

Land use and land cover change detection at Mirzapur Union of Gazipur District of Bangladesh using remote sensing and GIS technology

R Yesmin¹, A S M Mohiuddin¹, M J Uddin¹, and M A Shahid²

¹Dept. of Soil, Water and Environment, University of Dhaka, Bangladesh.

²Bangladesh Space Research and Remote Sensing Organization (SPARRSO), Bangladesh.

Email: mjuddin66@yahoo.com

Abstract. A study was conducted with a view to identify and quantify the changes in land use and land cover occurred during the last 20 years at Mirzapur Union of Gazipur district of Bangladesh using remote sensing and GIS technologies. Two LANDSAT TM images of 1989 and 2009 with 30mx30m spatial resolution were used to determine the temporal land cover changes. Subsequently, a ground verification was done in the study site. The study revealed that forest cover was decreased by 20.29 % and settlement area was found to increase by 28.64% and water bodies was decreased by 6.25 %. In the same period of time, bare land was found to increase by 20.91 % due to the effect of clearing of forest area which is not replanted again. A lot of new infrastructures has been built by this time. Population pressure becomes double enhancing the deforestation of Sal (*Shorea robusta*). Most prominent features are the emergence of brick fields and various industries. Thus, the above study demonstrated the usefulness of RS and GIS technology regarding resource management and urban planning.

1. Introduction

Land is one of the most important non-renewable natural resources. The continuous growth of population exerts a serious pressure on land which is associated with agricultural demand and use, urbanization and economic development, science and technology etc. These all are accelerating the global warming and associated devastating impacts on limited land and other natural resources. So land use and land cover (LULC) change is a major issue of global environmental change and an important field in this area of research. Timely and precise information on land use and land cover change detection of earth's surface is extremely important for understanding relationships and interactions between human and natural phenomena for better management of natural resources and in decision making. So land-use/land-cover change is an important field in global environmental change research. Inventory and monitoring of land-use/land-cover changes are indispensable aspects for further understanding of change mechanism and modeling the impact of change on the environment and associated ecosystems at different scales [1-2]. To detect land use and land cover change, a comparison of two or more satellite images acquired at different times can be used to evaluate the temporal or spectral reflectance differences that have occurred between them [3]. The results quantify the land cover changes and demonstrate the potential of multi temporal Landsat data to provide an accurate, economical means to map and analyze changes in land cover in a spatio-temporal framework. It is also used as inputs to land type for management and policy decisions with regard to



varied themes that has link with space such as urbanization, watershed management, deforestation, land degradation and so on.

The aim of this study is to monitor and analyze the spatio-temporal land use/land cover change patterns in Mirzapur union of Gazipur district in Bangladesh using multi-temporal Landsat imageries for the past 20 years (1989-2009).

2. Materials and methods

The study area, Mirzapur union of Gazipur district of Bangladesh (Figure 1) has been selected because migration of huge population is seen as because, it is very near to Dhaka mega city. It carries a good site for urban development center. As a result of population pressure, the local people are destroying forest, trees and valuable cultivable land for making various industries and brick fields etc. As a result, the forest area is gradually decreasing and the environment is changing significantly. Considering the above situations, two Landsat satellite image TM (Thematic Mapper) at resolution 30x30 m (projection: Bangladesh Transverse Mercator) were used in the present study. Some secondary data sources were also used such as topographical, soil and physiographic etc. The image related methodology adopted for this study involves both the Digital Image Processing (DIP) and GIS analysis. DIP was carried out in the computer system having the following software configuration; ERDAS IMAGINE- Image Processing Software was used for geo-referencing, classification, enhancement of the images and other related processing (Version 9.3). ARC Info Software was used for digitizing, displaying and analyzing all the vector layers. Landsat TM 1989 and 2009 were preprocessed to remove data errors and anomalies. Digital image processing system was executed to calculate the land cover (Figure 2).

