Bathymetric survey of Tsho Rolpa Glacier Lake -2002

Arun B. Shrestha[1]
Kamal P. Budhathoki[1]
Ram K. Shrestha[2]
Rishikesh Adhikari[3]

[1]*Department of Hydrology and Meteorology*
[2]*Department of Forest Research and Survey*
[3]*Butwal Power Company Limited*

ABSTRACT:
The bathymetric survey of Tsho Rolpa glacier lake was performed in the summer of 2002 using echo sounder and GPS. The survey showed the expansion of the lake by 0.35 km^2 after the measurement of 1994. The volume of the lake had increased by 15.8 million m^3. The maximum depth of the lake was also found to have increased by about 12 m.

1. INTRODUCTION

The glaciers in Nepal Himalaya are in a general condition of shrinkage. Many of these shrinking glaciers, especially the valley glaciers have glacier lakes at their terminus. Some of the glacier lakes grow in such a way that the large volume of water cannot be retained by the loose moraines and lead to catastrophic outburst which is commonly known as Glacier Lake Outburst Flood (GLOF). Among 2315 glacier lakes existing in Nepal, 26 have been identified as dangerous lakes, which are likely to outburst (ICIMOD/UNEP, 2001). Tsho Rolpa, Imja, Lower Barun and Thulagi were identified as the most dangerous ones. Tsho Rolpa is the largest glacier lake in Nepal. The danger of GLOF from this lake was recognized in the early 1990s. The lake was studied in detail by scientists from Nepal, Japan, the Netherlands and other countires. These studies included the bathymetric survey of the lake by WECS and JICA in 1994 (WECS/JICA, 1996). The survey was done in the winter of 1994. The frozen top of the lake was drilled using an auger and direct point-depth sounding was done. This survey estimated that the volume of the lake was 76.6×10^6 m^3 and the maximum depth of the lake was 130 m (Yamada, 1998). Recognizing the danger of a GLOF an early warning system (EWS) was established in 1998 and a mitigation project was launched in 1999. This project's activities included the construction of an open channel at the end moraine to lower the lake level by at least 3 m. The lake level lowering was achieved on June 24, 2000. An evaluation of the project noted that the lowering of the lake level has greatly minimized the risk of GLOF, although does not completely eliminate it. It suggested that for further lowering of the lake level several investigations need to be carried out, including a bathymetric survey of the lake. This paper presents the results of the bathymetric survey of Tsho Rolpa lake conducted by the Department of Hydrology and Meteorology (DHM) in the summer (June/July) of 2002.

2. LOCATION

Tsho Rolpa Glacier Lake is located at about 110-km north-east from Kathmandu at an altitude of 4580 m a.s.l. in the Rolwaling Valley, Ward No. 1 of Gauri Shankar Village Development Committee of Dolakha district of Janakpur zone (Fig. 1).

