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Lake configuration and change detection studies using Remote Sensing and GIS Techniques: A Study on Bogakine Lake, Bandarban, Bangladesh

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Abstract

Bogakine Lake popularly known as Boga Lake is a natural lake in the hill district of Bandarban. This lake is situated in Remakriparansa union under Ruma upazila, Bandarban, Bangladesh. The lake is rectangular. It is bounded on three sides by mountain peaks covered with thick bamboo bushes. It is a closed lake and there is a small spring named Boga chhara, which is 153m deep. There is no outlet for draining out water from the lake. The lake is composed of the soft rocks of the Bhuban Formation. The main source of water is the spring. The configuration and change detection study of the lake is done using remote sensing and geographic information system (GIS). Global Positioning System (GPS) is used for water depth point positioning, depth was measured using sounding method and Google Earth high resolution satellite imagery is used as the basic data source for this research. The lake depth map and 3D Mesh diagram has been generated using field depth data, which serves as the additional data source. The surface change detection is performed using Google Earth newly provided historical imagery options. Bogakine Lake and its adjacent area landuse map is derived from Google Earth imagery. In addition, surface elevation profile in different directions of lake, bathymetric mapping with bottom topographic profile, lake surface area and lake water volume has also been calculated using remote sensing and GIS techniques. The present study using geospatial technology on Bogakine Lake reveals that the lake area is 18.56 acres or 7.39 hectare (2010 Google Earth imagery) and the surface elevation of lake is not similar and it varies from 368 m to 389 meters.

Key words: Bogakine Lake; 3D mesh; Bathymetric map; Remote Sensing; GIS.

Introduction

Bogakain Lake popularly known as Boga Lake is a natural lake in the hill district of Bandarban. This lake is situated in Remakriparansa union under Ruma upazila, Bandarban, Bangladesh. The spatial extent of the study area in between 21^0 $58^/$ $40.286^{//}$ to 21^0 $58^/$ $57.02^{//}$ N latitude and 92^0 $27^/$ 55. $565^{//}$ to 92^0 $28^/$ $29.74^{//}$E longitude. Fig. 1 & 1a & b shows the location map of the study area. The lake is rectangular. It is bounded on three sides by mountain peaks covered with thick bamboo bushes. It is a closed lake and there is a small spring named Boga chhara, which is 153m deep. There is no outlet for draining out water from the lake. The lake is composed of the soft rocks of the Bhuban Formation. The main source of water is the spring. However, there are also other sources such as rainfall, surface drainage and spring seepage. The water of the lake is highly acidic, so no weed or plant can grow there. The lake attracts tourists because of its scenic beauty but it is inaccessible by any means of transport.

