and about 62% of their households have less than 0.4 ha of farmland (Magnani et al., 2015).

It is clear that the initiation of new agro-ecological zoning is important for a shining future to conserve agricultural land from the change to non-agricultural land usage. This zoning is also important for near-future social and food security.

The extent of the study area lies between 24.7587° north to 24.9787° north latitude and 90.3009° east to 90.6396° east longitude (Figure 1). There is a total of 10 unions in the study area. Bishka is the biggest with 3523.42 hectares area and the smallest one is Kakni with 2,512.80 hectares area. According to the 2011 census Tarakanda has 412,261 population (BBS, 2011). According to BBS (2011), there are 389 villages and 377 mouzas in the Tarakanda Upazila. The area is basically low laying, the elevation range is 0 to 24 meters, and the mean elevation is 14.82 meters, the highest mean elevation is 16.56 meters in Balikhan

Union and the lowest elevation accomplish with Dhakua Union with a mean elevation of 13.72 meters (Figure 2). The elevation standard deviation is only about 0.93 meters in the area.

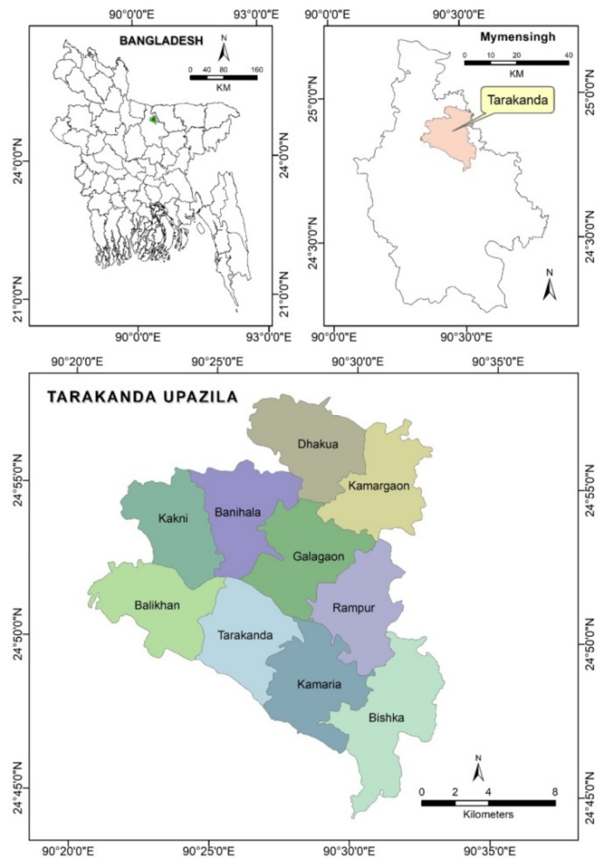

Figure 1: The Present Study Area (Tarakanda is an Upazila of Mymensingh District, Bangladesh)

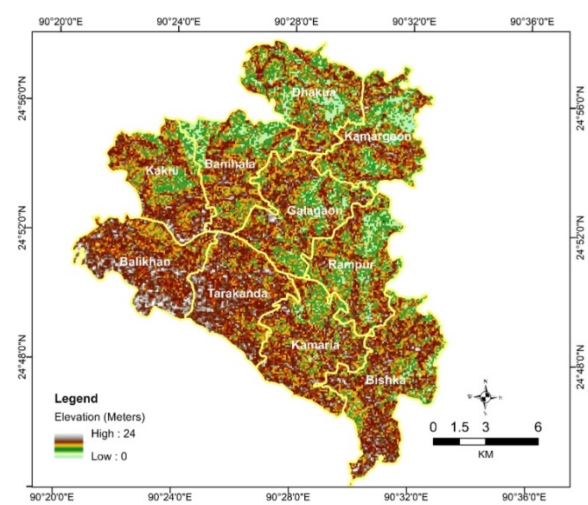

Figure 2: Elevation of the Study Area (Tarakanda Upazila- an Upazila of Mymensingh District of Bangladesh)

Source: SRTM DEM, (https://dwtkns.com/srtm30m,2015)

We know that dynamic changes have taken place in the agricultural sector of Bangladesh at a macro and micro level. Every farmer is trying to make their agriculture profitable. As a result, landuse has also changed in everywhere. Such an occurrence is happening in Tarakanda Upazila of Mymensingh District where the farmer is converting their agricultural land into fish farming. Therefore, in the present study, researchers gave their attention to find out the changing pattern of agricultural landuse in the study area using geospatial data.

Aims and Objectives of the Study

The study aims at deriving agricultural landuse shifting to fish farming between 1989 and 2018. The specific objectives are:

I. To find out the agricultural landuse pattern of Tarakanda Upazila for the year 1989, 2000, 2010 and 2018, because the agricultural land in this upazila is changing and turning into fish farming.

II. To analyze and map the agricultural landuse shifting to various sectors in the years from 1989 to 2018, and

III. To simulate agricultural landuse change by using CA Markov Matrix of Probability for the year 2026.

Materials and Method

Study Area

Due to human intervention on the surface, surface water and forest coverage are gradually decreasing in the macro and micro level. Under the circumstances, if surface water increases in a certain area, then naturally the question arises why it is increasing? Various primary data, especially the satellite data images show that the surface water of Tarakanda Upazila is gradually increasing. Therefore, Tarakanda Upazila has been identified as the present study area to find theanswerto the question.

According to BBS 2011, Tarakanda was a union, under the Phulpur Upazila in the Mymensingh District, but on 7 January 2013 (BNP, 2019), it was upgraded as an upazila consists of 10 unions namely Balikhan, Banihala, Bishka, Dhakua, Galagaon, Kakni, Kamargaon, Kamaria, Rampur and Tarakanda of Phulpur Upazila in the Mymensingh District. According to DAE (DAE, 2019) Tarakanda office, it contains 138 hectares of net cultivable fallow land and 198 hectares of total fallow land with the total area of 28116.72

hectares. The upazila has a population of 298220, the population density of 10.61 per hectare and a literacy rate of 37.11% respectively (BBS, 2011)

To protect the natural environment of Tarakanda Upazila, the agroecological zoning can be implemented to increase diversified agricultural production in terms of proper usage of the land, where, food production and housing are the prime objectives of landuse where, 67% of the total land in Bangladesh is cultivable and 80% of the cultivated land is used for rice with other crops (wheat, onion, garlic, pulse, potato, vegetables etc.) in rotation (Haque, 1994a). Agriculture also contributes to about 37% of the gross domestic product of Bangladesh. Of the total agricultural product, 77.7% comes from various crops and the rest from other farming components (MoF, 1986). In Tarakanda, farming is mostly subsistence and rice crop-based where integrated farm forestry may be an effective landuse system as it is widely practised by low and medium holding farmers.