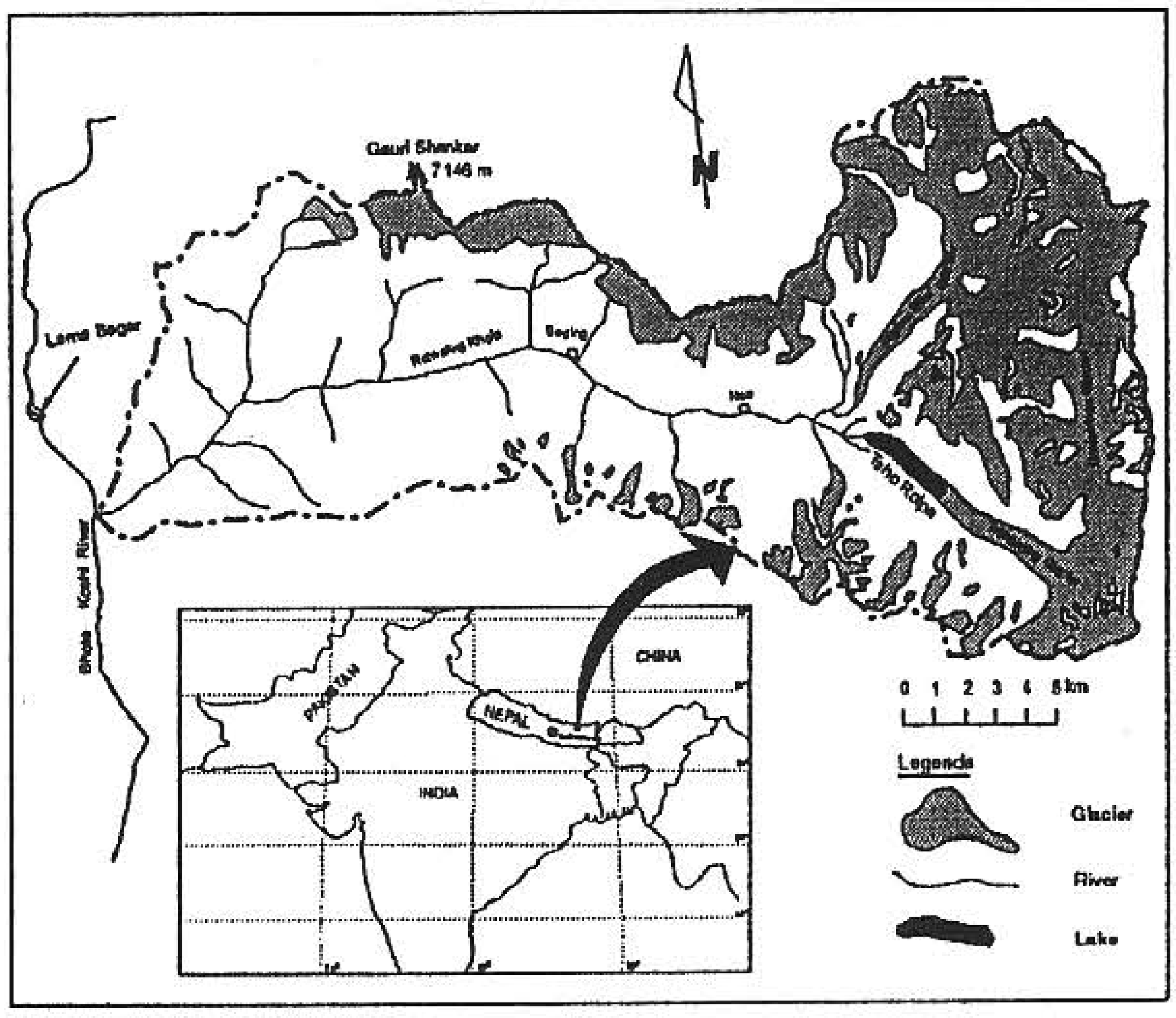

Figure 1. Location of Tsho Rolpa Glacier Lake.

3. METHOD

Unlike past bathymetric survey, this survey used echo sounder for the determination of the lake depth. This is perhaps the first time such method was employed for bathymetric survey in Nepal. Bathy 500 of Ocean Data, USA was used for the survey. A differential GPS (Northstar) was integrated with the echo sounder for spatial location. The instruments were mounted on an inflatable boat run by an outboard motor. (Fig. 2)