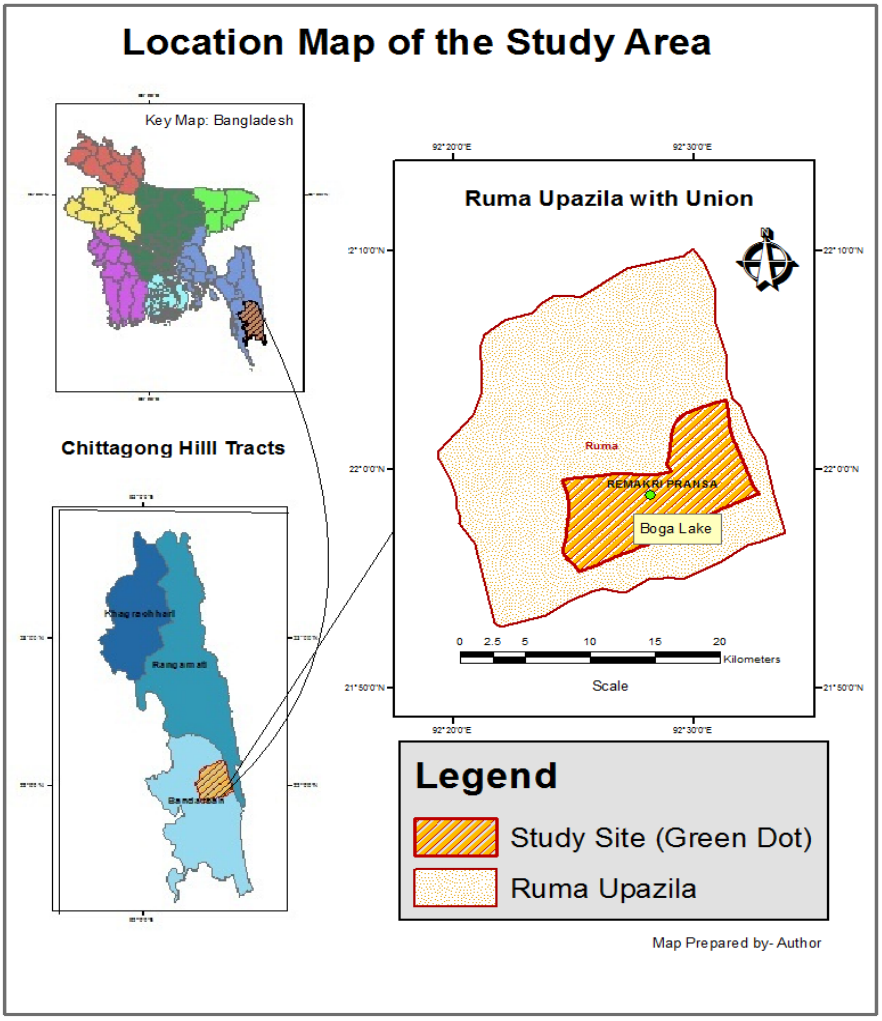


Fig 1: Location map of the study area

Source: Google earth-6.0v
(a)

Source: Google maps
(b)

Fig. 1(a) The satellite imagery of the Bogakine Lake and its adjoining areas and (b) the Terrain in and around the lake.

Objectives

The objectives of this study include:

- Identification of Bogakine lake and area delineation from Google earth satellite imagery
- To measure water depth of bogakine lake using sounding method with GPS survey
- To produce a contour map of bogakine lake on the basis of depth point data
- To know the lake bottom topography based on transect profile drawing in different direction of the lake and water volume calculation from surface to bottom considering its varied depth
- To detect change in the lake configuration and land use pattern of Bogakine lake and its adjoining areas based on Google earth satellite imagery (from 2003-2010) and recent field survey.

Database and Methodology

In order to study the lake configuration and landuse changes of Boga Lake and its adjoining areas, Google earth 6.0v high resolution satellite imagery based on 850 m eye altitude was considered. Using Google earth historical imagery facilities, three different time period satellite imagery (2003, 2009 and 2010) was finally considered for lake configuration and landuse change detection study. Particulars of the data are given in Table 1. Before acquisition of historical imagery using sliding bar four (4) place marks (co-ordinate information) was placed on satellite imagery in four (4) corners and the details are given in Table 2.

Table 1: Data information

Platform	Image Type	Bands	Date of Acquisition	Spatial Resolution
Google earth-6.0	JPEG	RGB (3,2,1)	Jan 2003	850m
Google earth-6.0	JPEG	RGB (3,2,1)	Nov 2009	850m
Google earth-6.0	JPEG	RGB (3,2,1)	March 2010	850m

Source: Google earth-6.0v (Historical imagery archive)

Table 2: Co-ordinate value of Google earth satellite image (Boga lake and its adjoining areas)

Placemark Name	Latitude	Longitude	Source
"B1"	21.9820722651	92.4648758789	Google earth
"B2"	21.9820420337	92.4744905618	Google earth
"B3"	21.9780558192	92.4744905618	Google earth
"B4"	21.9780251888	92.464949952	Google earth

Source: Google earth-6.0v

During field survey, water depth data was collected by boating and applying sounding techniques along with hand-held Garmin-GPS device. The data was finally used for water depth point positioning on Google earth satellite image. A contour map was generated using these depth data and the water volume was also calculated using this varied depth data (surface to bottom).

The Google Earth temporal imageries were supplemented with collateral information and ground surveys. The basic GIS and RS techniques followed were image geo-referencing, processing and interpretation and analysis using the softwares ERDAS IMAGINE 10 and Arc GIS 10 and Petrosys. Finally all the data were integrated in the GIS software to generate lake configuration and landuse maps and charts to understand landuse changes of the Boga lake and its adjoining areas. An attempt has also been made to develop bottom topographical structure by transect drawing and surface elevation profile developed based on transect drawing at different directions of the lake using Google earth newly added automatic surface elevation profile drawing options. A 3D mesh model of the Bogakine lake was also prepared to know its three-dimensional (3D) configuration. An overview of the inter-linked methods used in the study is presented in the following flow chart model Fig. 2.

