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Land-use changes of Kaliakair upazila of Bangladesh using Remote Sensing and GIS Technologies

KEYWORDS: Land use change, Remote Sensing, GIS, Crops, Forest covers, Urban areas.

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ABSTRACT *Land use and land cover changes of Kaliakair upazila, Bangladesh has been investigated using multi-date Landsat MSS/TM/OLI images of the year 1973, 1989 and 2014. ISODATA clustering as well supervised classification based on parallelepiped and maximum likelihood has been used to classify the dominant features such as green crops, forest vegetation, urban/built up areas and water bodies. The study has been complimented with GIS for inclusion of the settlement areas and features which could not be captured by 30 m resolution Landsat image using the aerial and google imagery. This has been done on the screen digitization. The analyzed image of 1973 showed only 15 hectares of built up areas, but in 1989 and 2014 a rapid increase of urbanization has been detected. It was around 161 hectare in 1989 and 2038 hectares in 2014. In 1973, the forest areas were around 2930 hectares but it has gradually reduced to around 2071 and 1617 hectares during the year 1989 and 2014 respectively. Boro rice was not present in 1973, but it has been found to be about 5471 and 8514 hectares in 1989 and 2014 respectively. The cause of such changes may be attributed to rapid population growth and speedy industrialization.*

1. Introduction

Land use is characterized by the activities of the people that involve using of lands for habitation, agricultural, forestry and industrial development and all sorts of small and large scale livelihood activities using lands of different cover types (FAO/UNEP, 1999). Often improper land use causes various forms of ecological imbalance and environmental degradation. Land use is a product of interactions between a society's cultural background, state, and its physical needs and the natural potential of land on the other hand. The human activities including industrialization, expansion of settlement caused the tremendous depletion of forest in Bangladesh. The expansion of population and need for increased food production and socio-economic development are the major drivers causing the land-use change in the country. Thus, it is of importance to map the land-use pattern and study the land-use and monitor the land cover changes. Such information is highly useful for planning the future land-use and industrial and urban development and management of natural resources.

Various techniques have been used for providing information about natural resource management. But use of remotely sensed data with the help of GIS may give the appropriate solutions for these problems in relatively small amount of time (Agarwal, 2000; Bakr, *et al*., 2010). For land-use mapping, supervised and unsupervised approaches are normally adopted for spectrally discriminate the surface features, well described in Campbell (2002), Kerle *et al*. (2004), Lillesand, *et al.* (2004), Jensen *et al.* (1996), Liu *et al.* (2002), Lunetta *et al*., (2004) and Coppin *et al*., (2004).

In this study attempt has been made to map the land use changes of Kaliakair upazila from 1973 to 2014 using Remote Sensing, GIS and GNSS technologies.

2. Study Area

Kaliakair is an upazila of Gazipur District in the Division of Dhaka, Bangladesh. It is located at 24° 00′ 25 .20″ to 24° 14′ 58.30″ N and 90° 00′ 04.65″ to 90° 21′ 23.70″ E. It is bounded by Mirzapur and Sakhipur upazilas on the north, Savar and Gazipur Sadar upazilas on the south, Gazipur sadar and Sreepur upazilas on the east, Mirzapur and Dhamrai upazilas on the west. The Bangshi river is almost dead. Haola and Makash Beels are notable. Population of kaliakair upazila is 165000, 232000, 267000 and 503000 in the census year of 1981, 1991, 2001 and 2011 respectively (*Population census 2011*). Figure 1 shows the Kaliakir upazila map of Bangladesh.