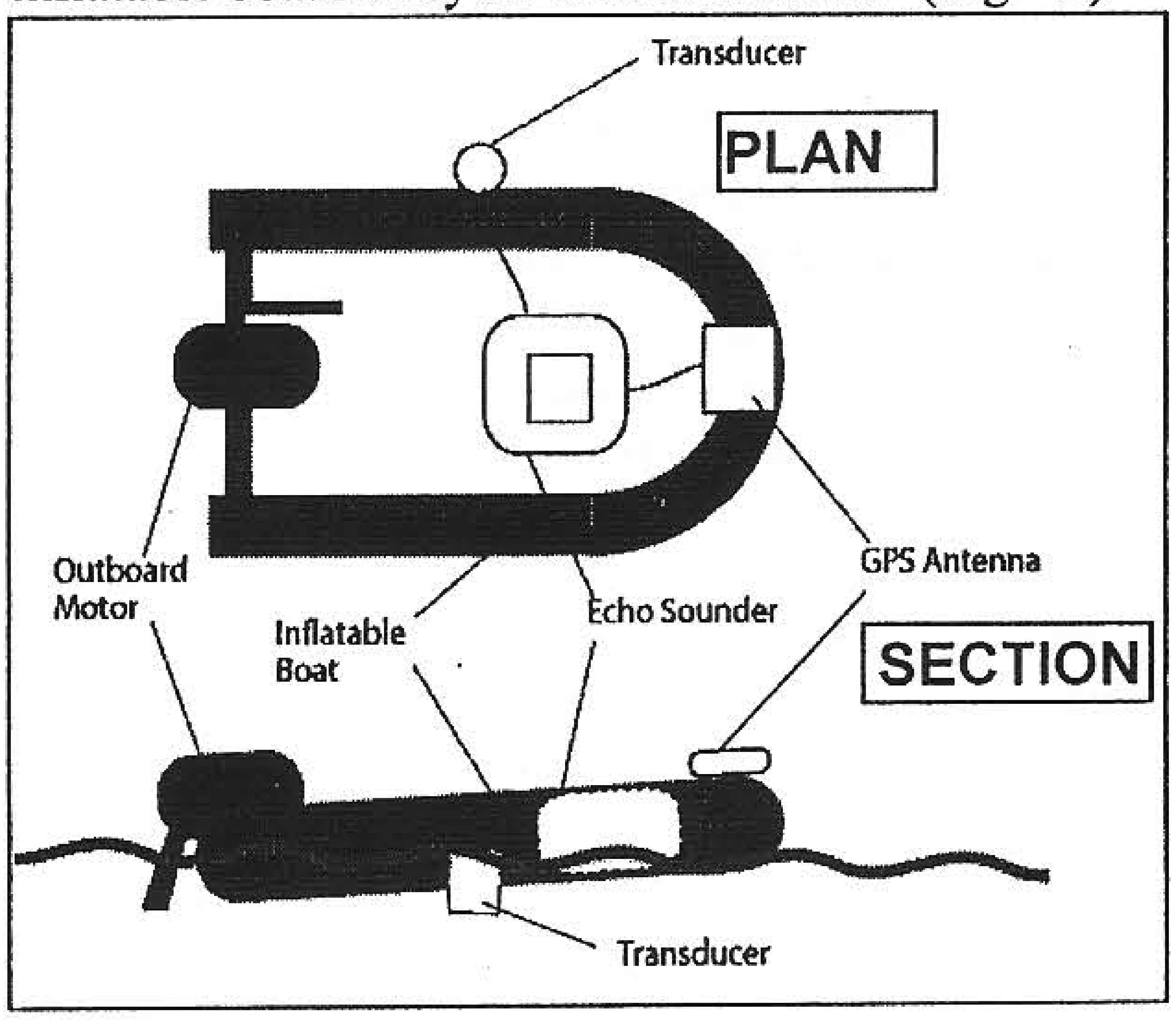

Figure 2. The instrument setup.

The boat was sailed along pre-established profiles on the lake during which the depth of lake was registered continuously on a strip-chart. The profiles of the survey are given in Figure 3. The chart was frequently marked and the positions were registered. After the survey, the chart was digitized in terms of depth and geographical coordinates.