Flow chart of Methodology

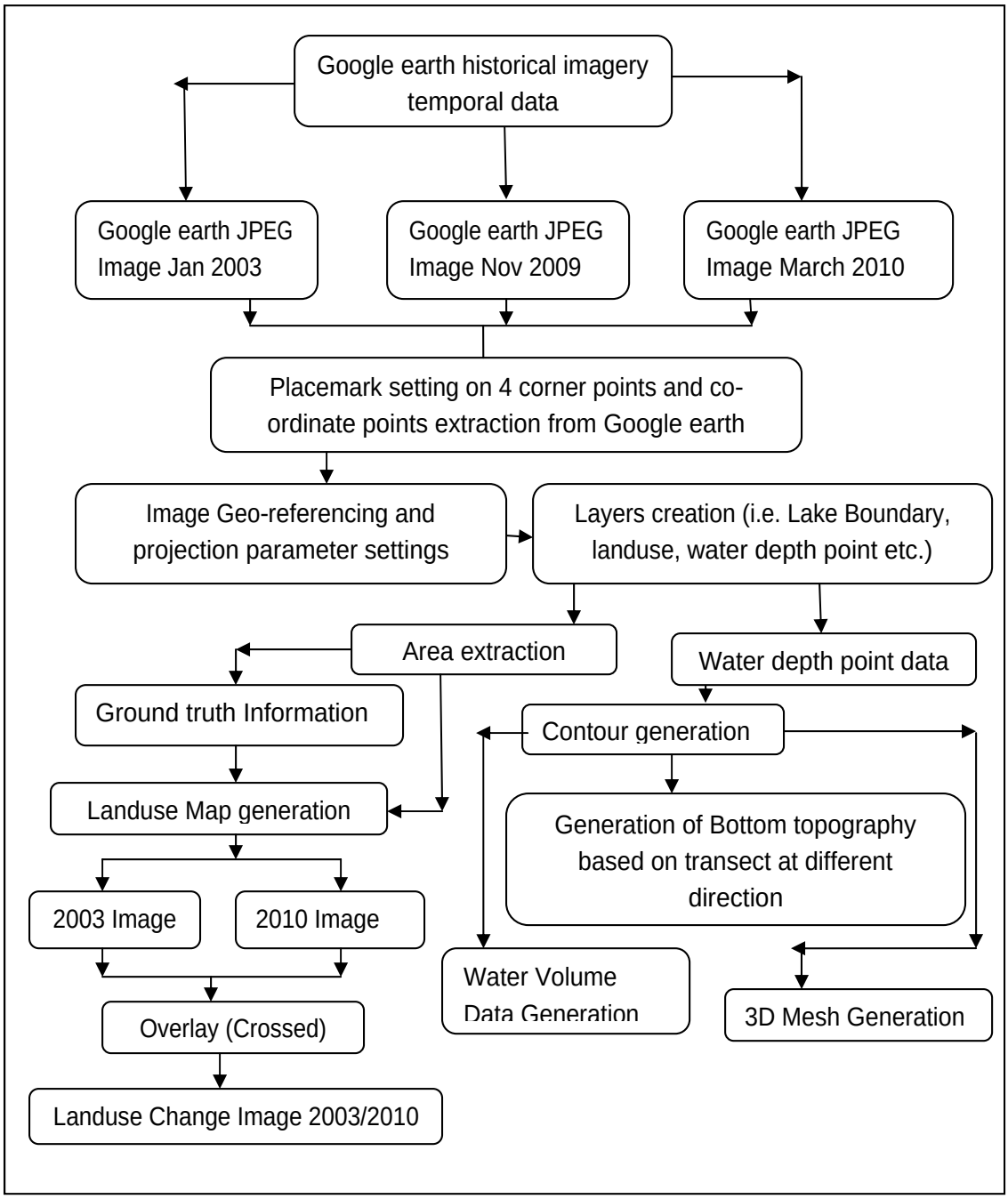


Fig. 2: Flow chart depicting methods and procedures used in the study

Result and Discussion

Map products derived from remote sensing are usually critical components of a GIS. Remote sensing image is an important technique to study both spatial and temporal phenomena. Through the analysis of remotely sensed data, one can derive different types of information that can be combined with other spatial data within GIS. The integration of the two technologies creates a synergy in which the GIS improves the ability to extract information from remotely sensed data and Remote sensing in turn keeps the GIS up-to-date with actual environmental information. Like in all models,

however, both maps and thematic data are abstractions or simplifications of the real world.

The lithological components of the area clearly show that the area is a part of fore-arc basin. Naturally it will be devoid of any considerable volcanism. Volcanic rocks are only located in the northwestern part of Bangladesh (Khan, 2000). Generally volcanic lakes are circular/elliptical in shape (Sigurdsson, *et. al*), but Boga lake is rectangular in shape (Fig.3 a). Volcanic lakes are formed at the top of the volcanic cone that is at the crater. The topographic contour pattern does not reveal any cone shape with a sharp cut at the top (Fig.3 b).

Topographic pattern at the bottom of the lake is very much interesting, it shows a NNE-SSW trending strong lineament (along B1 transect, Fig.3b). Several profile sections are prepared to understand the nature of the lineament. B2 transect is taken across the trend line of the lineament (Fig.3b) and it shows a fault like pattern with left side going down (Fig. 3c). Occurrence of this type of faults in this area is common, lineaments occur in conjugate set in this region (Nandy, 2001). Orientation of the lineament in the lake is matching with the fault system as well as the lineament pattern of the area. Considering all the points discussed above we may conclude that the origin of the lake is associated with fault and the major lineament is the actual fault line.

