

Morphometry Characteristics Delineation and Bathymetry Mapping of Lake Dal, Kashmir valley, India using Geospatial Techniques

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ABSTRACT

During recent decades human impact on lake ecosystems has increased due to intensification of agriculture, irrigation, water consumption, and electrical purposes. Particularly strong changes have been observed in shallow lakes, which are more sensitive to environmental changes and characterized by unfavorable morphometric parameters. (Agnieszka E.Lawniczak *et al.*, 2011) Bathymetry is a key element of surface water body, which includes the shape, area, volume and depth (N.Khare, *et al.*, 2008 and N.Basos, *et al.*, 2014). Bathymetry survey are maps that can be used to describe the lakes physical characteristics and also help in learn more about the effects of climate change on the environment. Bathymetry mapping in lake Dal using echo sounders forms first of its kind to prepare the bathymetry map and delineate various morphometry characteristics based on the geospatial analysis. Garmin 178 sounder has been used to carry out Bathymetry survey and Global positioning system (GPS) are used to compute Longitude, latitude, depth and water temperature. Results of the field survey are used to generate contour maps, morphometry maps and base maps. The Maximum depth of the lake is 6.4 meters, which is traced at the western part of the lake. Several morphometric parameters for the Dal lake has been computed which includes Maximum Length (7.76 Km), Maximum Effective Length (5.99 Km) Effective width of (3.02 Km), Relative Depth 0.15 %, Length of Shore line (29.93 Km) Shore Line Development (2.24) and the Total Lake Area (14.11 Sq Km)

1. Introduction

Bathymetry is the study of land surfaces inside the water bodies, which exhibits the shape and depth of lake (José de Anda, *et al.*, 2012). Lakes with Bathymetry data has significant value in understanding hydrology. Primary characteristics which includes Lake Morphometry and bottom surface topography or Bathymetry of the lake and the maps are similar to toposheets where the contour determines points that are of equal altitude. Bathymetry maps connect points of corresponding depths which is a primary method used to define lake physical topographies. Also this helps in understanding the function of lake systems for which the variety of measurements like surface area, maximum length and width, mean width, mean depth, maximum depth, mean depth, shoreline length, shoreline development and lake volume can be Figured (Army Corps of Engineers, 2001, Cole, T.M. and S.A. Wells, 2001, Gardner, J.V. and P. Dartnell, 2001, Hughes, B.V. and C.M. Taube, 2000, Morgan, L.A., *et al.*, 2001 and Welch, P.S. 1948).

Morphology describes the shape of the lake, whereas the dimension of shapes in respect to various contexts has been described as morphometry, output of complete representation of lake morphometry is bathymetry maps. Morphometry parameters are mandatory for any professional lake management scheme to understand lake functions, its shape and the structure of a lake basin leads to a good prediction on how human-induced events may affect water levels in that system (Anon, 2001). Lake Morphometry can be derived by

variety of sources, but more precise outputs are achieved using the modern day geospatial techniques which includes both GIS and remote sensing.

2. Study Area

Spatial Extent of present study area falls between the latitudes 34° 2' 4.48" E to 34° 13' 48.36" E and 74° 46' 33.96" N to 75° 9' 32.976" N and located in Kashmir valley, north-west of Jammu and Kashmir (Fig:1). The lake catchment is not only highly diverse but also covers a huge area of 312.90 km² The general relief of the catchment is a basin which comprises the Dal lake situated at an altitude of approximately 1583 m and a steep cliff at an elevation of 4390 m located along eastern watershed. The flat areas of the catchment are mostly used as cropland, horticulture and built-up where human activities have intensified during the last few decades. The mountainous areas are mostly covered by forest, grassland, scrub lands, and the hilly regions consist of natural vegetation and barren land, respectively. Most of the surface runoff carrying the eroded soil and sediments originate from these mountainous and hilly areas of the catchment. The geological formations of the catchment area are dominated by alluvium, Panjal traps and agglomerate slates (Wadia 1971; Varadan 1977; Data 1983; Bhat 1989).

3. Data and Methodology

Bathymetry data has been generated using Garmin Echo sounder which records the geographic coordinates along with

depth of the Lake. Surveys have been carried out in very tranquil conditions, where the GPS Echo sounders are fixed over the boat and have been driven at constant speed. Readings were taken at regular intervals traversing in the Zigzag directions (Fig. 2) and vice versa, both waypoints and

tracks were recorded and after completion data were downloaded and plotted using geospatial techniques. Base maps for the study area has been generated with the help of Toposheets and Satellite images. QGIS has been used to georeference and vectorise the base map.