Primarily, the problem was understood through literature review. The main objective of the study was agricultural landuse shifting to fish farming in Tarakanda Upazila between 1989 and 2018. To meet the objective both primary and secondary data were considered. Primary data generated from toposheets (SoB, 2013) (with a scale of 1: 25,000), collected from a survey of Bangladesh (SoB) and satellite data comprised with Landsat 4-5 TM (https://glovis.usgs.gov/, 1989, 2000 and 2010) for the years 1989, 2000 and 2010 and Landsat OLI_TIRS (https://glovis.usgs.gov/, 2018) for the year 2018 were selected and collected from USGS Glo Vis (Table 1). The study considered November month images considering sky condition of the country. The spatial resolution of these images was 30 meters.

Method

There are a lot of techniques to extract landuse/cover from satellite images, such as unsupervised and supervised classification, and different indices. The following six methods were followed for the present study: firstly, the selected images were collected; secondly, collected images were extracted and layers were stacked in Erdas Imagine 2014 (https://www.hexagongeospatial.com/, 2014). Thirdly, image preprocessing function radiometric corrections- haze reduction, noise reduction and histogram equalization were performed in Erdas Imagine. Fourthly, the AOI (Area of Interest) was extracted from the images using Tarakanda shape (Figure 3: RGB of the images, Bands 3,2,1). Fifthly, different landuse of the study area were identified through Iso Cluster Unsupervised Classification and Interactive Supervised Classification. Finally, different tools and matrix were used to detect the change of agricultural land to fish farming (Figure 4). Total three landuse/cover were identified in the present study, these are agricultural uses, water body (those are maximum fish farming) and others (Table 2)

Table 1: Specifications of Landsat Satellite Data

<table>
<tr><th>Date</th><th>Path/ row</th><th>Spacecraft_id</th><th>Sensor</th><th>Bands and Wavelengths</th><th>Cloud cover (%)</th><th>Land cloud cover (%)</th><th>Resolution (meters)</th></tr>
<tr><td>11/20/1989</td><td rowspan="3">137/43</td><td rowspan="3">LANDSAT_5</td><td rowspan="3">TM</td><td rowspan="3">Band 1: 0.45-0.52
Band 2: 0.52-0.60
Band 3: 0.63-0.69
Band 4: 0.76-0.90
Band 5: 1.55-1.75
Band 6: 10.40-12.50
Band 7: 2.08-2.35</td><td>0</td><td>0</td><td rowspan="4">30</td></tr>
<tr><td>11/2/2000</td><td>1</td><td>1</td></tr>
<tr><td>11/14/2010</td><td>0</td><td>0</td></tr>
<tr><td>11/20/2018</td><td>137/43</td><td>LANDSAT_8</td><td>OLI_TIRS</td><td>Band 1: 0.43-0.45
Band 2: 0.45-0.51
Band 3: 0.53-0.59
Band 4: 0.64-0.67
Band 5: 0.85-0.88
Band 6: 1.57-1.65
Band 7: 2.11-2.29
Band 8: 0.50-0.68
Band 9: 1.36-1.38
Band 10: 10.6-11.19
Band 11: 11.50-12.51</td><td>0.06</td><td>0.06</td></tr>
</table>

Source: https://glovis.usgs.gov/, 1989, 2000, 2010, 2018

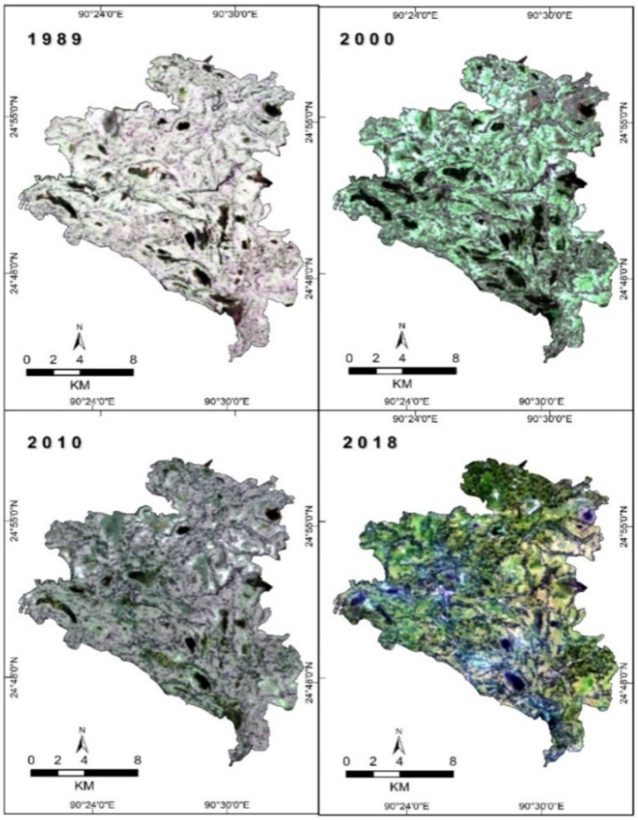

Figure 3: Landsat Dataset of Tarakanda Upazila for 1989, 2000, 2010 and 2018 in RGB (Bands 3,2,1)

Source: https://glovis.usgs.gov/, 1989, 2000, 2010 and 2018

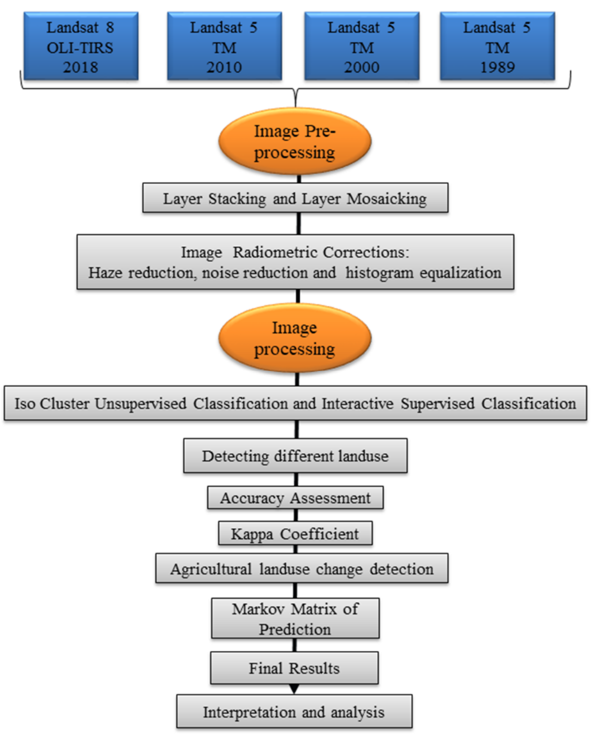

Figure 4: The Present Study Workflow

Table 2: Landuse/Cover Type in Tarakanda Upazila

Landuse/cover types	Description
Agriculture	Cropland, livestock, framland, arable land etc.
Water body	Permanent and seasonal wetlands, low lands, marshy land, river and khal, etc
Others	Landfills and bare area, residential, commercial, transport, vegetation and forest etc.

