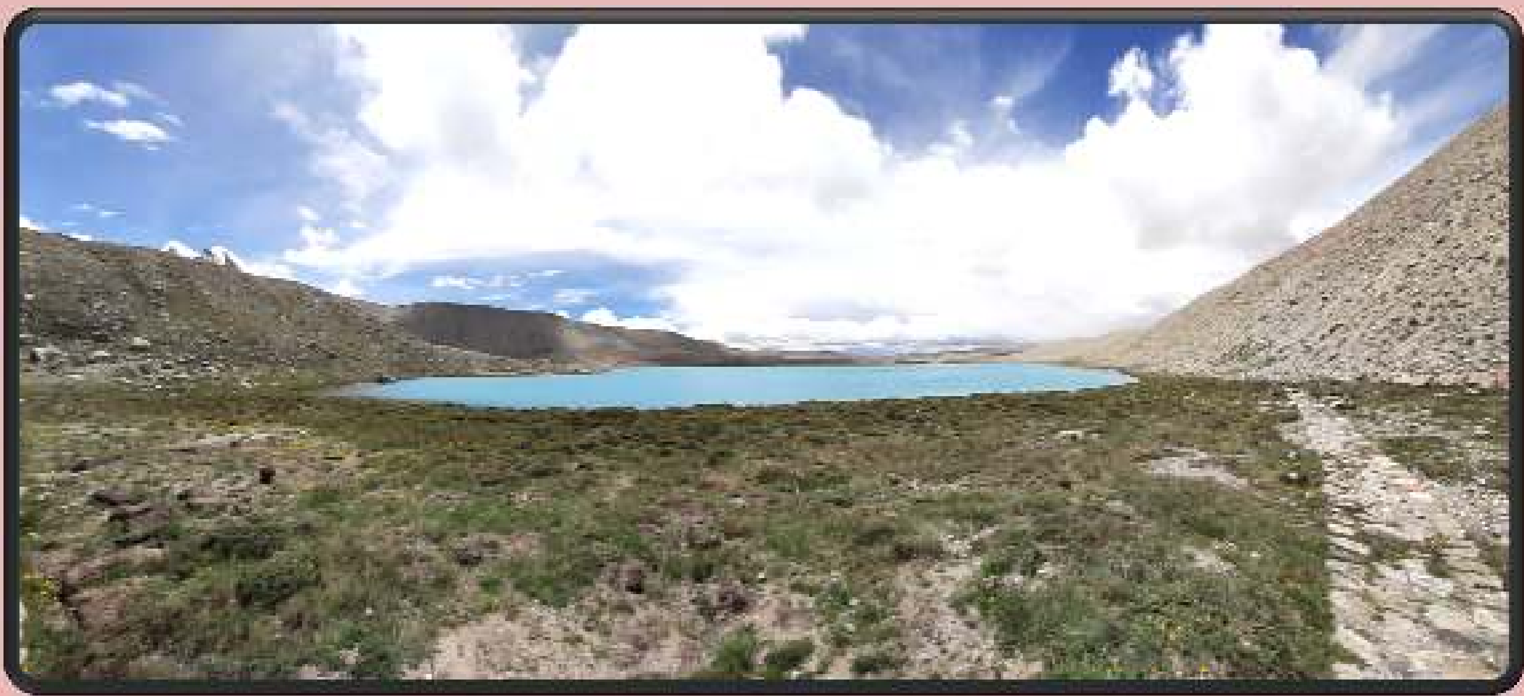
CHAPTER 5

Summary, Conclusions and Recommendations



Summary, Conclusions and Recommendations

Glaciers are significant because they give immediate information on climate change. Mountain glaciers are extremely susceptible to temperature and precipitation variations. They quickly adapt to minute changes in local temperature by modifying their mass balances, which affect their sizes and may thus, be utilized as a climate indicator. As a result, because snow and glacier melt water are important sources of fresh water for mountain rivers. Hence, inventorying the glaciers is essential for their quantification in all respects.

The data gaps in the Inventories by various agencies like GLIMS and ICIMOD acted as an inspiration for this research. This Eastern Himalayan Glacier Inventory, represented the state of glaciers between 2004 -2007 as this was the time period when the glaciers were mapped. It tried to replenish the lack of organization of the database in GLIMS and missing delineation of accumulation and ablation areas.