2.1 Geo-referencing

Each of the images was geo-referenced. A sufficient number of Ground Control Points (GCPs), which were readily identifiable on the image and on pre-rectified image, were selected for calculations of a least-square fit, and the results were then used to adjust the image to image coordinates. Preferred GCPs were taken from recognizable, permanent features such as road intersection, pond, large building and the points were well dispersed for accurate rectification. The images were projected on to a plane, then rotated and scaled to a map projection system. For each image transformation, a root square means (RMS) error was calculated. The maximum RMS error was 1.5 pixels. This corresponds to a ground distance of 45 m for the TM images. Using this procedure, each raw satellite image was resampled, using the nearest neighbor algorithm, and transformed in to a file referenced to the Universal Transverse Mercator (UTM) projection.

2.2 Classification

A digital classification scheme was developed which categorized major land cover types (water bodies, forest, settlement, and bare land). Digital satellite images were classified using image processing techniques to enable the assignment of land cover classes to areas of similar spectral characteristics. Both supervised and unsupervised methods of classification were done. Unsupervised classification was based on ISODATA algorithm available in the ERDAS Imagine software. While the supervised classification method was based on maximum likelihood algorithm. The following chart depicts the techniques used to obtain land cover classes in vector form (Figure 3).

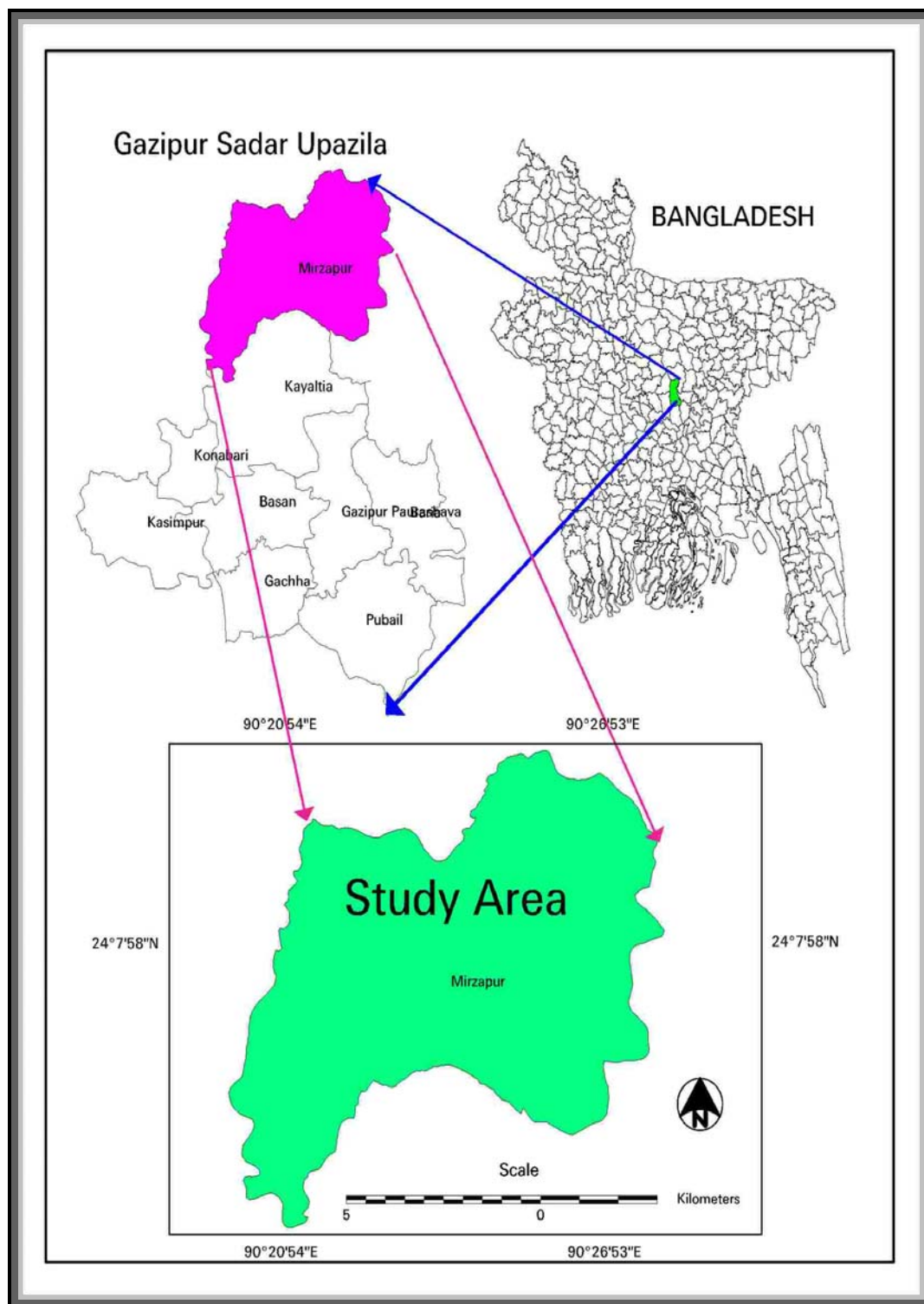


Figure 1. Location map of study site (Mirzapur Union of Gazipur District).