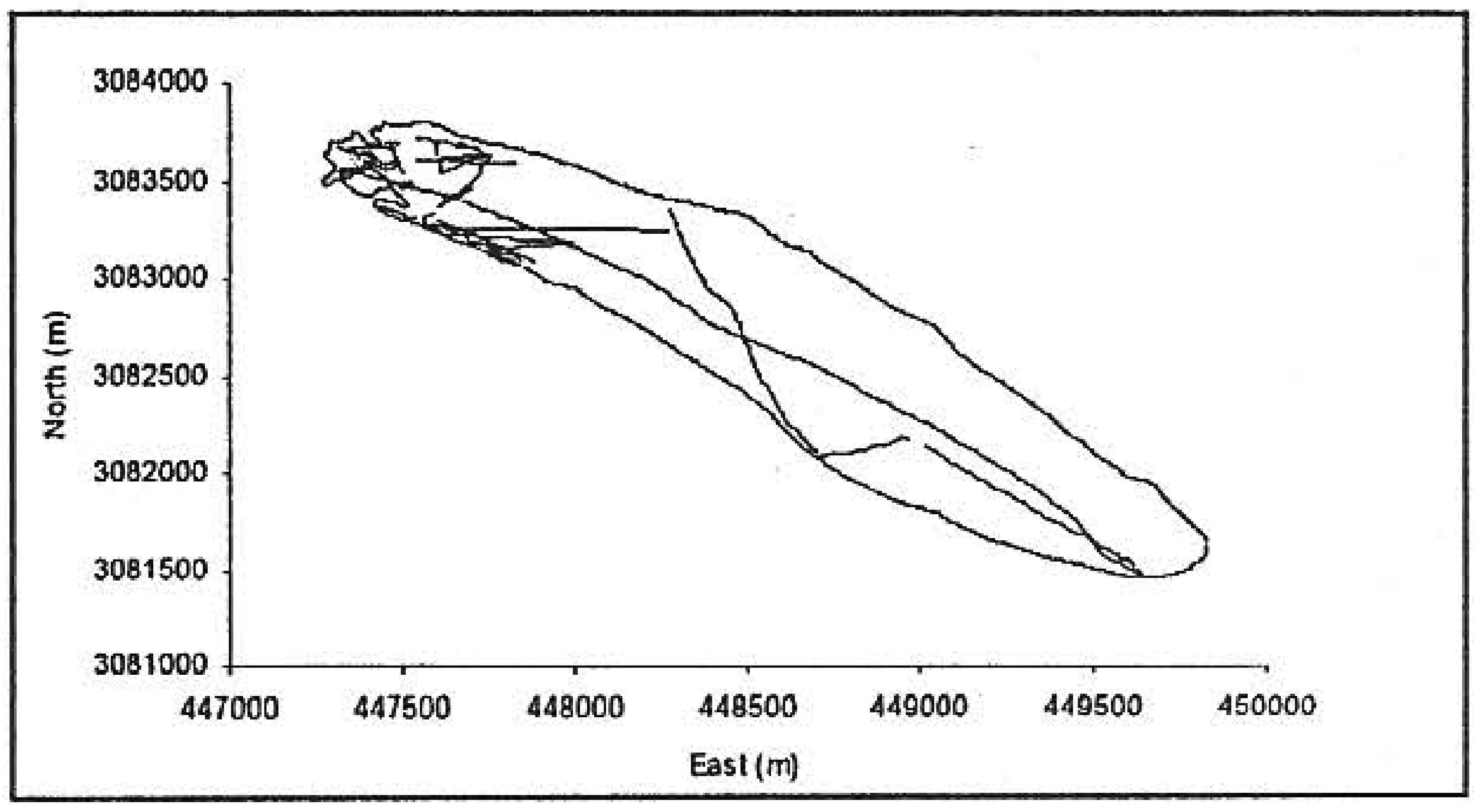

Figure 3. The survey profiles

All the end points of the profiles were also fixed by triangulation survey. The echo sounder measurements were compared with direct depth measurement at depths up to 5 m. The differences were well below 5%. This comparison could not be carried out at greater depth as there was no means to hold the boat stable for the measurement.

4. RESULTS AND DISCUSION

The bathymetric map prepared from the survey of 2002 is given in Figure 4. For comparison the bathymetric map of 1994 is also given. The recent map is more detailed than that of 1994. The survey was done so that vertical resolution of 2 m at the end part of the lake and 10 m on the rest can be achieved.