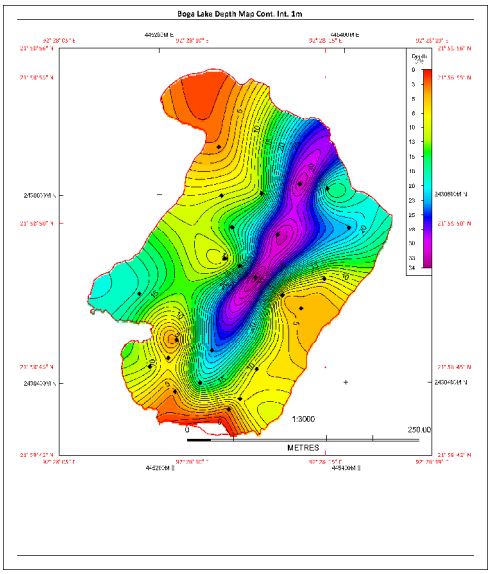


Fig 3 (a): Contour map generation based On Water depth data

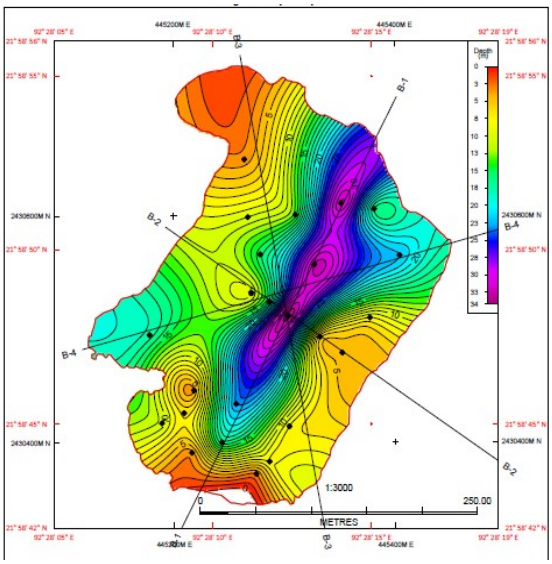


Fig3 (b): Transect Line Construction in different direction of Lake to know the Bathymetric Profile

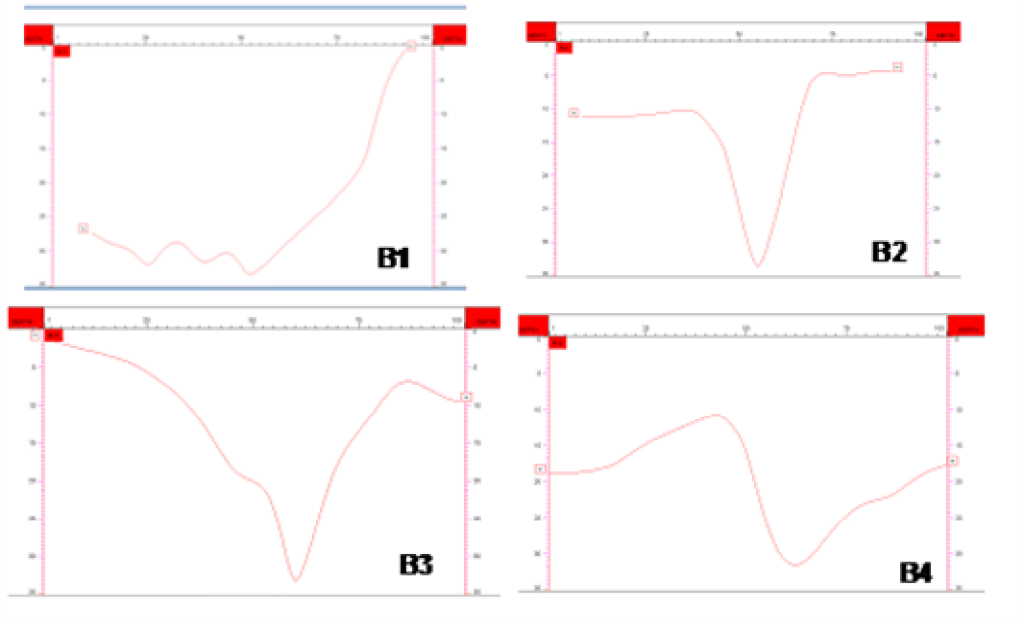


Fig: 3c. Transect profile showing Bottom Topography according to varied depth of Boga Lake (c.f. 3b).