Markov Model in Landuse/Cover Change

The classified landuse/cover (LU/LC) were used to generate a Markov Transitional Matrix of landuse/cover change between 1989 and 2026. Later the Markov Matrix of Probability was used to simulate landuse/cover change for the period for 2018 to 2026. Markov model is a convenient tool for simulating LU/LC change. Markov model describes LU/LC change from one period to another and used this as the basis to project future changes (Logsdon et al., 1996). Markov model has provided a simple methodology by which a dynamic system could be analyzed and examined (Muller and Middleton, 1994; Dongjie et al., 2008; Huang et al., 2008; Dadhich and Hanaoka, 2010). Researchers have tested the accuracy of the Markov model (Jianping et al., 2005; Zhang et al., 2011).

The transition matrix is a product with the state vector at an initial time gives at a later time. The state-transition matrix can be used to obtain the general solution of linear dynamic systems. A transitional matrix can represent changes from one state to another state. According to the transition matrix, the LU/LC class will change to another class in the future, given the present state of the class (Kumar et al, 2014). The matrix equation is as follows:

$$P = \begin{pmatrix} P_{1,1} & P_{1,2} & \dots & P_{1,j} & \dots & P_{1,S} \\ P_{2,1} & P_{2,2} & \dots & P_{2,j} & \dots & P_{2,S} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ P_{i,1} & P_{i,2} & \dots & P_{i,j} & \dots & P_{i,S} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ P_{S,1} & P_{S,2} & \dots & P_{S,j} & \dots & P_{S,S} \end{pmatrix}$$

Source: Gagniuc, 2017

Based on the above transitional equation, the agricultural landuse change was predicted for the year

2026 by using the matrix of agricultural landuse between 2010 and 2018.

Accuracy Assessment

To assess the accuracy, some 110 sample points were cross verified with the Google Earth Pro. Using Erdas Imagine Software opening two views and taking the classified image in one view and Google Earth Pro image in another view the samples were investigated. Here, Erdas Imagine's two tools such as Link views ( ) and Inquire (Inquire) were used to cross investigate the samples of the classified images and Google Earth Pro images. Finally, the overall accuracy for the different year was calculated. According to accuracy assessment in 1989, there was a 3.05 percent absolute error, which is 858 hectares of the total land area at 97 percent accuracy level with a Kappa coefficient of 0.93. In 2000, there was a 6.15 percent absolute error, which is 1,729 hectares of the total land area at 93 percent accuracy level with a Kappa coefficient of 0.85. In 2010, there was a 3.88 percent absolute error, which is 1091 hectares of the total land area at 96.2 percent accuracy level with a Kappa coefficient of 0.94. Similarly, in 2018, there was a 3.08 percent absolute error, which is 866 hectares of the total land area at 96 percent accuracy level with a Kappa coefficient of 0.94 (Table 3).

Table 3: Overall Accuracy Assessment

Year	Absolute errors (percent)	Absolute errors (in hectares)	Overall accuracy (percent)	Kappa coefficient (T)
1989	3.05	858	97	0.93
2000	6.15	1729	93	0.85
2010	3.88	1091	96.2	0.94
2018	3.08	866	96	0.94

Source: Satellite Image (https://glovis.usgs.gov/, 1989, 2000, 2010 and 2018) and (Google, 2019) and Field Survey, 2019

Results and Discussions

The image analysis result shows that, in 1989, there was 16463.7 hectares or 58.55% of the land in agriculture in Tarakanda Upazila; similarly 3688.47 hectares or 13.12% of the land was in the water body and 7964.55 hectares or 28.33% of the land was in other uses (Figure 5, Table 4). Furthermore, in 2000, there was 14750.91 hectares or 52.46% of the land in agriculture; 4202.46 hectares or 14.95% of the land was in the water body and 9163.35 hectares or 32.59% of the land was in other uses in upazila (Figure 5, Table 4). In 2010, there was 14264.64 hectares or 50.73% of the land in agriculture; 4406.04 hectares or 15.67% of the land was in the water body and 9,446.04 hectares or 33.60% of the land was in other uses in upazila (Figure 5, Table 4). Finally, in 2018, there was 13,116.42 hectares or 46.65% of the land in agriculture; 5206.59 hectares or 18.52% of the land was in the water body and 9,793.71 hectares or 34.83% of the land was in other uses in upazila (Figure 5, Table 4).

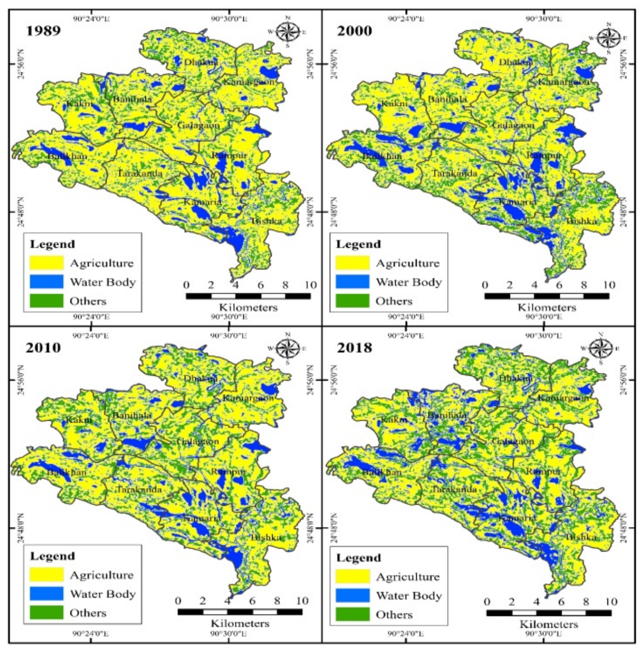

Figure 5: Landcover Change of Tarakanda Upazila from 1989 to 2018

Source: Based on Landsat Satellite Images (https://glovis.usgs.gov/, 1989, 2000, 2010 and 2018)

Table 4: Landuse/Cover in Tarakanda Upazila from 1989 to2018

Landcover Class	1989 (area in hectares)	%	2000 (area in hectares)	%	2010 (area in hectares)	%	2018 (area in hectares)	%	Yearly Change (%)
Agriculture	16463.7	58.55	14750.91	52.46	14264.64	50.73	13116.42	46.65	- 0.40
Water body	3688.47	13.12	4202.46	14.95	4406.04	15.67	5206.59	18.52	0.18
Others	7964.55	28.33	9163.35	32.59	9446.04	33.60	9793.71	34.83	- 0.21
Total	28116.72	100.00	28116.72	100.00	28116.72	100.00	28116.72	100.00	

Source: Landsat Satellite Image Classification Results (https://glovis.usgs.gov/, 1989, 2000, 2010 and 2018)

Agricultural Landuse Changes from 1989 to 2018 and Prediction from 2018 to 2026

The image analysis result shows that the agricultural land uses are gradually decreasing during the studied period. There was 16463.7 hectares or 58.55% of the agricultural land in 1989 in the Tarakanda Upazila. But in the year 2000, the agricultural land stood at 14750.91 hectares or 52.46% of the total land. In 2010, the agricultural land stood at 14264.64 hectares or 50.73% of the total land and in 2018, the agricultural land stood at 13116.42 hectares or 46.65% of the land (Figure 5, Table 4). Markov prediction shows that in 2026 the agricultural landuse will be 12284.58 hectares or 43.69% of the total landcover.