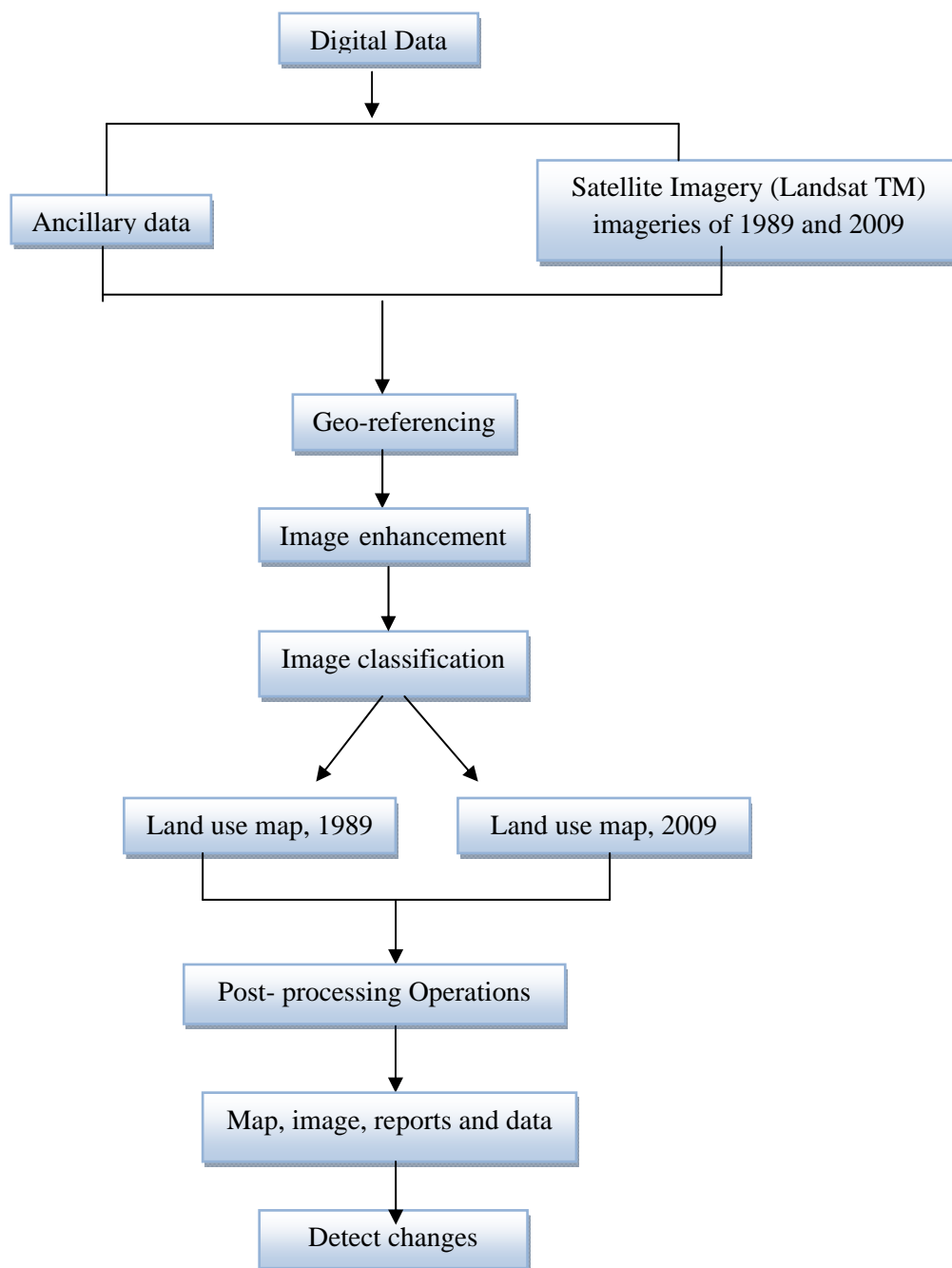


Figure 2. Depicting methods and procedures used in the study.

Unsupervised classification of TM images for 40
classes with signature file generation

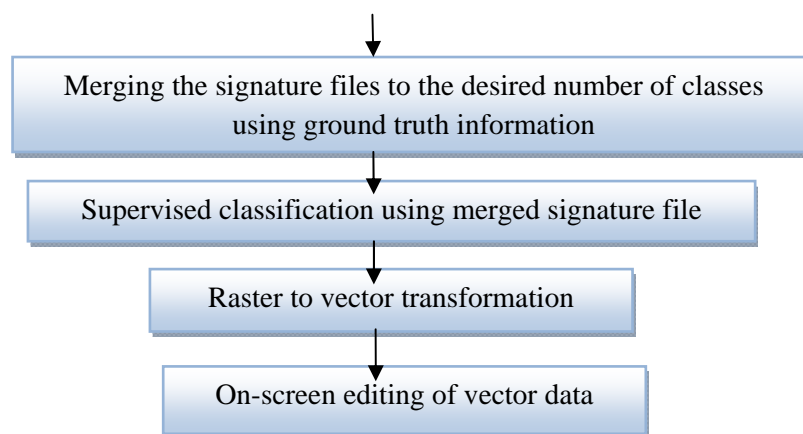


Figure 3. Techniques used to obtain land cover classes.

Four broad land cover classes were assigned each of the two images in time series: settlement, water body, forest, bare land (fallow land). To verify the land cover classes in the field the authenticity of the class boundary were checked. The location positions with latitude and longitude were noted down and geo-features characteristics were recorded in the field and then independently these records were examined whether the interpreted classes in the maps were right or wrong. Area calculation of the final four classes was done for both of the images.

3. Results and discussion

A classified image of the land cover 1989 (Figure 4) and 2009 (Figure 5) were done where four classes of land cover were identified and interpreted such as forest area, settlement, water bodies, bare (Fallow) land. The class forest was consisting of mainly Sal forest (*Shorea Robusta*). Adjacent crop fields and trees were included in settlement because of lower resolution of the images. The forest was identified in the satellite images due to its color in the images and by the knowledge of the position of the Sal forest in the study area. In 1989, about 2986.74 ha or 34.35% land was found to be occupied with forest area which was declined to 2380.59 ha or 27.38% in the year of 2009 (Figure 6). Within this 20 years period, the forest was decreased by 606.01 ha or 20.29%. The main cause of deforestation is the expansion of agricultural land which results clearing of forest cover especially in the plane areas where the highest population density exist. After deforestation some part of *Madhupur* forest has been converted to banana and pineapple plantation [4]. Some of the deforested area has been converted to rubber garden by the government. Population and economic pressures are two prominent factors leading to clearing of forests [4].