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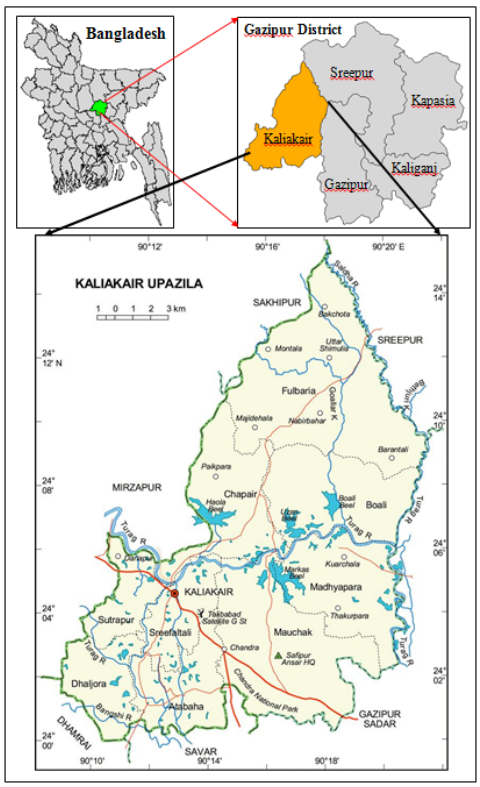

Figure1: Study area (Kaliakair upazila)

3. Data used and methodology

3.1 Remote sensing data

Landsat MSS data of 80 meter resolution of 1973, Landsat TM and OLI data of 30 meter resolution of 1989 and 2014 covering the study area have been used in the study. Table-1 shows the Landsat TM frame number & dates of study data and figure 2 shows the 137/43 frame of Landsat8, 2014 covering the study area. TM data downloaded from U.S. Geological Survey server (http://glovis.usgs.gov). All the captured data are converted to IMG format.

Table-1: Satellite data used in land use classification of Kaliakair Upazila

Satellite	Sensor	Number of spectral bands	Acquisition Date and Time		Frame
LAND-SAT	MSS	4	02021973	Around 09:45 (local time)	147/43
			09111973		
	TM	7	28011989		137/43
			13031989		
	OLI	8	30012014		
			30032014		
Ancillary Data	Aerial (Multi-spectral)	3	1983		
	Aerial (Panchro-matic)	1	2001		
	Google		2014		

3.2 Field survey data

GPS data collected from field for geo-reference as well as field verification of satellite data interpretation.

3.3 Ancillary data

Google imagery of 2014 has been used for small area settlement delineation using on the screen digitization. The aerial photographs have been used for 1983 and 2001collected from SPARRSO for the same purpose. The GIS layer of Upazila boundary of Bangladesh has been used for sub-setting the area of interest (Kaliakair upazila) from the digital Landsat frame of 137/43. Statistical data collected from the Bangladesh Bureau of Statistics (BBS) have been used for validation of remote sensing results. The field investigation has also been performed to validate the interpretation of the imagery.

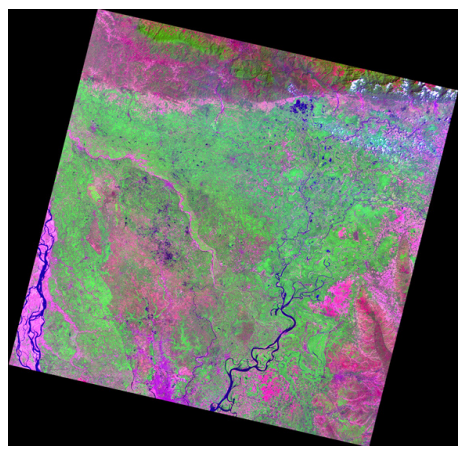

Figure 2: Atmospheric corrected and geo-referenced image of Landsat8 (OLI) 137/432 frame

3.4. Data analysis and preparation of land-use maps

The data analysis involves atmospheric correction ((Hadjimitsis et al., 2010), geometric correction, spectral classification and preparation land-use maps. For atmospheric correction, the method of dark water pixels having near-zero percent reflectance i.e., free from intervention of the parameters like turbidity has been used. For geo-referencing of the image, ten ground control points (GCPs) were collected using GPS reference the respective points in the imagery of 2014. The rest of the images were geo-referenced using the image of 2014 as the base image.