The decreasing rate of agricultural land is strongly negative, where the correlation coefficient, r = -0.96 and regression,y= -1052.8x + 17281 (Figure 6). Research shows that a total of 1712.79 hectares agricultural land has reduced between 1989 and 2000 (Table 5). Similarly, between 2000 and 2010 a total of 486.27 hectares agricultural land has reduced and between 2010 and 2018 a total of 1184.22 hectares agricultural land has reduced and between 2018 and 2026 about 832 hectares of land will decrease. Finally, between study period from 1989 to 2018 a total of 3347.28 hectares of agricultural land has reduced (Table 5) and between 1989 and 2026 a total of 4179 hectares agricultural land will decrease. Figure 7 shows that 6.09 percent of agricultural land loses between 1989 and 2000. Between 2000 and 2010 the loss was 1.73 percent and between 2010 and 2018 the loss was 4.08 percent. As a result, a total of 11.9 percent of agricultural land loss during the study period during 1989 to 2018 and Markov prediction shows that 14.86 percent of agricultural land will be lost by Tarakanda Upazila (Figure 7).

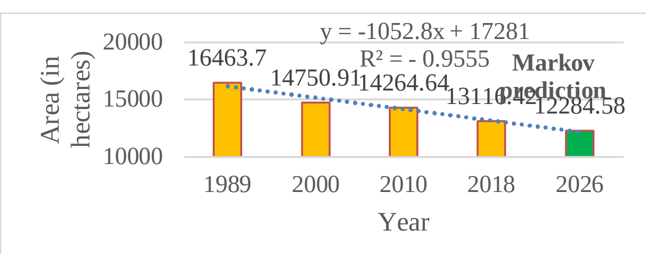

Figure 6: Trend of Agricultural Landuse/Cover Change in Tarakanda during 1989-2018

Source: Data extracted from Landsat satellite images (https://glovis.usgs.gov/, 1989, 2000, 2010 and 2018)

Table 5: Tabular Information of Agricultural Landuse/ Cover Change in Tarakanda between 1989 and 2026

Year	Agricultural use (in hectares)	AgriculturalLanduse Changes (in hectares)				
		1989-2000	2000-2010	2010-2018	2018-2026*	1989-2026
1989	16463.7					
		-1712.79				
2000	14750.91					
			-486.27			
2010	14264.64					-4179.12
				-1148.22		
2018	13116.42					
2026*	12284.58				-831.838	

* Data predicted by using Markov Model (Bremaud, 2013)

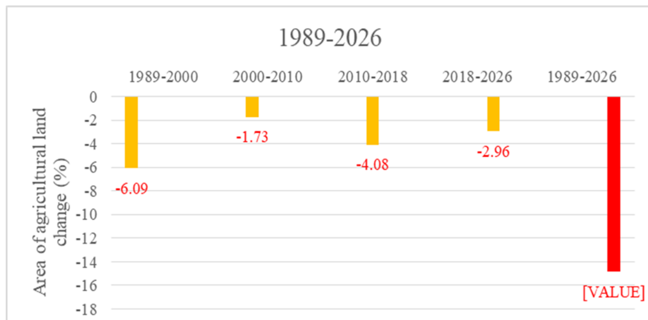

Figure 7: Percentage of Agricultural Landuse/Cover Change during 1989-2026

Source: Data Extracted from Landsat Satellite Images (https://glovis.usgs.gov/, 1989, 2000, 2010 and 2018)

Table 6: Agricultural Landuse/Cover Change in Tarakanda Upazila from 1989 to 2018

Union	1989 (area inhectares)	2000 (area in hectares)	2010 (area in hectares)	2018(area in hectares)	R^2
Balikhan	1637.28	1207.89	1431.9	1320.84	-0.54
Banihala	1450.26	1517.85	1214.28	964.17	-0.88
Dhakua	1490.04	1743.39	1424.43	1188.9	-0.65
Galagaon	1951.47	1789.11	1489.77	1581.39	-0.90
Kakni	1498.5	1628.37	1315.89	1244.43	-0.78
Tarakanda	1718.28	1442.88	1337.94	1265.94	-0.97
Kamargaon	1644.75	1396.53	1564.56	1380.42	-0.62
Kamaria	1578.87	1063.53	1330.11	1121.13	-0.63
Rampur	1623.87	1308.15	1382.22	1374.48	-0.67
Bishka	1848.51	1633.32	1753.65	1652.4	-0.62

Source: Data Generated by using ArcGIS 10.3.1 (ESRI, 2015) Zonal Statistics as Table from Landsat satellite images (https://glovis.usgs.gov/, 1989, 2000, 2010 and 2018)

The union's zonal statistics show that the highest agricultural land was lost by the Tarakanda Union at a rate of 0.97 in the study period 1989 to 2018. The next position hold by Galagaon Union, where the decreasing rate is 0.90. The Banihala Union is also losing agricultural land at a high rate where the rate is 0.88. The lowest land losing condition was found in Balikhan Union, where the rate is 0.54 (Table 6). The important message is that all union's of the Taranada Upazila has lost their agricultural land at a significant rate in the study period from 1989 to 2018.

Agricultural Landuse Change Dynamics in Tarakanda

Surface activities are constantly changing. In GIS and remote sensing analysis, we see that a cell involved in a particular activity may be transformed into another activity. On the other hand, cells of other activities are also being transformed and involved in a particular activity. In fact, this is the dynamics of landuse change.Through this process, any particular activity increases and decreases and remained unchanged. Similarly, in Tarakanda Upazila, agricultural land is being converted into fish farming in the same process. The process is described below.

The results show that from 1989 to 2000 the agricultural land of the Tarakanda Upazila has increased 3,454.2 hectares and decreased 5,171.4 hectares and 11,314.17 hectares area has remained common in the agricultural sector (Figures 8 and 9, Table 7). On the other hand, between 2000 and 2010 the agricultural lands of the Tarakanda Upazila have increased 4,328.55 hectares and decreased 4,813.47 hectares and have remained common about 9,955 hectares in the agricultural sector of the area. Similarly, between 2010 and 2018 the agricultural land use has increased 3,045.51 hectares and decreased 4,195.26 hectares and the area has remained common about 10,088 hectares in the study area (Figures 8-10, Table 7).