For this study, Geocoded Indian Remote Sensing Satellite (IRS) AWiFS data (2004-2007) on 1:50000 scale at the end of ablation season (July to September) were used. Therefore, FCC product of conventional band combinations of Band 2 (0.52-0.59 μm), 3 (0.62-0.68 μm), 4 (0.77-0.86 μm) and with additional Short Wave Infrared (SWIR) band (1.55-1.70 μm) were employed to map the glaciological features.

This was a repository of digital vector points, lines and polygons. These vector layers were stored in distinct layers as shape files and geodatabases, both of which are supported by the Arc (10.2) Software. The compilation and calculation of various glacial characteristics, such as area calculations for ablation areas, accumulation zones, supra glacial lakes and so on, as well as the orientation of glaciers and glacial lakes dimensions such as width, length, elevation, etc. are investigated systematically.

In the present study, various components of the glaciers of the Eastern Himalayas, primarily the Sikkim and Bhutan Himalayas, were investigated. The manual digitization of the glaciers and the various features inherent inside the glaciers had been the most time-consuming task.

Inventorying a massive database with roughly 1545 glaciers in the research region is a vital resource in the world of glaciers. Analyzing such a large database without any sub-divisions would have been inadequate for the study. As a result, the glaciers in the research area were divided into three elevation groups: <4000 metres, 4000-5000 metres and >5000 metres.

The statistics revealed that, Bhutan had the highest glacier concentration in the 4000-5000 metre elevation category, accounting for 60.56% of the total glaciated land. Sikkim has the most glaciers in the >5000 metre elevation category, covering around 65.56% of the area and accounting for 31.73% of the glaciers. In terms of glacier percentage, the highest was recorded in the 4000-5000 metre elevation category for both Sikkim (62.90%) and Bhutan (62.95%). Bhutan, on the other hand, had the lowest number of glaciers (19) and the least area (6.91%) covered by them in altitude beyond 5000 metres. However, the average glacier size was relatively large, measuring around 13 kilometres. While the <4000 metre elevation class had the lowest average glacier size across the entire research region. These findings reflect that the favorable climatic circumstances are responsible for the significant rise in glacier size and frequency with altitudinal advancement.

This Inventory undoubtedly has the potential to include additional information, such as the average depth and volume of each glacier, which can address many key concerns such as sea-level variations.

The Hazard Zonation of the MDLs was the second phase in this investigation. Thus, utilising the Glacier Inventory data of the lakes, hazard identification and delimitation of potentially impacted areas, including identification of the elements at risk, were critical steps conducted for GLOF risk management. The first step in this was to identify the hazardous lakes which were susceptible to floods. GLOFs are not recurring flood events like rain-caused floods. Since their occurrences are uncommon and are induced by certain trigger events across time, thus identifying these trigger points using remotely sensed data was critical. The subsequent identification of components such as elevation, curvature, lake depth, volume and most crucially, the slope of the area extracted from the region's DEM was predicated on the basis of modelling technique to be implemented.

The Hazard Zonation Map of both Sikkim and Bhutan were generated using the Weighted Overlay Model in GIS environment. After the recognition of the hazardous lakes, potentially affected locations were delineated and the components at risk were revealed. Undoubtedly, these techniques were laced with ambiguity and possible drawbacks yet, they have shown to be effective tools in GLOF risk management.

With persistent climate change, the danger of GLOF’s is expected to grow owing to the emergence and modification of distinct factors affecting the vulnerability of the glacial lakes. Thus, these kind of research must be done in repetitive means over the years to foresee the GLOFs and protect the mankind from these hazards.

Owing to the rapid changes occurring in the cryosphere, the years originally considered to be an adequate re-inventory period must be reassessed. The increasing use of satellite-based approaches should enable considerably more regular inventory, which is presently sought. Thus, glacier inventory at this scale should be done at least on a decadal basis using high resolution optical and Synthetic Aperture Radar (SAR) imagery.

The findings of this database may be used to update the Himalayan Glacier Database, offering new information to glacier dynamics and climate change experts. This information may also be utilized in models to determine suitable sites for hydroelectricity generation stations, irrigation water demands and other applications such as industrial and domestic.