The multi-temporal Landsat imagery has been used which helps identification of perennial and seasonally varying features of land-use. The RGB false colour composite has been prepared for visualizing the land features. Then the multi-spectral classification using unsupervised (ISODATA) and supervised classification (Parallelepiped and Maximum Likelihood techniques) and results have been compared. Based on the field investigation and secondary data, it is found that the supervised classification using maximum likelihood provide best results. The major classes such as forest, settlement, urban/built-up areas and crop lands have been identified through interpretation of the classified imagery based on spectral signature, field information, data collected from BBS and visual interpretation of Google images and aerial photographs. Different steps of preparation of land-use maps have been given in Figure-3.

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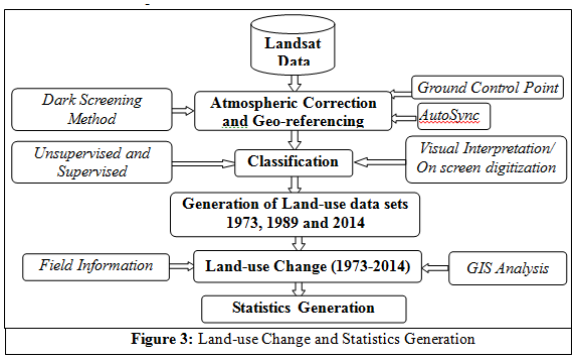

Figure 3: Land-use Change and Statistics Generation

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4. Results and Discussions

Changes of land-use such as settlement, forest, agriculture, water bodies, urban area have been analyzed based on the visual interpretation and multispectral digital classification of Landsat imagery. The results of the analysis are discussed below.

4.1 Visual Interpretation of Temporal Images of Kaliakair upazila

The false colour composite imagery (FCC) of 3 February, 1973, 13 February, 1989 and 30 January, 2014 has been shown in Figure-4. It is seen that the vegetation appear green, land areas light yellow and water blue. In the image of 2014, the built-up area is found to have magenta color. Figure-5 compares the FCC (7, 4, 2) of 30 January and 30 March 2014 with a temporal gap of 2 months.

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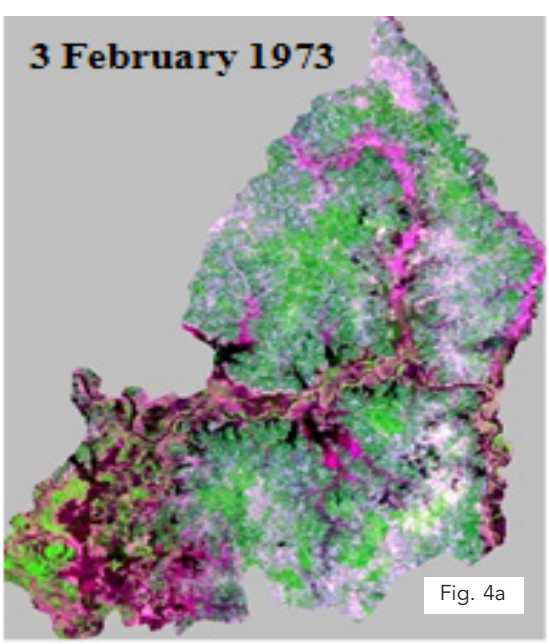
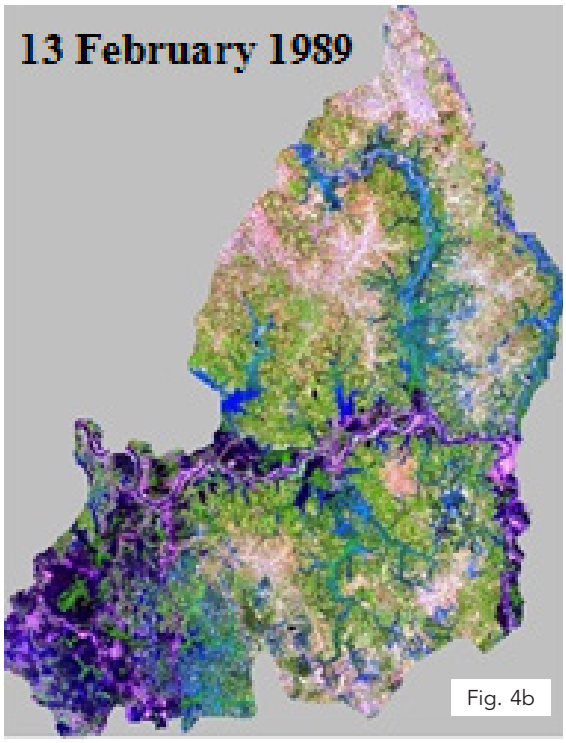
The imagery demonstrates the dynamic change of surface feature. It is clearly seen that the some areas which are seen to have water, has been covered by green vegetation (boro rice) in 30 March. Some areas, which were found to have green vegetation in 30 January have been found to be harvested and then have the signature of bare soil. The dark green tone appearing in both the images indicate the forest and settlement areas.