To measure agricultural landuse change Erdas Imagine Zonal Change's Image Difference tool was used. Using image difference tool three types of data were extracted, such as decreased, unchanged and increased. The results show that the decreased trend of agricultural lands is more or less constant in the study period from 1989 to 2018, where the correlation coefficient, r = -0.99 (Figure 10, Table7). Similarly, the increasing trend of agricultural land is not regular which is fluctuating and the correlation coefficient is also negative, where r = - 0.31 (Figure 10, Table7) and the net decreased trend of the agricultural land dynamics correlation coefficient, r= -0.46. Furthermore, the common agricultural land area is decreasing gradually during study time from 1989 to 2018 (Figure 11, Table 7). During 1989 to 2000 the common agricultural land area was 11,314 hectares, it has reduced to 9,955 hectares between 2000 and 2010 and further, it has dropped to 10,088 hectares between 2010 and 2018. Finally, the agricultural lands stood 10,266 hectares between 1989 to 2018 (Figures 8,9 and 11, Table 7).

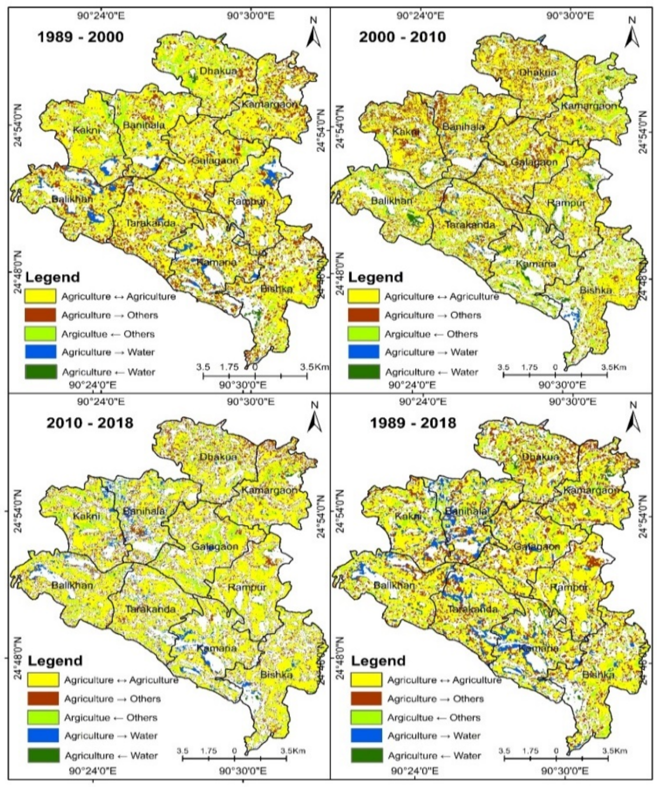

Figure 8: Agricultural Landuse Change Dynamics in Tarakanda Upazila from 1989 to 2018

Source: Data extracted by using Combinatorial And Operation from Landsat satellite images

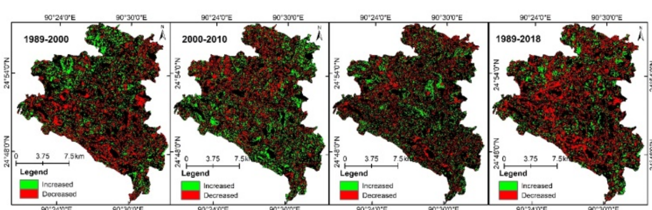

Figure 9: The Spatial Movement of Agricultural Landuse Change: Increase and Decrease in Tarakanda Upazila from 1989 to 2018

Source: Based on Landsat satellite images (https://glovis.usgs.gov/, 1989, 2000, 2010 and 2018)

Table 7: Model Statistics of Agricultural Landuse Change Dynamics in Tarankanda Upazila from 1989 to 2018

Year	Decreased area (in hectares)	Unchanged area (in hectares)	Increased area (in hectares)	Net decrease (in hectares)	Common agricultural area (in hectares)
1989-2000	5171.4	11370.94	3454.2	1717.2	11314.17
2000-2010	4813.47	10100.83	4328.55	484.92	9954.9
2010-2018	4195.26	10240.2	3045.51	1149.75	10088.19
1989-2018	6219.54	45610.29	2867.67	3351.87	10266.03
	R^2 = -0.99		R^2 = -0.31	R^2 = -0.46	R^2 = -0.82

Source: Based on Landsat satellite images analysis (https://glovis.usgs.gov/, 1989, 2000, 2010 and 2018)

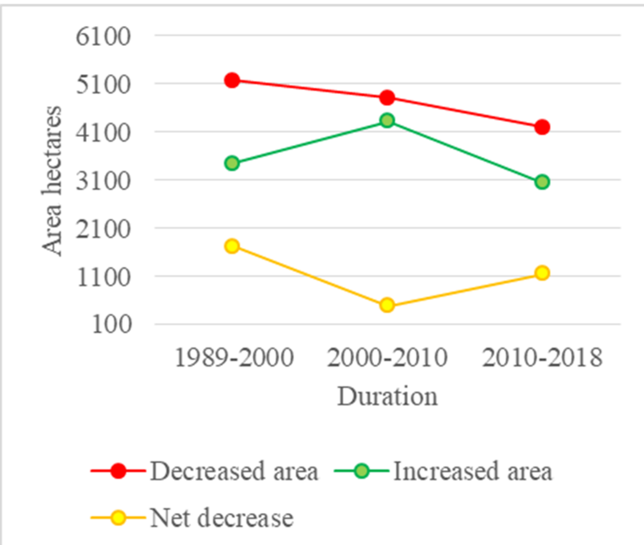

Figure 10: Increase and Decrese Trends of Agricultural Landuse in Tarakanda Upazila during 1989 to 2018

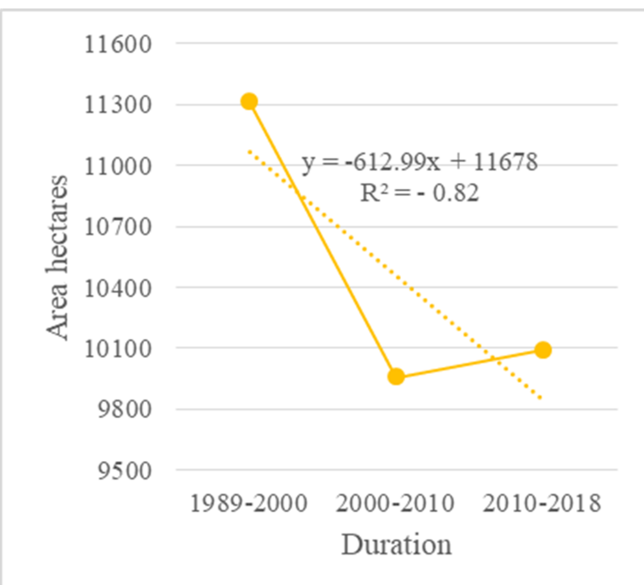

Figure 11: Trends of Common Agricultural Landuse in Tarakanda Upazila from 1989 to 2018

Source: Based on Landsat satellite images analysis (https://glovis.usgs.gov/, 1989, 2000, 2010 and 2018)

Transitional Matrix of Agricultural Landuse Change from 1989 to 2018 and 2018 to 2026

According to the transitional model, the sectoral movement of agricultural landuse change is always toward other uses such as settlement, landfills, bare area, commercial, transport etc. (Table 8). The change in agriculture to agriculture has decreased during the study period from 1989 to 2018. It was 40.24 percent during 1989-2000 and it has reduced to 35.41 percent during 2000-2010 and similarly, it was 35.88 percent from 2010 to 2018. According to Markov model prediction agriculture to agriculture movement will be reduced, which will be 32.81 percent in 2026. The transitional movement in agriculture to agriculture is negative and the trend is -0.67, where the regression, $y = -2.1802x + 41.535$ (Figure 12).