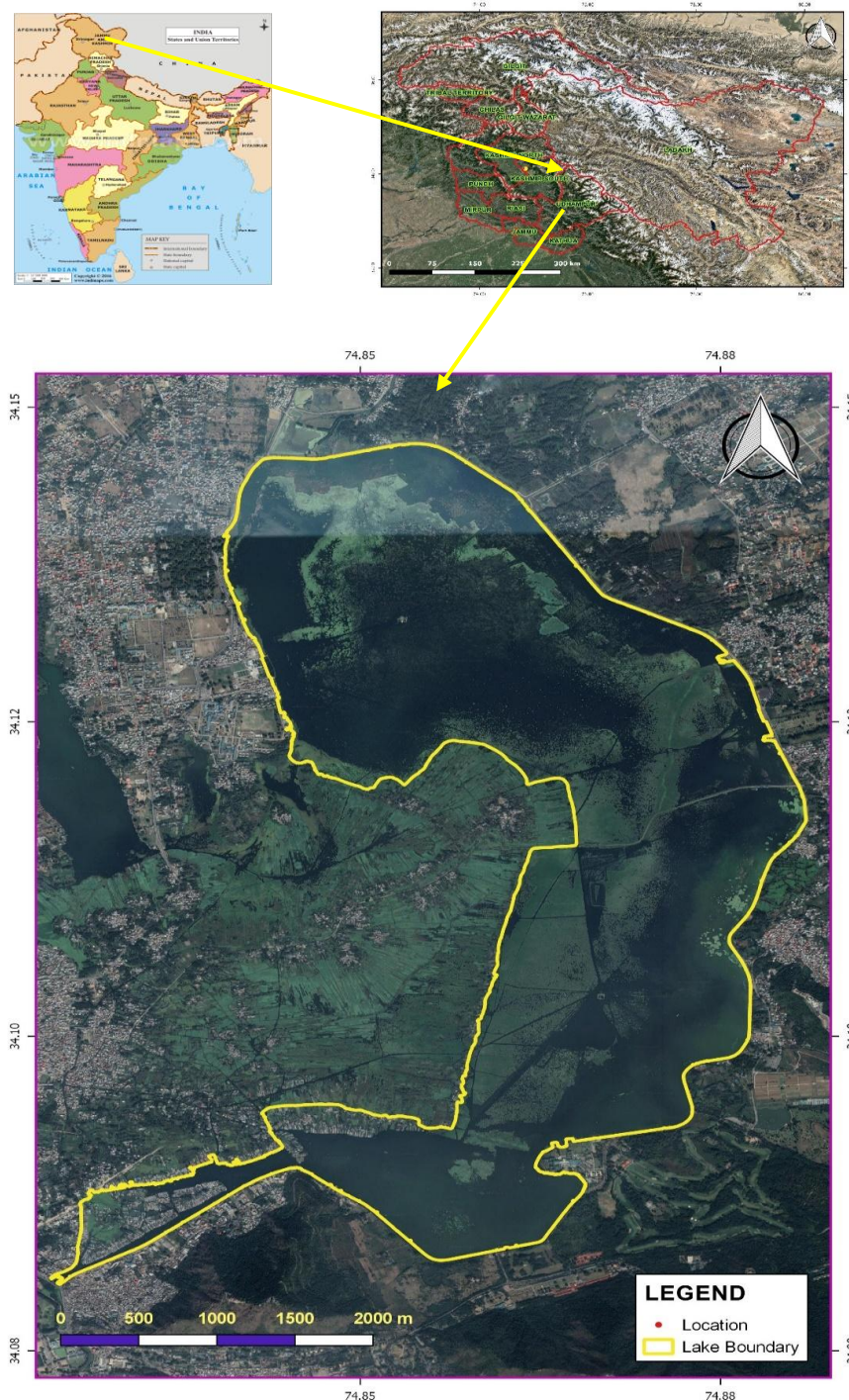


Figure 1: Study area Location Map

Shuttle Radar Topographic Mission (SRTM) digital elevation data, originally produced by National Aeronautics and Space Administration (NASA) and National Geospatial Agency (NGA), is a major invention in digital mapping of the world, and brings a major development in the accessibility of high quality altitude data for large portions of the tropics and other areas of the developing world. The SRTM DEM of 1 arc resolution has been used in the present study to delineate the lake boundary, which

has been processed using QGIS and terrain surfaces have been seen in detail to superior extent. Slope and various other Morphometric parameters which includes Maximum Length of the Lake (Lmax), Effective Length (Le), Maximum width (Bmax), Effective width (Be), Shore Length, Total Area of the lake has been generated using geospatial tools. Shoreline development is a catalogue for regularity of shoreline; they are calculated based on the length of the shoreline and area of the lake, which

are important because it replicates the potential for development of littoral groups.