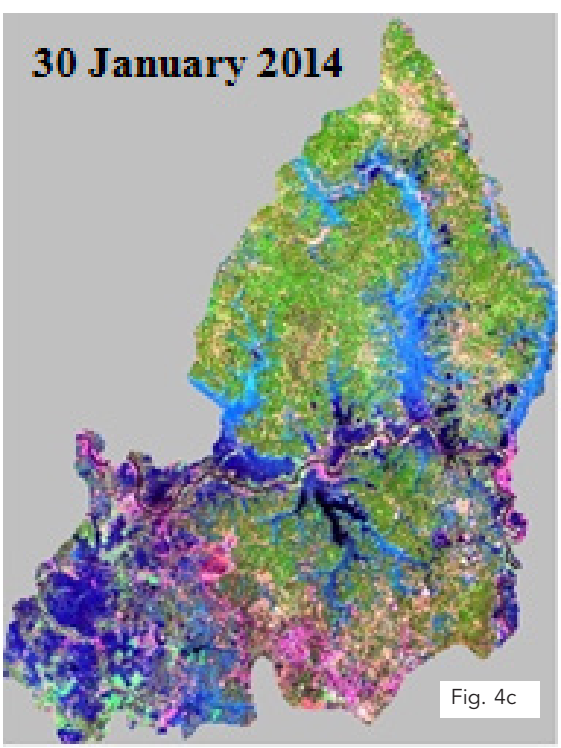


Figure-4: Extracted FCC 5(R), 7(G), 4(B) images of Kaliakair Upazila during 1973, 1989 and 2014.