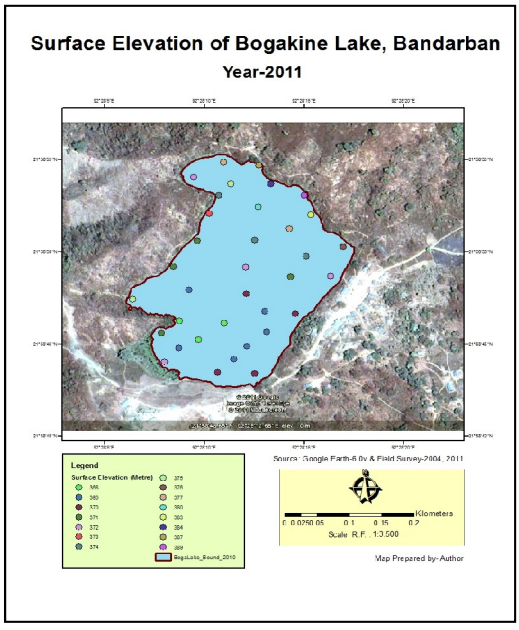


Fig: 4 Lake Water surface elevation data extracted using Google earth (Elevation in Meter)

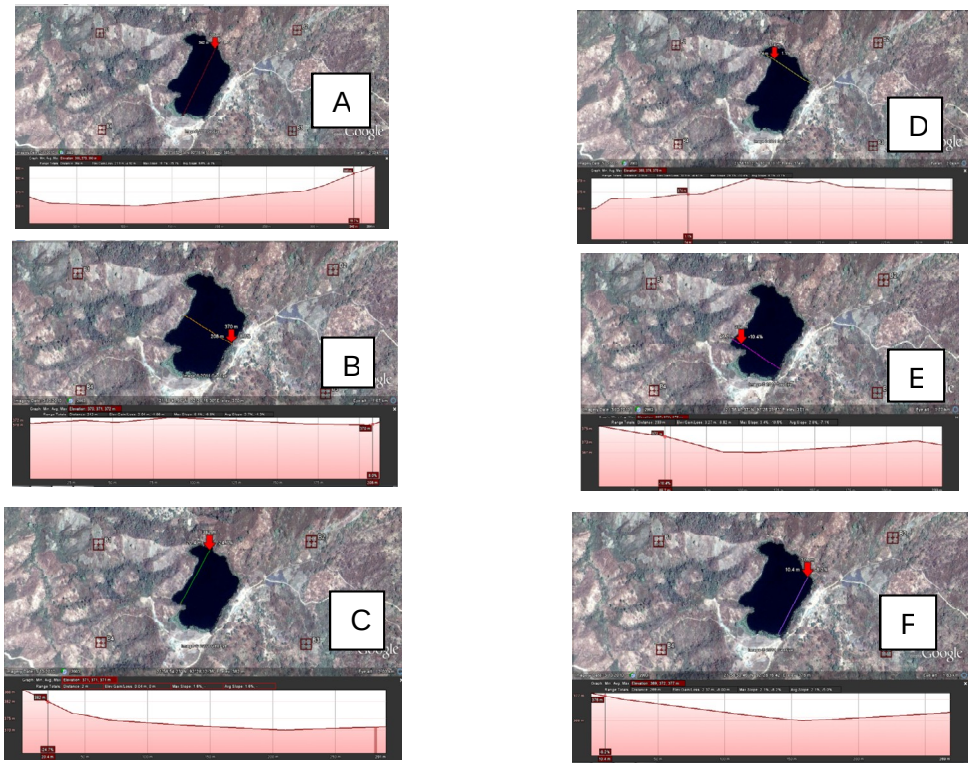


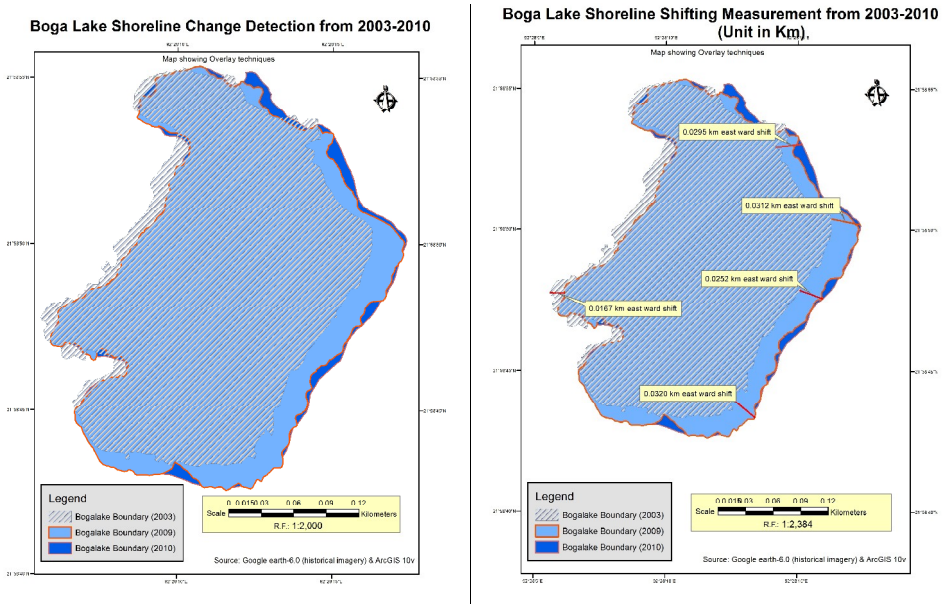
Fig: 5 Automated Lake surface elevation profile measurement based on transect drawing at different direction of lake using Google earth 6.0