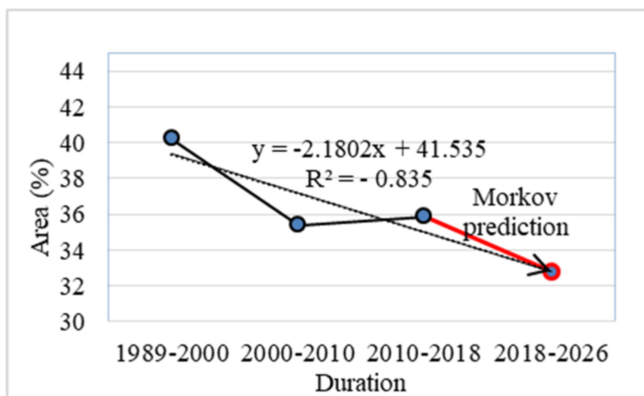

Figure 12: Percentage of Agricultural Landuse Changes (Agriculture to Agriculture) from 1989 to 2018

The movement of agriculture to water is positive, where correlation coefficient, r = 0.42 and regression, $y = 0.4552x + 2.2763$, during 1989-2000 it was 3.28 percent, during 2000-2010 it stood 2.19 percent and between 2010 and 2018 it stood 3.99 percent. Finally, between 1989 and 2018 agriculture to water landuse shifting was 6.63 percent (Table 8 and Figure 13). According to Markov model prediction, the agricultural landuse shifting to water body will be 4.20 percent in 2026 (Table 8, Figure 13).

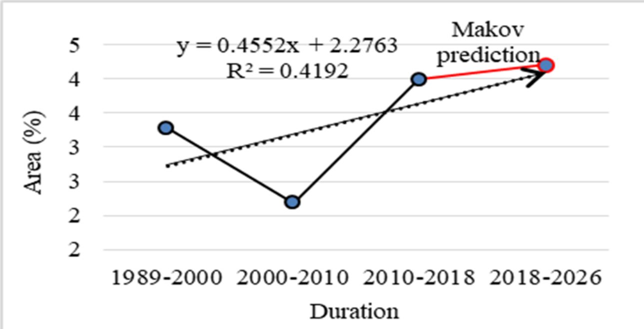

Figure 13: Percentage of Agricultural Landuse Changes (Agriculture to Water Body) from 1989 to 2018

Source: Based on Landsat satellite images analysis (https://glovis.usgs.gov/, 1989, 2000, 2010 and 2018)

Shifting of agriculture to other uses is another big threat to reducing agricultural land. The result shows that about 15.5 percent of agricultural land has shifted to other sectors between 1989 and 2018 (Table 8 and Figure 14). Facts show that the rate is decreasing, where the correlation coefficient r = -0.89 and regression y = -2.0907x + 17.839. During 1989-2000 it was 15.11 percent, and it stood 14.93 percent during 2000- 2010 and further during 2010-2018 it has reduced to 10.93 percent (Table 8 and Figure 14). Finally, Markov model prediction shows that in 2026 the change will be 9.48 percent (Table 8 and Figure 14). Agriculture to other uses, the trend is negative, but the amount of change is very high in volume. Therefore, movement between these sectors should be reduced for future food security.

Agricultural landuse has reduced through shifted to another sector, at the same time it has gained from other sectors also. The result shows that about 11 percent of the land has gained by the agricultural sector from other uses between 1989 and 2000. During 2000-2010 it has gained 12.95 percent of the land from other uses and similarly, from 2010 to 2018 it has gained 9.94 percent of the land from other uses (Table 8 and Figure 15). The prediction shows that in 2026 about 9.98 percent of the land will be gained by the agriculture sector from other uses (Table 8 and Figure 15). Water to agricultural landuse shifting is very low, during 1989-2000 about 1.0 percent land has shifted to water to agriculture and during 2000-2010 about 2.5 percent land has transferred to water to agriculture and similarly, 2010 to 2018 about 0.9 percent of the land was transferred to water to agriculture. The transfer rate negative, where correlation coefficient, r = - 0.21 and regression y = -0.7268x + 14.291.

Table 8: Model Statistics of Agricultural Landuse Change Dynamics in Tarakanda Upazila from 1989 to 2018

Agricultural landuse change	1989-2000		2000-2010		2010-2018		2018-2026*	
	Area (hectares)	%	Area (hectares)	%	Area (hectares)	%	Area (hectares)	%
Agriculture → agriculture	11314.17	40.24	9954.90	35.41	10088.19	35.88	9226.44	32.81
Agriculture → water	922.68	3.28	614.79	2.19	1122.21	3.99	1180.12	4.20
Agriculture → other use	4248.72	15.11	4198.68	14.93	3073.05	10.93	2664.48	9.48
Agriculture ← other use	3200.31	11.38	3642.03	12.95	2795.22	9.94	2807.43	9.98
Agriculture ← water	253.89	0.90	686.52	2.44	250.29	0.89	393.3	1.40
Total Area	28116.72		28116.72		28116.72		28116.72	

*Prediction by using Markov model (Bremaud, 2013)

Source: Based on Landsat satellite images analysis (https://glovis.usgs.gov/, 1989, 2000, 2010 and 2018)

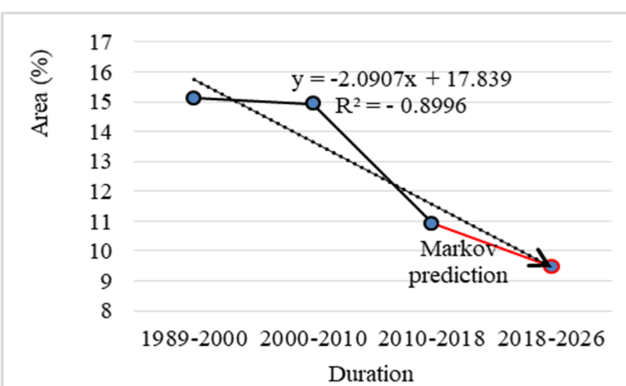

Figure 14: Percentage of Agricultural Landuse Changes (Agriculture to Other Uses) from 1989 to 2018