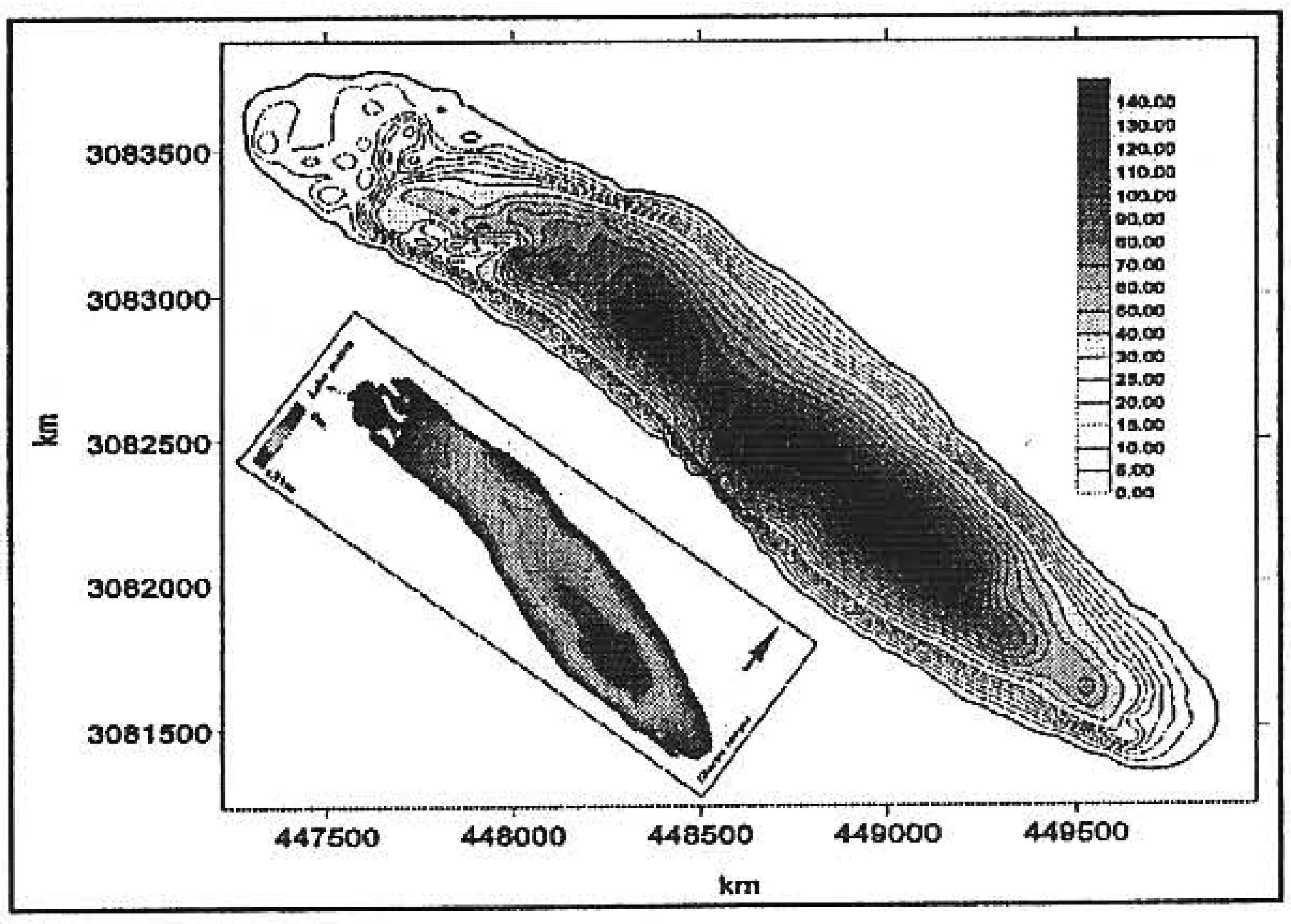

Figure 4. The Bathymetric map of Tsho Rolpa. The map is not corrected for the shoreline. For comparison the map of 1994 is given in the inset. The depth scale is in m.

The longitudinal section from the natural outlet and the glacier terminus is shown in Figure 5. The maximum depth measured in 2002 was 142 m, 10 m deeper than in 1994. Considering the lake level during the survey (4577.5 m a.s.l. as opposed to 4580 m a.s.l. in 1994) the absolute increase in depth is 12.5 m. This could be either because the 1994 survey simply missed the deepest point or because of the existence of dead ice below the lake water and it's melting. The latter is more likely as the bathymetric map (Fig. 4) shows the region of deepest depths are almost same in both years. The longitudinal section clearly shows that the glacier terminus has retreated about 25 to 30 m in past 8 years.