Figure 2: GPS Echo sounder setup and bathymetry collection in Lake Dal

4. Results and Discussions

Bathymetry Map

Based on the hydrographic survey, Bathymetry map was generated with the help of open source software QGIS and it has been identified that the depth of the lake increases towards the central part (Fig. 3) and the maximum depth of the lake have been identified as 6.4 meters in the south west part of the lake. Also the bathymetry map exhibits that the lake is having steep slope along the western part and gentle slope in the northern part up to certain distance and sudden increase in its depth were also noticed. The Bathymetry map of 1.5 m interval shows N-S oriented linear crescent shaped lake steeper at the south eastern part and flatter to gently sloping on the bank. The gentle slope in the northern and western part is attributed to rapid accumulation of sediments from the catchment area.

5. Morphometry Characteristics

The morphometry is a unit that has direct relation with the process occurring within the lake. The significant morphometric characteristics evolved for the lake Dal are given in Table 1. Maximum Length (L_{max}) and Effective length (L_e) (Fig. 4) for Lake Dal has been calculated as 7.76 and 5.99 km respectively. The Effective Breadth (B_e) may not cross land or islands and the effective width is computed as 3.02 Km. Direction of the Major Axis is defined by compass direction of the maximum length (L_{max}). It is the direction in which the lake is oriented N-S orientation, Length of Shore line is 29.93Km and surface area is calculated as 14.11Sq Km.

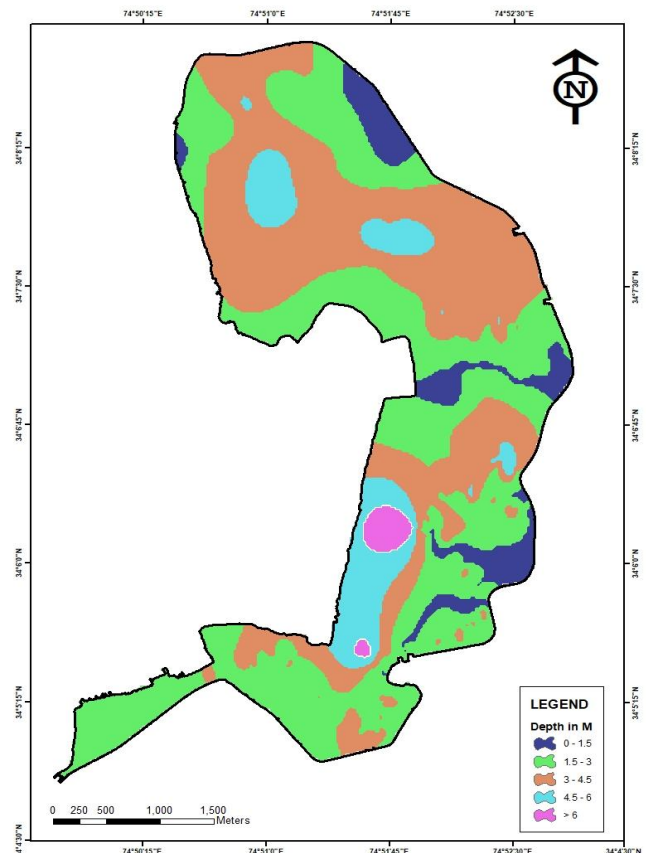


Figure 3: Bathymetry Map of Lake Dal

Table 1: Morphometry Parameters of Lake Dal

| Sr. No | Morphometry Parameter | Values |
|--------|------------------------------------|-------------|
| 1 | Total Lake Area | 14.11 Sq.Km |
| 2 | Maximum Length (L_{max}) | 7.76 km |
| 3 | Maximum Effective Length (L_e) | 5.99 km |
| 5 | Effective width (B_e) | 3.02 Km |
| 6 | Direction | N-S |

| | | |
|----|----------------------------|-----------|
| 7 | Lake Depth(Dm) | 6.4 m |
| 8 | Relative Depth (Dr) | 0.15 % |
| 9 | Length of Shore line (L) | 29.93 Kms |
| 10 | Shore Line Development (F) | 2.24 |