Lake surface elevation profile drawing with slope measurement

As we have seen that lake surface elevation point value varies over the lake therefore an attempt has been made to check the elevation profile diagram in different direction (horizontal and longitudinal) with transect drawing. With the latest facility provided by Google earth, surface elevation profile can be automatically created maintaining its distance and slope and considering its length and width. In Fig. 5 A is the first elevation profile. In this section transect line drawing, the width is 309m and maximum slope is 21.9% which indicate that this part falls under steep area (based on standard slope percentage equation) and average slope is 7.6% which indicates moderate slope. Fig. 5B (horizontal direction), here the width is 213m, maximum slope is 2.6% and average slope is 2.2 % which falls under gentle slope category. Fig. 5C is a longitudinal section where maximum slope is 19.7% and average slope is 8.7% which indicates steep and moderate to steep slope category. Fig. 5D is a horizontal transect which is 221m length and maximum slope is 13.4% and the average slope is 3.6% and this further indicates that the slope is moderate to steep and moderate. In Fig. 5F maximum slope is 8.2% and average slope is 5.0% indicating moderate to steep and moderate slope category. Therefore, from the overall lake surface elevation profile it can be said that this lake basically belongs to moderate to steep slope category. This profiles and slope category clearly indicates that lake surface elevation is not same and the lake configuration is also not same, it varies according to its varied elevation and slope distribution (source: Google earth).

To analyse the lake configuration change of Boga lake three (3) different years temporal satellite imagery arc coverage overlay techniques is used and the spatial

analyst tool of ArcGIS 10v is used to calculate the changes in the configuration of Boga lake (Fig. 6a & b). Surface area of Boga lake is 7.39 hectare in the year 2010 and the other two years satellite data shows that lake area is 6.56 and 7.22 hectares in 2003 and 2009 respectively (Table-3). The Lake shore length is 1.29 Km. Surface elevation of Lake is not similar and it varies in different parts and the value ranges between 368 m to 389 m which is shown in Fig. 5A to F. An eastward shift trend is seen which needs further neotectonic analysis for the study area.



(a) **(b)**

Fig: 6. (a) & (b) Change detection of the Boga lake configuration

Water volume

The volume calculations are based on the geometric volume estimation of solid shapes. This is the product of the shape's base multiplied by its height means its depth wise area volume calculation. Grid geometry Rows-434 Cols-405 Cell size X: 1.0 Cell size Y: 1.0, Cell refinement: 1, Effective X: 1.00 Y: 1.00, -33.7 to 0.0 scale factor 1.00 and for volume calculation the unit considered is in meter. By considering 1 meter contour interval from surface to bottom part maximum 71,825 sq m slice area has been identified and total water volume area of Boga lake is 1,001,979 cubic meter.

3D mesh Diagram of Boga Lake: According to varied depth data, contour planning has been performed and 3D mesh diagrammatic model has been developed to visualize the hilly natural lake in 3D environment as shown in Fig. 7.

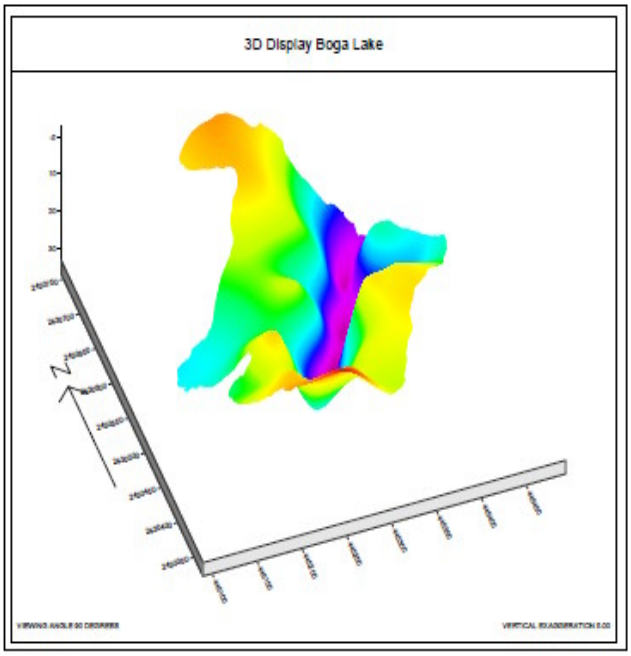
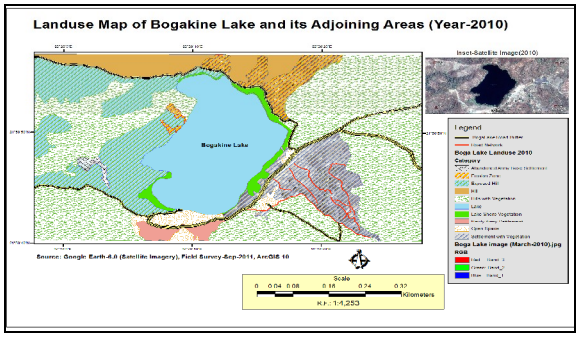
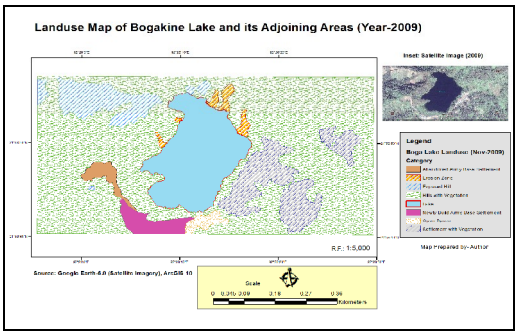