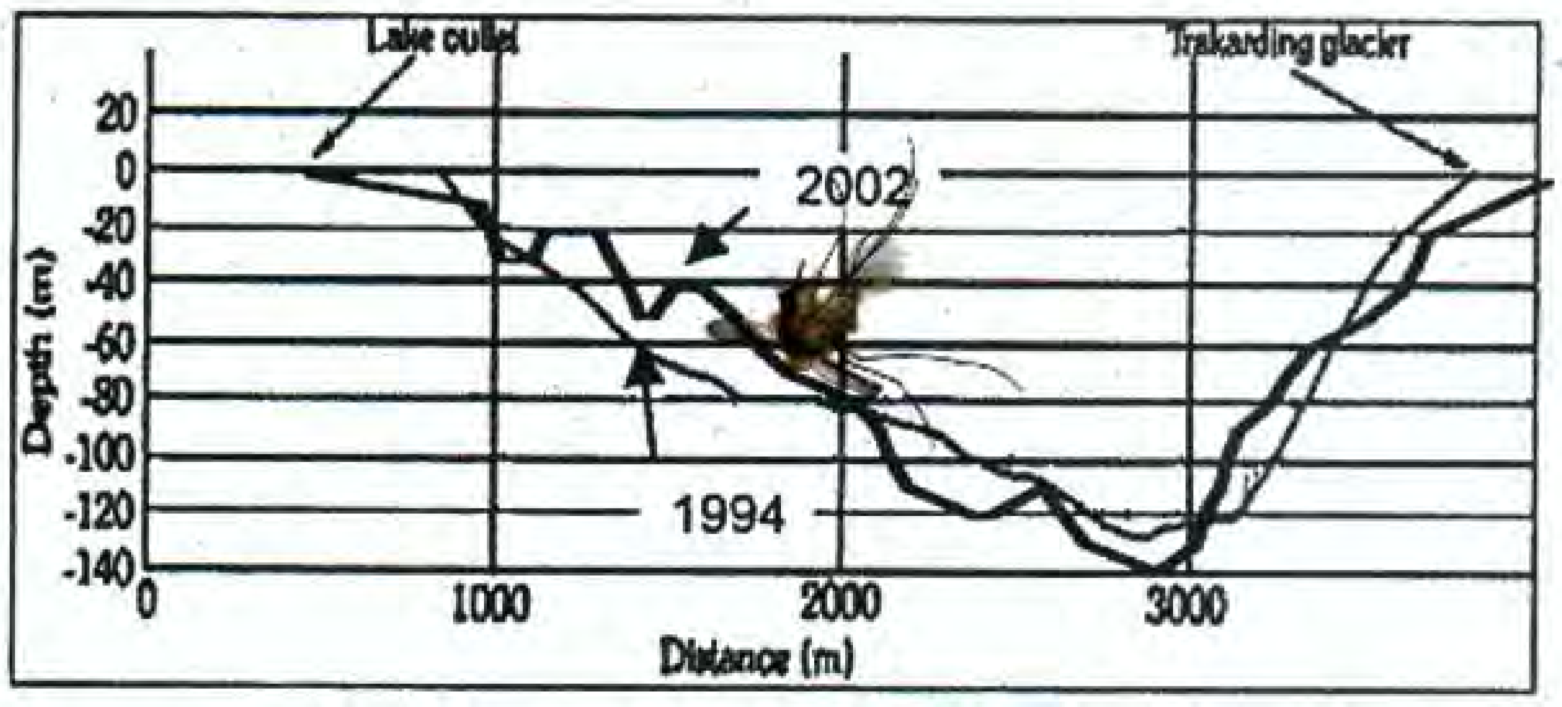

Figure 5. Longitudinal section of the lake.

The depth-area relationship in 2002 and 1994 is shown in Figure 6. The surface area in 1994 was 1.39 km^2, which has increased by 0.37 km^2 to 1.76 km^2 in 2002. The depth-volume relationship is shown in Figure 7. The volume of water in the lake was 92.4×10^6 m^3 in 2002, 15.8×10^6 m^3 larger than that in 1994. The volume in 2002 was after the lake level lowering activities were undertaken. Without the lake level lowering, the volume of the lake would have been 97.7×10^6 m^3.