Settlement or homestead was appeared in all part of the study area and it was found to be lean, semi-compact, compact and semi-sprinkled pattern. The land cover class settlement includes houses, markets, shops, adjacent lands and associated trees, crop land, road and industrial area etc. Extensive

areas of settlement were found to be mixed with vegetation. In the satellite images, settlement class was appeared as mixed color. In 1989, area occupied by settlement was 3959.55 ha or 45.54%. In 2009, the area occupied by settlement was 5093.10 ha or 58.58% of the total area. So, settlement area was increased by 28.64% between 1989 to 2009 (Figure 6). Population census report by BBS (2009) also indicates the increasing trends of population by those years [5].

Water bodies were identified in images by dark tone (blue, black color in classified images) that reflects very little amounts of light that varies upon turbidity (the higher the turbidity, the higher will be the light reflectance and lighter will be the color). Water bodies also identified by their shape, as rivers are appeared meandering and pond are rectangular in shape. In 1989, area of water bodies was occupied by 445.41 ha or 5.12% of total study area. In 2009, the areas occupied by water bodies was 413.46 ha (4.8%) So, water bodies were found to have decreased to 31.95 ha or 6.25% of the total area (Figure 6). The results were in well accordance with the findings of the authors [6, 7]. According to semi detailed soil survey data of SRDI [8]. Landsat TM image data revealed that the water bodies in terms of area coverage prevailed a decreasing trend in Savar Upazila of Bangladesh over time [9,10]. This change might take place due to sedimentation/siltation, shifting of water flow direction and rising of river beds.

Bare/Fallow land showed a white signature and fine grain size of the sands formed smooth surface. Low moisture content of bare soil (due to dry season) appeared to be in brighter tone than that of the other features. In 1989, bare land area was 669.33 ha or 7.7% and in 2009 it was 809.91 ha or 9.31% in 2009. The result indicated that the bare land was increased by 140.58 ha (20.91%) during the last 20 years (Figure 6). The causes of increasing bare land might be due to clearing of forest area for fuel and other purposes. Baid or lowland depression which was identified in the satellite images due to its shape. From the TM image analysis, the feature baid in 1989 was 1856.52 ha of total study area (21.35%) where in 2009, the area was 1156.86 ha (13.30%) which was found to be decreased by 699.66 ha (37.71%) (Figure 6). In most cases, this baid area was occupied by settlement which was due to increasing pressure of population. In Mirzapur union, brick fields were dominantly observed in both sides of the bank of the river Lubundaha where part of wetland turned into fallow lands. In these areas, brick fields are increasing day by day as the urbanization is going fast in the study site.

4. Conclusion

A significant change was detected in land use and land cover in the Mirzapur union of the Gazipur district of Bangladesh during the last 20 years (1989-2009). The changes occurred in different land covers like forest, water bodies were decreased by 20.29%, 6.25% respectively and where settlement (homestead), bare land (fallow land) were increased by 28.64% and 20.91% respectively. All of these changes were absolutely due to the increase of population or unplanned urbanization destroying the local forest resources.