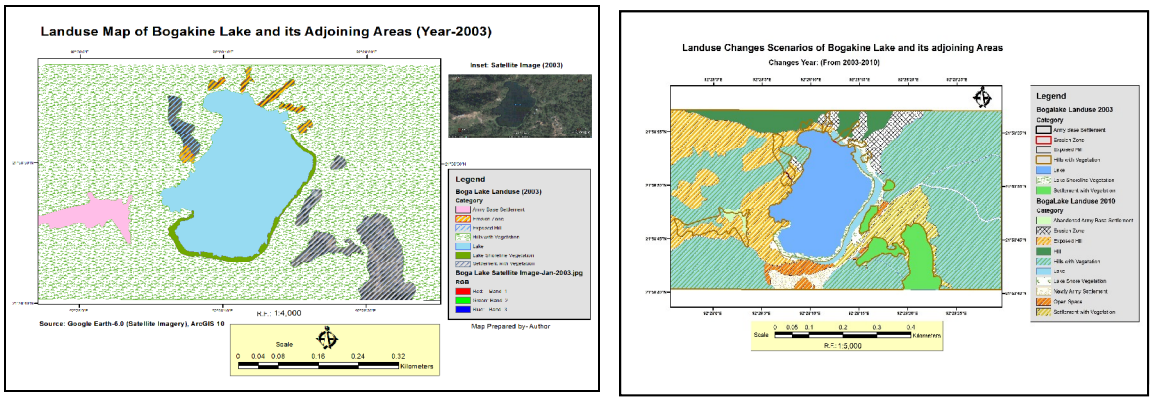
Fig: 7 Three (3)D Display of Boga Lake

Landuse mapping and Change detection

Landuse categories identified in the study area are abandoned army base settlement, erosion zone, exposed hills, hills, hills with vegetation, lake, open space, settlement with vegetation. Major part of the study area is covered by hills with vegetation which shares 48% in the year 2010 satellite image, followed by exposed hill and lake area 16% and 15% respectively. On the other hand, in 2009 and 2003 satellite imageries hills with vegetation is 66.33% and 78.22% respectively which is much higher than 2010 (Fig.8 & 8a). Due to increased hill erosion over the last few years, which was witnessed during the field surveys and with satellite image interpretation, it has been identified that some highly erosion affected area the surface sediments are being deposited in the lake and ultimately it is changing lake basin configuration.







Source: Google earth 6.0 (Satellite imagery) & ArcGIS 10v & Field Survey-2011

Fig: 8 Landuse map of Bogakine Lake and its adjoining areas (year: 2003-2010)

Table- 3: Comparison of Landuse map of Boga Lake and its adjoining areas based on temporal satellite data (area shows in hectares unit and percent distribution)

Landuse Category	Area (Hectares) Year-2010	Area (%)	Area (Hectares) Year-2009	Area (%)	Area (Hectares) Year-2003	Area (%)
Abandoned Army Base Settlement	0.207102	0	0.616	1.25	0.99	1.97
Erosion Zone	1.740832	4	0.578	1.18	0.424	0.84
Exposed Hill	8.113259	16	3.132	7.739249	0.357	0.71
Hill	2.417874	5	-	-	-	-
Hills with Vegetation	23.941815	48	32.6	66.33	39.37	78.22
Lake	7.38881	15	7.216	14.68	6.558	13.03
Lake shore Vegetation	0.846269	2	-	-	0.467	0.93
Newly Army Settlement	0.652458	1	-	-	-	-
Open Space	1.013763	2	0.471	0.96	-	-
Settlement with Vegetation	3.53782	7	4.537	9.23	2.166	4.3
Total	49.86	100	49.15	100	50.33	100