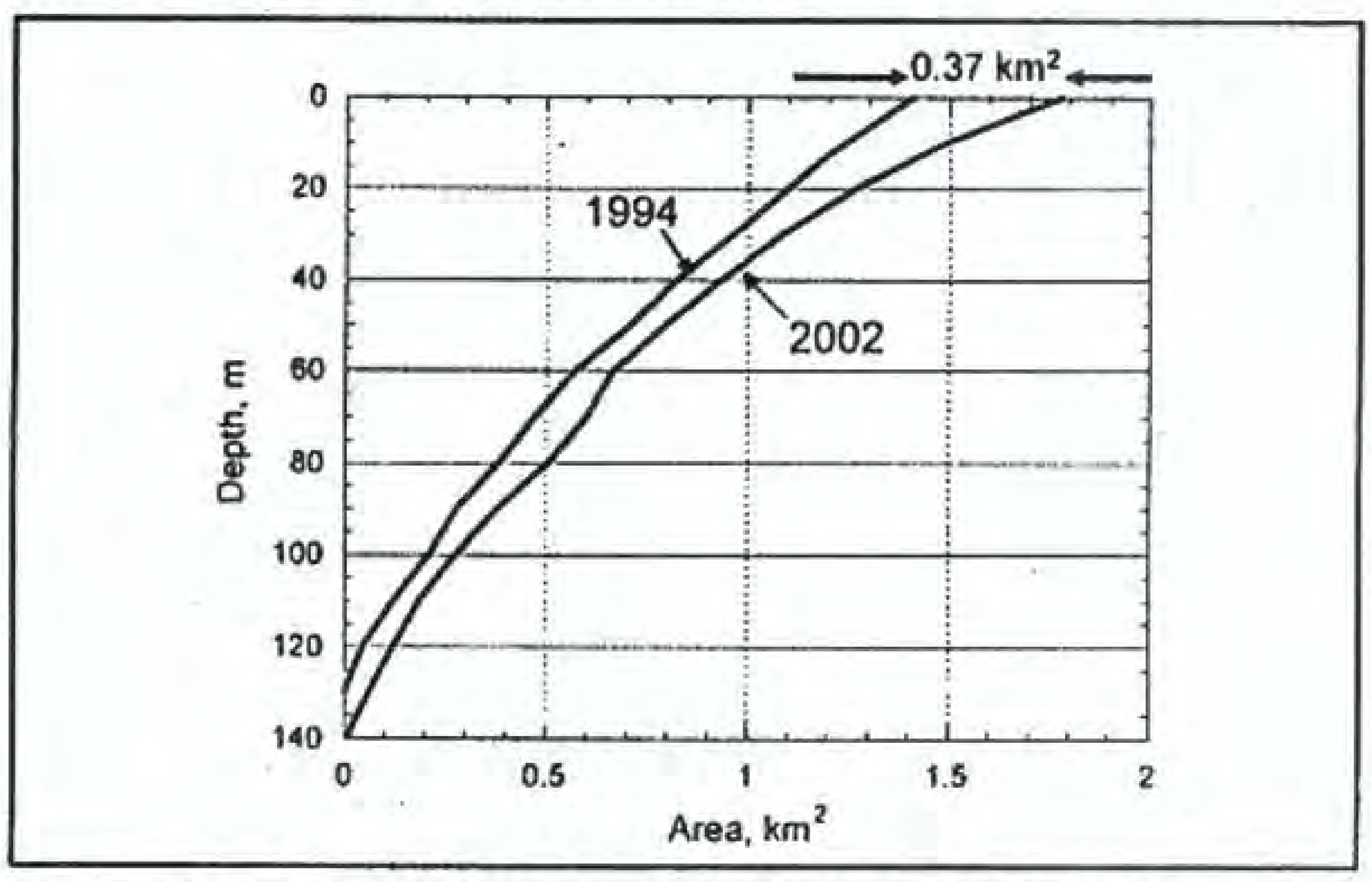

Figure 6. The depth-area curve of Tsho Rolpa.