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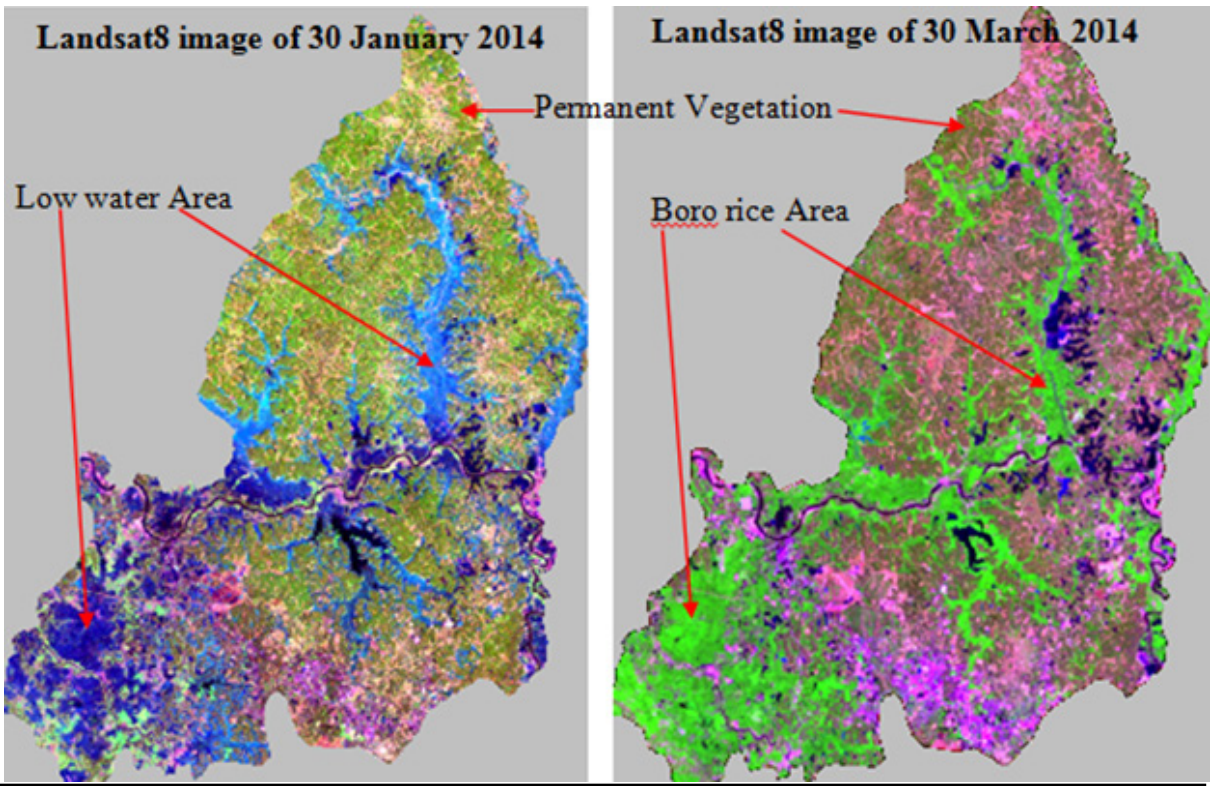

Figure 5: Multi-temporal FCC (7, 4 and 2) of Landsat8

4.2 Preparation of Land-use maps

For preparing the land-use maps for the year 1973, 1989 and 2014, the multi-spectral classification of the imagery of the respective years has been performed. On comparing the results, it is found that the supervised classification provides the best results. The major land-use classes were identified in the classified imagery based on the spectral signatures. The features such as settlement and built-up areas which are not captured by Landsat imagery are obtained through on-screen digitization of aerial photographs and google imagery. Using GIS technology, the layers generated by satellite data interpretation and on screen digitization are stacked together and the land use maps are prepared (Figure-6, 7 and 8). The area coverage of the land-use features are then calculated for the reference years and displayed in Table-2. The year-wise discussions of the land-use maps are described below.

a)Land use of 1973

The land-use map (Figure 6) shows that, five broad types of land use of Kaliakair upazila in the year 1973. It is clearly seen from the table 2 that in 1973 area of settlement occupied maximum about 11117 hectares and built up area was minimum about 15 hectares only. Multiple crops/bare land area was observed about 10756 ha. Water bodies were almost double about 6000 hectares compare to forest area. Boro rice was not visible during this time.