Source: Google earth satellite imagery and ArcGIS 10v software

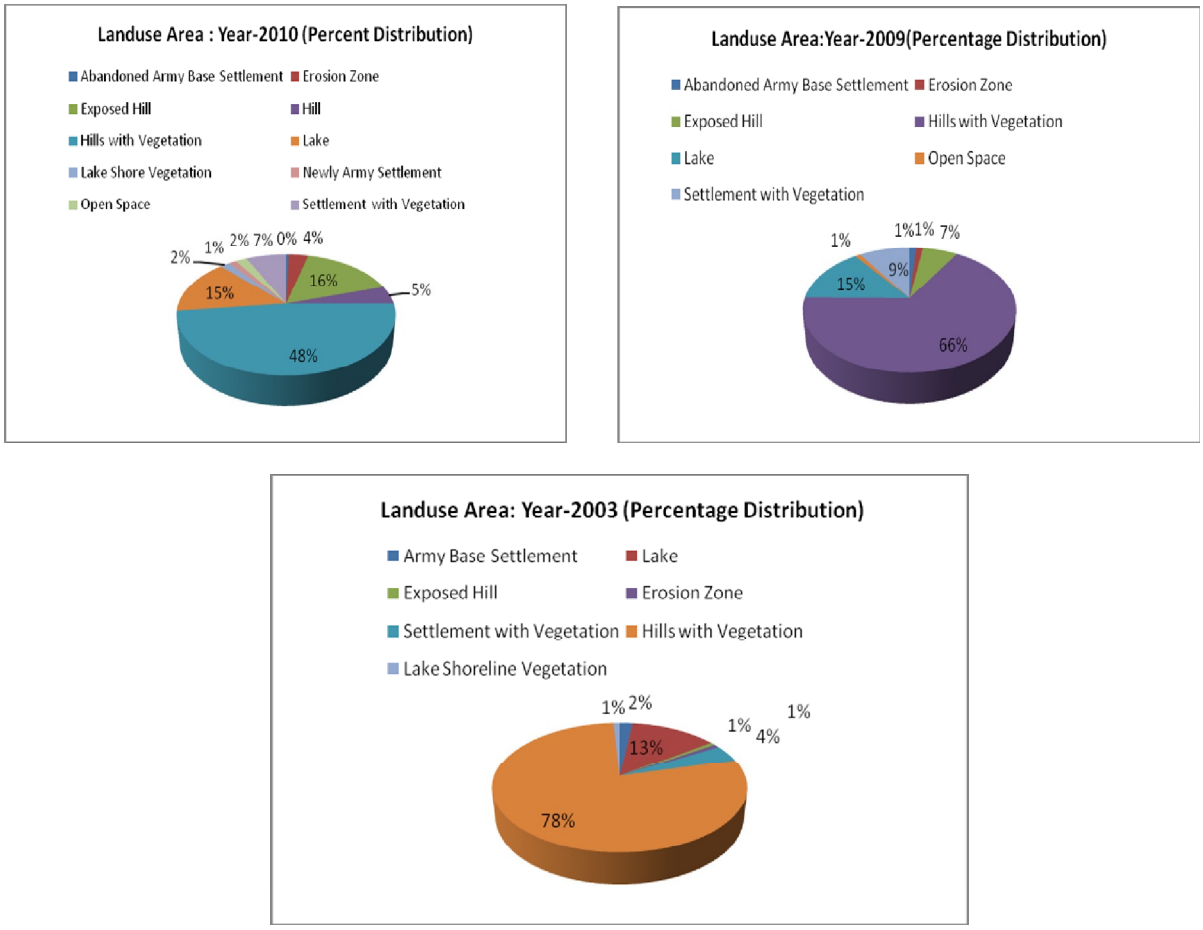


Fig.8a Pie diagram showing the landuse change from 2003 to 2010

The lake shore vegetation is naturally increasing and it is observed from 2003 to 2010 satellite images. The resultant data (Table-3) clearly shows that lake shore area is being affected very much due to the natural hill erosional activities. Due to human pressure and increase of recreational and tourism activities in and around lake, the surrounding hills are facing severe erosion. In landuse change detection map it has been found that the Hills with vegetation are declining. This category shares 78.22% in 2003, 66.33% in 2009 and only 48 % in 2010 (source: Google earth-6.0 satellite imagery, Fig. 8 & 8a). Satellite image and field observation from 2003 to September 2011, clearly shows that, the local human interference is increasing day by day as the study area is being declared by Govt. of Bangladesh as recreational and tourism area.

Conclusion

The study has indicated the potential use of Google earth remote sensing data in studying lake configuration and land use change. GIS techniques integrated in this study has proved its high end capabilities of spatial analysis. In this study Google earth high resolution satellite images were used satisfactorily for the identification of lake configuration and landuse change detection. It is observed that the area under landuse pattern changed remarkably from 2003 to 2010. Decrease in vegetation is the result of

natural and anthropogenic activities in the study area. The spatial changes in the lake configuration and its shift towards east needs detail neotectonic study.

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- http://www.fejb.org/fejb @ bangla.net
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Details Information regarding Research Paper and Author's Biography

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