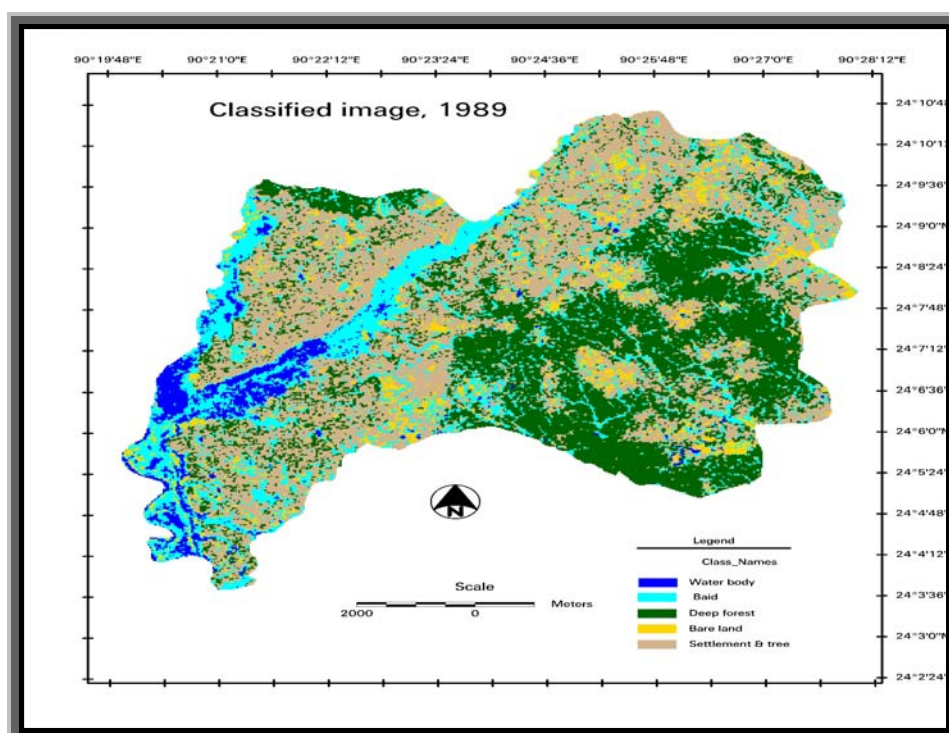


Figure 4. Land cover map of the year 1989.

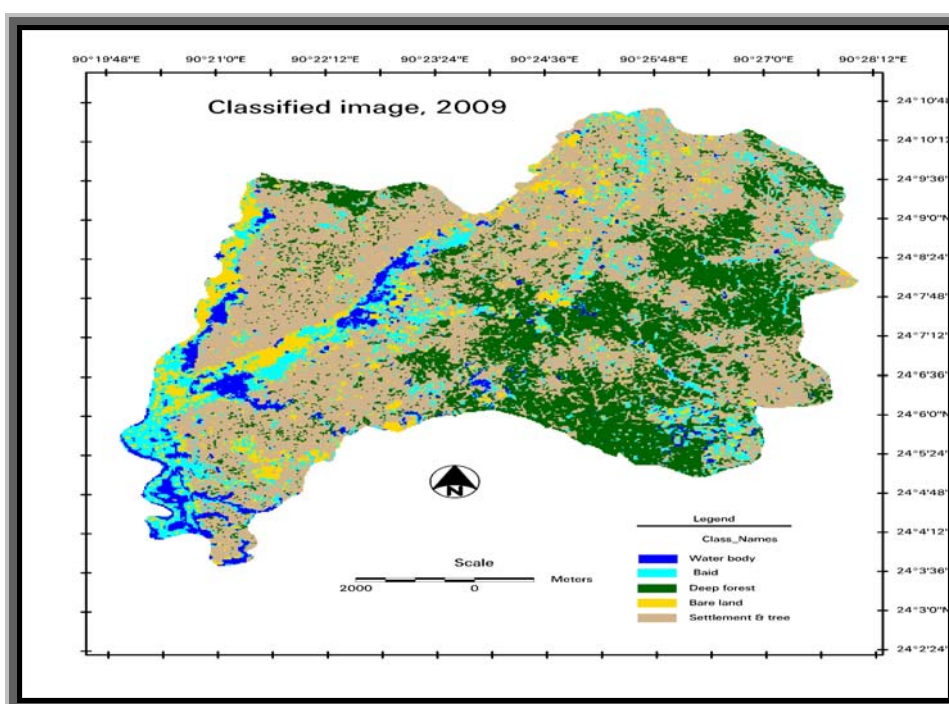


Figure 5. Land use and land cover map of the year 2009.