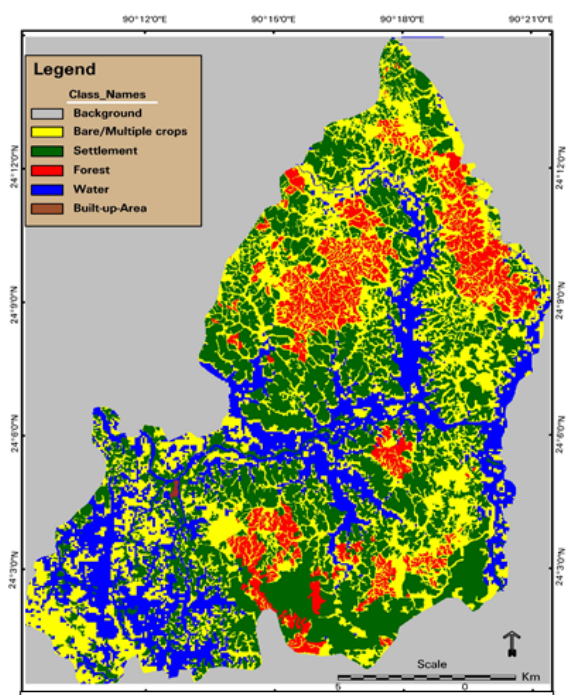

Figure 6: Land-use map of 1973

b)Land use of 1989

In 1989, observation and data analysis shows that seven broad types of land use of Kliakair upazila (figure 7). It is clearly seen from the table 2 that in 1989 area of settlement occupied also maximum about 12293 hectares and built up area was minimum about 171 hectares. Multiple crops/bare land was observed about 8189 ha. Boro rice plantation activities were found about 5471 hectares. Water area was about 2563 hectares and forest found about 2071 hectares.

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c)Land use of 2014

In 2014, data analysis shows that land use of Kliakair upazila (figure 8). It is clearly seen from the figure 8 and table 2 that, in 2014 area of settlement occupied maximum about 11020 hectares and water area was minimum about 1501 hectares. Boro rice area was observed about 8514 hectares. Multiple crops area was found about 6054 hectares. Forest area was found less about 1617 hectares compare to developed area about 2038 hectares.

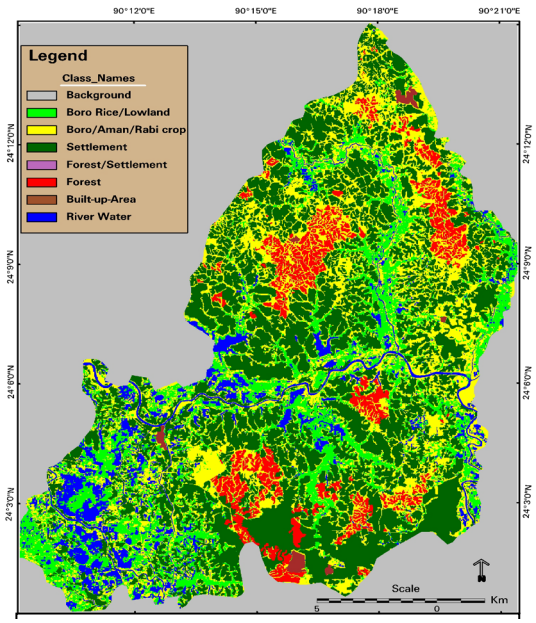

Figure 7: Land-use map of 1989

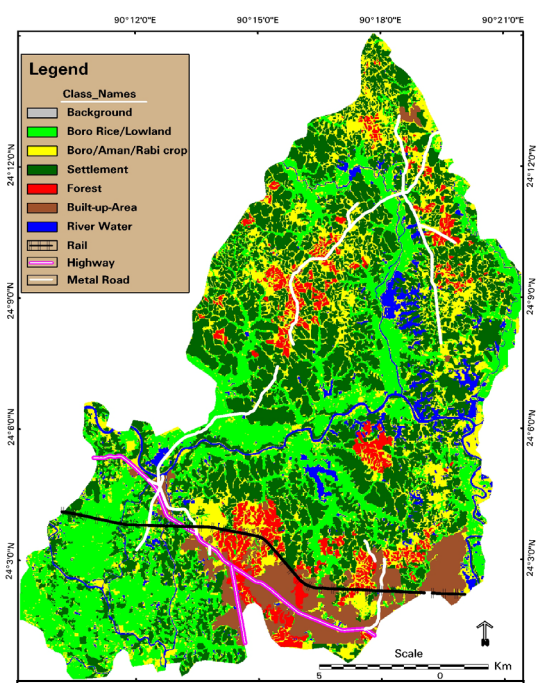

Figure 8: Land-use map of 2014

Table 2: Land use changes, Area in (ha) and % of coverage during 1973, 1989 and 2014