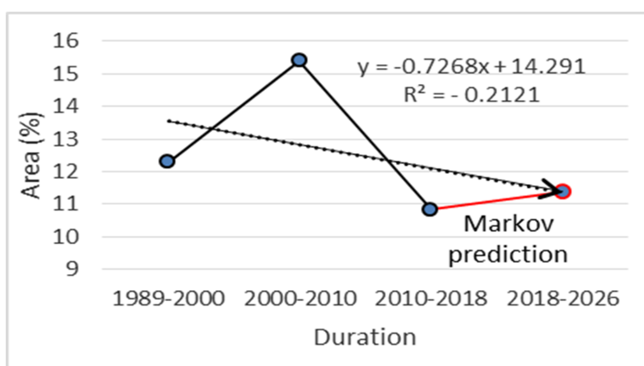

Figure 15: Percentage of Agricultural Landuse Increase by Adding Land from Water Bodies and Other Uses from 1989 to 2018

Source: Based on Landsat satellite images analysis (https://glovis.usgs.gov/, 1989, 2000, 2010 and 2018)

Conclusions

Dynamics of agricultural landuse changes and quantification of the agricultural landuse pattern of Tarakanda Upazila was shown in this paper by using geospatial techniques. Geospatial techniques help to calculate the shifting of sectoral movement of agricultural landuse changes. Results show that the Upazila has lost its agricultural land dominance during the study period about 3347 hectares which is about 12 percent of the total land area. The forecasted data shows that in 2026 the total agricultural land will be decreased by about 4197 hectares which will be about 15 percent of the total landuse. In 1989, there were 16463 hectares agricultural land in Tarakanda Upazila, it has decreased to 13116 hectares and will be 12284 hectares in 2026 according to the predicted data. The common shifting of land from agriculture to agriculture is decreasing. During 1989-2000 it was 40.24 percent but in 2026 it will be 32.81 percent. The shifting trend is strongly negative, where r = -0.84. Similarly, a vast amount of agricultural land always shifted to other uses. On average, about 3546 hectares or 12.6 percent of agricultural land has shifted in each decade to other uses, which is alarming for the policy-makers. Because if the trend continues, shortly we face serious trouble in food security. Therefore, attention should be given on rural master planning of landuse immediately.

References

BBS (2011). Agricultural Census of Bangladesh: Ministry of Planning, Government of the People's Republic of Bangladesh, Bangladesh Bureau of Statistics, Dhaka, Bangladesh.

BBS (2015). Yearbook of Agricultural Statistics, Statistics and Informatics Division (SID): Bangladesh Bureau of Statistics, Dhaka, Bangladesh, 2016.

BNP (2019). Tarakanda Upazila, Bangladesh National Portal, Government of the People's Republic of Bangladesh. http://tarakanda.mymensingh.gov.bd/site/page/3ed3d97c-1e86-11e7-8f57-286ed488c766/%E0%A6%8F%E0%A6%95%20%E0%A6%A8%E0%A6%9C%E0%A6%B0%E0%A7%87%20%E0%A6%A4%E0%A6%BE%E0%A6%B0%E0%A6%BE%E0%A6%95%E0%A6%BE%E0%A6%A8%E0%A7%8D%E0%A6%A6%E0%A6%BE%20%E0%A6%89%E0%A6%AA%E0%A6%9C%E0%A7%87%E0%A6%B2%E0%A6%BE?fbclid=IwAR2EY40FMpVeEhhpZaQXBltaAH86j0eg25dMjmyBsNWrE72eteiLgDWeMOI

Bremaud, P. (2013). Markov Chains: Gibbs Fields, Monte Carlo Simulation, and Queues. Springer Science & Business Media. p. ix. ISBN 978-1-4757-3124-8. Archived from the original on 23 March 2017.

Brondizio, E.S., Moran, E.F., Wu, Y. (1994). Landuse Change in the Amazon Estuary: Patterns of Caboclo Settlement and Landscape Management. *Human Ecology,* 22 (3), 249–278.

Chilar, J. (2000). Landcover Mapping of Large Areas from Satellites: Status and Research Priorities. *International Journal of Remote Sensing* 21: 1093–1114.

Dadhich, P. N. and Hanaoka, S. (2010). Remote sensing, GIS and Markov's method for landuse change detection and prediction of Jaipur district. *Journal of Geomatics and Geosciences*. 4:9–15.

DAE (2019). Baseline Survey, Tarakanda Upazila, Department of Agriculture, Government of the People's Republic of Bangladesh.

Dewan, A.; Yamaguchi, Y. (2009). Land use and land cover change in Greater Dhaka, Bangladesh: Using Remote Sensing to promote sustainable urbanization. *Applied Geography*. 29, 390–401.

Dongjie, G., Weijun, G., Kazuyuki, W. and Hidetoshi F. (2008). Landuse change of Kitakyushu based on landscape ecology and Markov model. *International Journal Geographical Information Science,* 18:455–468.

ESRI (2015). ArcGIS 10.3.1, Desktop Package Map For ArcGIS Runtime Patch, Environmental Systems Research Institute 380 New York Street Redlands, CA 92373-8100.

FAO (2000). Forest Resources of Bangladesh, Country Report; Forest Department, Food and Agriculture Organization of the United Nations: Rome, Italy, p. 91.

FAO (2014). FAOSTAT. Food and Agriculture Organization of the United Nations, Rome, Italy.

Gagniuc, P. A. (2017). *Markov Chains: From Theory to Implementation and Experimentation.* USA, NJ: John Wiley & Sons. 9–11.

Google (2019). *Google Earth Pro*. US Dept of State Geographer, Image Landsat/Copernicus, Data SIO, NOAA, US Navy, NOA, GEBCO.

Haque, M.A. (1994a). Prospect of Agroforestry in Bangladesh. Village and Farm Forestry in Bangladesh. Bangladesh Agricultural University, Mymensingh, and Swiss Agency for Development and Cooperation, Dhaka.

Haque, M.A. (1994b). Integrated Farm Forestry in Bangladesh. Village and Farm Forestry in Bangladesh.

Bangladesh Agricultural University, Mymensingh, and Swiss Agency for Development and Cooperation, Dhaka.

Hasan, M.N., Hossain, M.S., Bari, M.A. and Islam, M.R. (2013). Agricultural land availability in Bangladesh. SRDI, Dhaka, Bangladesh, 42.

https://dwtkns.com/srtm30m. (2015). SRTM DEM, 30-Meter SRTM Tile Downloader, https://dwtkns.Com/srtm30m.https:// en. wikipedia. Org / wiki/Stochastic_matrix

https://glovis.usgs.gov/app?fullscreen=0. (2000). USGS GloVis, Landsat 4-5 TM C1 Level-1, https://glovis.usgs.gov/app?fullscreen=0.

https://glovis.usgs.gov/app?fullscreen=0. (2010). USGS GloVis, Landsat 4-5 TM C1 Level-1, https://glovis.usgs.gov/app?fullscreen=0.

https://glovis.usgs.gov/app?fullscreen=0. (1989). USGS GloVis, Landsat 4-5 TM C1 Level-1, https://glovis.usgs.gov/app?fullscreen=0.

https://glovis.usgs.gov/. (2014). USGS GloVis, United States Geological Survey. https://glovis.usgs.gov/app?fullscreen=0.

https://glovis.usgs.gov/app?fullscreen=0. (2018). USGS GloVis, Landsat 8 OLI_TIRS C1 Level-1, https://glovis.usgs.gov/app?fullscreen=0.

https://www.hexagongeospatial.com/, (2014). Hexagonal Geospatial, Hexagon's Geospatial Division. Hexagon AB © 2019.