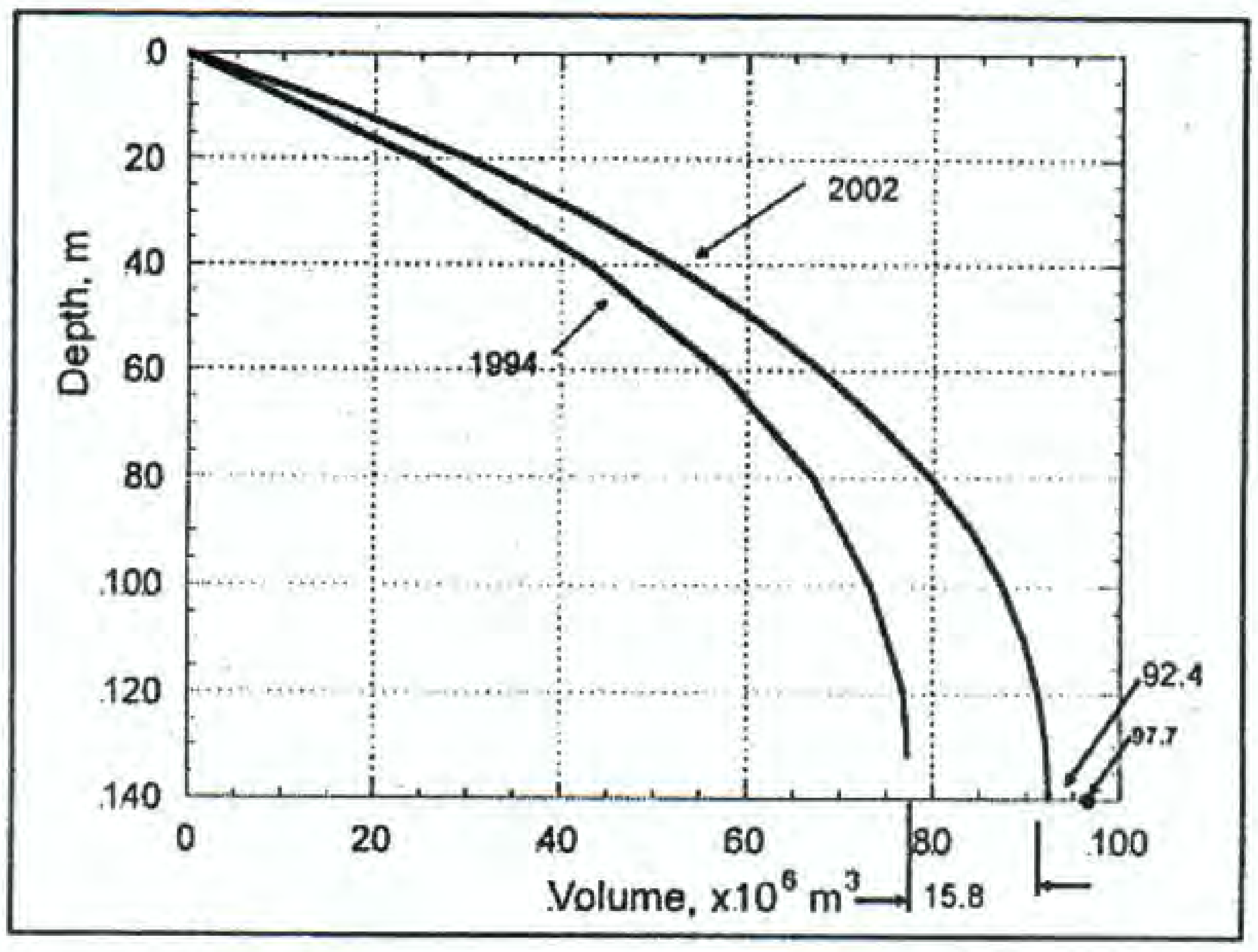

Figure 7. The depth-volume curve of Tsho Rolpa

5. CONCLUSION

Success in Tsho Rolpa lake has shown that combination of an echo sounder and a GPS is a fast and reliable method of conducting bathymetric survey, especially in the harsh condition of glacial lakes

This study showed significant change in area, volume of stored water and depth of Tsho Rolpa Lake. Similar survey is necessary to conduct in a regular basis to have up to date information about the lake condition. This method can be replicated in other lakes to conduct bathymetric survey.

6. REFERENCES

ICIMOD/UNEP, 2000. Inventory of Glacier, Glacial lakes and Glacial lake Outburst Floods. Monitoring and Early Warning Systems in Hindu Kush-Himalayan Region. Nepal. International Centre for Integrated Mountain Development, August 2001.

Yamada, T., 1998. Glacier Lakes and its Outburst Floods in the Nepal Himalaya. Monograph No. 1, March 1998. Data Center for Glacier Research, Japanese Society of Snow and Ice.

WECS/JICA, 1996. Report on the investigation of Tsho Rolpa Glacier Lake, Rolwaling Valley, August 1996.