Land Use	Season-wise Area (ha) and Percentage (%)		
	1973	1989	2014
Water	6016.11 (19.51)	2563.46 (8.34)	1500.56 (4.88)
Bare/Multiple Crops	10756.14 (34.88)	8189.31 (26.63)	6054.6 (19.69)
Only Boro		5471.17 (17.79)	8514.10 (27.69)
Settlement	11117.00 (36.05)	12293.48 (39.98)	11020.98 (35.85)
Forest	2930.20 (9.50)	2071.01 (6.74)	1616.65 (5.26)
Built up Area	15.13 (0.05)	160.96 (0.52)	2038.38 (6.62)

4.3 Land use changes 1973 to 2014

It is clearly seen from the table 2 that, during the year 1973, 1989 and 2014, the area of settlement occupied maximum about 11117 hectares, 12293 hectares and 11021 hectares respectively. Observation and data analysis shows that during 1973 to 1989 decreased of settlement due to increasing of population (*Population census 2011)* and during 1989 to 2014 decreased of settlement due to rapid increasing tendency of built up area.

Built up area was found about 15 hectares (0.05%), 161 hectares (0.5%) and 2038 hectares (6.62%) of total land during the year 1973, 1989 and 2014 respectively. Data analysis observed that about 1040% increased of built up area in between 1973 to 2089 and about 1273% in between 1989 to 2014 due to rapid increasing of industrialization. Most of the built up areas are visible in south, south-east part of the Kaliakair upazila (figure 8) but a number of scattered industry was also observed inside forest during the field visit.

Boro rice was not visible in 1973 (table 2) because during this time Boro rice plantation activities were not established. Agriculture extension office and local people also gave same statement during the field visit. Boro rice plantation activities were observed about 5471 hectares (**17.79%)** and 8414 hectares (**27.69%**) of total land during the year 1989 and 2014 respectively (table 2).

From bar diagram (Figure 9), it is clearly seen that water bodies, bare/multiple crop area and forest area are decreasing during 1973 to 2014. On the other hand Boro rice area and build up areas are increasing tendency during the same period. Bar diagram also shows that during 1973 to 1989 increasing trend of settlement and during 1989 to 2014 decreasing trend of settlement.

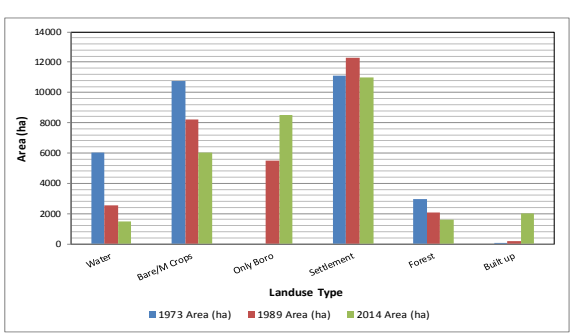

Figure 9: Bar diagram of different land use type during 1973, 1989 and 2014

5. Conclusions and Recommendations

The study shows that the Landsat multi-date and multi-spectral imagery in association with high resolution aerial photographs and Google images are capable of high quality land-use maps.

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The land-use maps have been produced for Kaliakoir upazila for 3 time frames 1973, 1989 and 2014. The broad land-use features identified are forest, settlements, agriculture, urban/built-up areas and water bodies. The results show large changes in the forest and built-up areas. The area of forest has decreased and that of built-up area has increased. Study reveals that about 2023 hectares area of land has been converted urban area during the last 41 years (1973-2014). About 1324 hectares forest converted to settlement as well as urban area. The area of water bodies in 1973 was about 6000 hectare but it decreased to about 2563 hectare in 1989 and about 1500 hectare during 1989 to 2014. The cause of intensive land use changes of Kaliakair Upazila may be attributed to rapid increase of population and industrialization.

For future development planning and developing land-use strategies and policies the past and current land-use maps of whole country of Bangladesh would be highly useful as base information. The satellite technology offers the best and quickest means of preparing such land-use maps and monitoring the land-use dynamics. This study demonstrates the usefulness of landsat or similar remote sensing data for country wise land-use mapping and change detection.

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