Huang, W., Liu, H., Luan, Q., Bai, M. and Mu, X. (2008). Monitoring Urban Expansion in Beijing, China by multi temporal TM and Spot Images. IEEE Proc, IGARSS. 4:695–698.

Islam, M.S. and Ahmed, R. (2011). Land use change prediction in Dhaka city using GIS aided Markov chain modeling. *Journal of Life and Earth Science*, 6, 81–89.

Jaim, W. and Begum, R. (2003). Changes in Land Use Pattern in Bangladesh over the last two Decades. Bangladesh *Joural of Agricultural Economics.,* 26, 87–96.

Jianping, L,I., Bai, Z. and Feng, G. (2005). RS-and-GIS-supported forecast of grassland degradation in southwest Songnen plain by Markov model. *Geo-spatial Information Science*. 8:104–06.

Kachhwala, T.S. (1985). Temporal monitoring of forest land for change detection and forest cover mapping through Satellite Remote Sensing. In: Proceedings of the 6th Asian Conference on Remote Sensing. National Remote Sensing Agency, Hyderabad, 77–83.

Kramer, R., van Schaik, C., Johnson, J. (eds.) (1997). Protected areas and the defense of Biodiversity. Oxford University Press, London.

Lambin, E, F., Helmut, J. Geist, E. L. (2003). Dynamics of Land-Use and Land-Cover Change in Tropical Regions. Annual Review of Environment and Resources 28:1, 205-241

Lo, C.P., Choi, J. (2004). A hybrid approach to urban land use/cover mapping using Landsat 7 enhanced thematic mapper plus (ETM+) images. *Int. J. Remote. Sensing.* 25 (14), 2687–2700.

Logsdon, M. G., Bell, J, E. and Westerlund, V. F. (1996). Probability mapping of landuse change: a GIS interface for visualizing transition probability. *Computer Environment Urban Systems*. 20:389– 398.

Magnani, R.; Oot, L., Sethuraman, K., Kabir, G. and Rahman, S. (2015). Food and Nutrition : Technical Assistance III Project: Washington, DC, USA. 1–69.

MoF. (1986). Research Plans for Integrated Aquaculture, Report no 7: Fisheries research institute – Bangladesh, The People's republic of Bangladesh, Ministry of fisheries and livestock Fisheries Research Institute. FAO/UNDP TA- PROJECT BGD 83-010, IDA/WB AGRICULTURAL RESEARCH II PROJECT

Muller, R.M. and Middleton J. (1994). A Markov model of land-use change dynamics in the Niagara region, Ontario, Canada. *Landscape Ecology*. 9:151–157.

Perfecto, I., Vandermeer, J. (2010). The Agroecological Matrix as Alternative to the Land-Sparing / Agriculture Intensification Model. Proceedings of the National Academy of Sciences of the United States of America 107, 5786–5791

Phalan, B., Onial, M., Balmford, A., and Green, R.E. (2011). Reconciling Food Production and Biodiversity Conservation: Land Sharing and Land Sparing Compared. Science 333(6047): 1289-1291

Planning Commission. (2009). Steps Towards Change: National Strategy for Accelerated Poverty Reduction II (Revised). FY 2009-11. Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Quasem, M.A. (2011). Conversion of agricultural land to non-agricultural uses in Bangladesh: Extent and

Rahman, M. M. (2011). Workshop on Climate Change and its Impact on Agriculture,Seoul, Republic of Korea, 13-16 December.

Rahman, M.R.; Shi, Z.H.; Chongfa, C. (2009). Land Use/Land Cover Change Analysis using Geo-Information Technology: Two Case Studies in Bangladesh and China.

International Journal of Geoinformatics, Vol. 5, Issue 2. 2009.

Rahman, M.T., Hasan, M.N. (2003). Assessment of shifting of agricultural land to non-agricultural land in Bangladesh, SRDI.

Rahman, S. (2010). Six decades of agricultural landuse change in Bangladesh: Effects on crop diversity, productivity, food availability and the environment, 1948–2006. *Singapore Journal of Tropical Geography,* 31, 254–269.

Riebsame, W.E., Meyer, W.B. and Turner, B.L. (1994). Modeling Landuse and Cover as Part of Global Environmental Change. *Climate Change,* 28: 45–64.

Ruiz-Luna, A. and Berlanga-Robles, C.A. (2003). Landuse, Landcover Changes and Costal Lagoon Surface Reduction Associated with Urban Growth in Northwest Mexico. *Land. Ecol.* 18:159–171.

Selcuk, R., Nisanci, R., Uzun, B., Yalcin, A., Inan, H. and Yomralioglu, T. (2003). Monitoring Landuse Changes by GIS and Remote Sensing Techniques: Case Study of Trabzon, http://www.fig.net/pub/morocco/proceedings/TS18/TS18_6_reis_el_al.pdf 5.

SOB (2013). 1: 25,000 Scale Topographic Map for Entire Bangladesh. Improvement of Digital Mapping System of Survey of Bangladesh (IDMS). Survey of Bangladesh. Ministry of Defence. Government of the People's Republic of Bangladesh.

Struhsaker, T. (1998). A Biologist's Perspective on the Role of Sustainable Harvest in Conservation. *Conserv. Biol.*, 12: 930–932.

Terborgh, J. (1999). *Requiem for Nature.* Island Press, Washington, D.C.

Turner, M.G. and Ruscher, C.L. (2004). Change in Landscape Patterns in Georgia, USA.*Landscape Ecology,* 1 (4): 241-251.

Uddin, K. and Gurung, D. (2010). Landcover Change in Bangladesh- A knowledge Based Classification Approach. 41-46 .

Uddin, M.; Anwar, M.; Rahman, M. and Mobin, M. (2014). An Iinvestigation on the Pattern of Landuse Change in Dhaka) a Cty Using Remote Sensing and GIS Application. *Journal of Environmental Science and Natural Resources,.* 7, 105–109.

WFP (2006). Technical Assistance to NGO's, in Rural Bangladesh, Socio-Economic Profiles of World Food Programme (WFP) Operational Areas and Beneficiaries; United Nations World Food Programme: Dhaka, Bangladesh, 1–190.

Wilson, G. (2010). Multifunctional 'Quality' and Rural Community Resilience. Transactions of the Institute of British Geographers 35: 364–381

Yuan, F., Sawaya, K.E., Loeffelholz, B., Bauer, M.E. (2005). Land cover classification and change analysis of the Twin Cities (Minnesota) Metropolitan Area by multi-temporal Landsat Remote Sensing. *Rem. Sen. Envi*. 98, 317–328.

Zhang, R., Tang, C., Ma, S., Yuan, H., Gao, L. and Fan, W. (2011). Using Markov chains to analyze changes in wetland trends in arid Yinchuan plain, China. *Math Computer Modelling* 54:924–930.