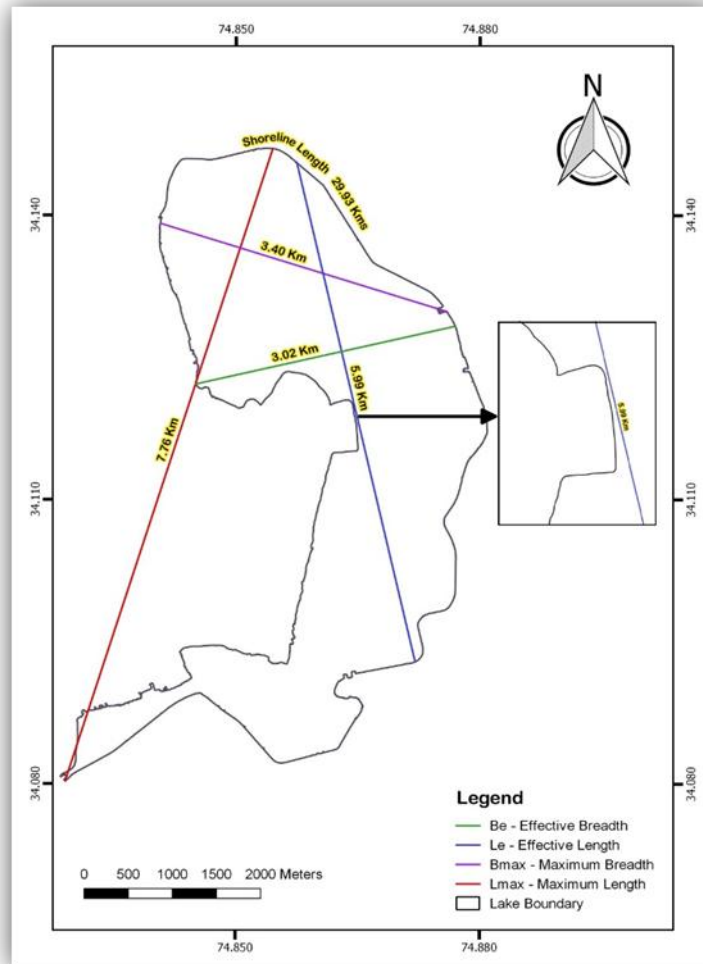


Figure 4: Morphometry Map of Lake Dal

6. Conclusion

Morphometric characteristics and Bathymetry map of Dal lake exhibits, that the lake is having the maximum depth of 6.4 meters with the 5.99 Km, effective length and 1.82 km mean width. Shoreline is the fringe of land at the edge of a water

body, the derived shoreline length of Lake Dal is 29.93 km. The degree of irregularities in the shoreline are determined as shoreline development. The shoreline development of the Lake Dal is 2.24, which indicates crinkled nature of the shore and favours for the breeding of the organisms.

References

1. Khare N., Chaturvedi SK., Saraswat R., Srivastava R., Raina R., & Wanganeo A., (2008). Some morphometric characteristics of Priyadarshini water body at Schirmacher Oasis, Central Dronning Maud Land, Antarctica with special reference to its bathymetry., Indian journal of Marine Sciences, Vol 37(4), 438-438.
2. Basos N., Martins F and Rodrigues J., (2014). Bathymetry interpolation for hydrodynamic modeling, Lisboa 24, 25 – 26.
3. José de Anda., Jesus Gabriel Rangel-Peraza., Oliver Obregon., James Nelson., Gustavious., Williams P., Yazmin Jarquín-Javier., Jerry Miller and Michael Rode., (2012). The Use of Digital Elevation Models (DEMs) for Bathymetry Development in Large Tropical Reservoirs, Bathymetry and Its Applications, Dr. Philippe Blondel (Ed.), ISBN, 978-953-307-959-2.
4. Army Corps of Engineers, (2001). Engineering Design and Hydrographic Surveying, Manual No. 1110-2-1003, Department of the Army, Washington, DC.
5. Cole T.M and Wells S.A., (2001). CEQUAL-W2 A Two-dimensional, Laterally Averaged Hydrodynamic and Water Quality Model, Version 3.1 Instruction Report EL-00-01. U.S, Army Corps of Engineers.

6. Gardner J.V and Dartnell P., (2001). Multibeam SONAR survey of Crater Lake, Oregon, Data, GIS, images, and movies. U.S. Geological Survey, Digital Data Series DDS-72.
7. Hughes B.V and C.M. Taube., (2000). Mapping lakes with echo sounders. In J.C. Schneider (Ed.), Manual of Fisheries Survey Methods II: with periodic updates. Ch. 10. Michigan Department of Natural Resources, Fisheries Special Report 25.
8. Morgan L.A., Shanks W.C., Loyalvo D., Webring M., Lee G., Stephenson W.J., and Johnson S.Y., (2001). In R.J. Anderson and D. Harmon (Eds.), Yellowstone Lake: Hotbed of chaos or reservoir of resilience, 6th Biennial Scientific Conference on the Greater Yellowstone Ecosystem.
9. Welch P.S.,(1948). Limnological Methods, The Blakiston Company, Philadelphia, 381 pp.
10. Jawak S.D., Vadlamani S.S and Luis A.J.,(2015). A Synoptic Review on Deriving Bathymetry Information Using Remote Sensing Technologies: Models, Methods and Comparisons. Advances in Remote Sensing, 4, 147-162.
11. Yousuf A. R., and Ioadri M. Y., (1986). Distribution of *Polyarthra vulgaris* Carlin (Rotifera: Monogonota) in a warm monomictic lake of Kashmir, India, J. Indian Inst, Sci., 66, pp. 405-410.
12. David Rankin., Freshwater Ecosystems and Human Populations: Great Lakes Case Study: Bulletin 107.