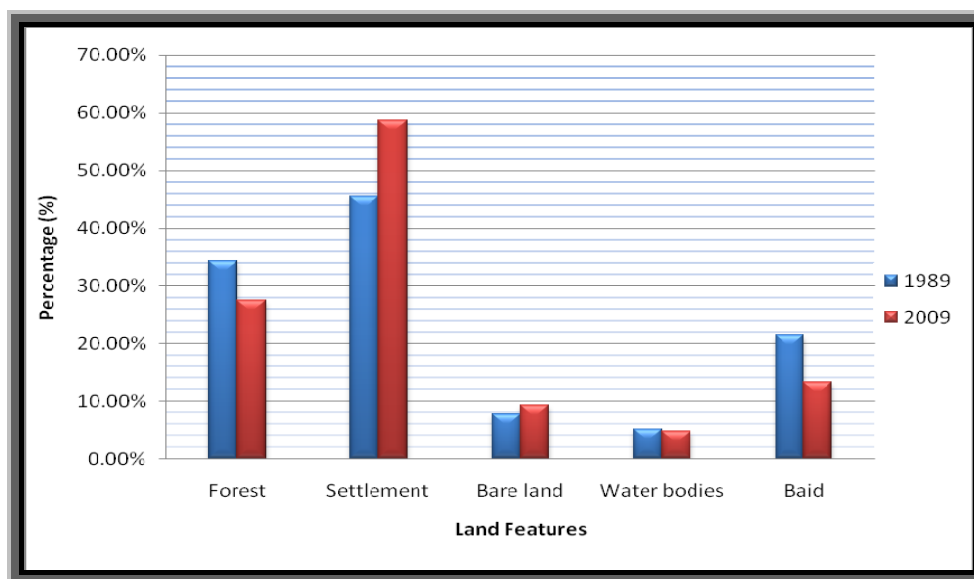


Figure 6. Land cover change in the Mirzapur Union Over the years 1989 and 2009.

5. References

- [1] Tunner B L, II Skole D, Sanderson S, Fischer G, Fresco L and Leemans R 1995 *Land use and land-cover change; Science/Research Plan*. IGBP Report No. 35. HDP Report No. 7, International Geosphere-Biosphere Programme, Stockholm, Sweden, 132p.
- [2] William E, R William B M and Turner B L 1994 *Modeling land use and land cover as part of global environmental change*. *Climatic Change*. **28**: 45–64.
- [3] Yuan D and Elvidge C D 1998 Land cover change detection pilot study: Washington D.C area experiments. *Remote sensing of environment*. **66**: 166- 78.
- [4] Uddin K and Gurung D R 2010 *Land cover change in Bangladesh: A knowledge based classification approach*. 10th International Symposium on High Mountain Remote Sensing Cartography, International Center for Integrated Mountain Development, Kathmandu (ICIMOD). Khumaltar, Lalitpur. Nepal. Pp.41-46.
- [5] BBS 2009 Population Census of Bangladesh. Community Series: Zila-Dhaka. *Statistical Yearbook of Bangladesh*. Bangladesh Bureau of Statistics (BBS). Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.
- [6] Momtaz F 2009 *Remote Sensing and GIS techniques in land use and land cover assessment of Savar Upazila with detailed classification of Amin Bazar union and Sarulia mouza*. MS thesis. Dept. of Soil, Water and Environment. University of Dhaka. Bangladesh.
- [7] Akhter S 2009 *Assessment of land cover change in Savar Upazila with detailed land cover study at Kaundia union and Birulia mouza: A RS-GIS Approach*. MS Thesis. Dept. of Soil, Water and Environment. University of Dhaka. Bangladesh.
- [8] SRDI 1992 *Land and Soil Resource Utilization Guide of Gazipur Sadar Upazila*. Soil Resource Development Institute (SRDI). Ministry of Agriculture. Bangladesh.

- [9] SPARRSO 1997 *Annual report. Bangladesh Space Research and Remote Sensing Organization (SPARRSO)*. Ministry of Defense. Bangladesh.
- [10] SPARRSO 2006 *Annual report. Bangladesh Space Research and Remote Sensing Organization (SPARRSO)*. Ministry of Defense. Bangladesh.