

# Chapter 5

## Spatial Data Input and Attribute Data Handling

One of the main objectives of the present study is to develop a digital database of glaciers and glacial lakes using geographic information systems (GIS). A digital database is necessary for the monitoring of glaciers and glacial lakes and to identify the potentially dangerous lakes. GIS is the most appropriate tool for spatial data input and attribute data handling. It is a computer-based system that provides the following four sets of capabilities to handle geo-referenced data: data input, data management (data storage and retrieval), data manipulation and analysis, and data output can be found in Arnoff (1989).

Any spatial features of the Earth's surface are represented in GIS by the following:

- **area/polygons:** features which occupy a certain area, e.g. glacier units, lake units, land use units, geological units etc;
- **lines/segments:** linear features, e.g. drainage lines, contour lines, boundaries of glaciers and lakes etc; and
- **points:** points define the discrete locations of geographic features, the areas of which are too small to illustrate as lines or polygons, e.g. mountain peaks or discrete elevation points, sampling points for field observations, identification points for polygon features, centres of glaciers and lakes etc, and attribute data refer to the properties of spatial entities.

The spatial entities described above can be represented in digital form by two data models: vector or raster models. In a vector model the position of each spatial feature is defined by a series of X and Y coordinates. Besides the location, the meaning of the feature is given by a 'code'. In a raster model, spatial data are organised in grid cells or pixels, a term derived for a picture element. Pixels are the basic units for which information is explicitly recorded. Each pixel is assigned only one value.

For the present study, integrated land and water information system (ILWIS) 2.23 for Windows is used for the spatial and attribute database development and analysis. ILWIS for Windows is an object oriented image processing and geographic information system. Analysis and modelling in a GIS requires input of relevant data. The topographic maps of the 1960s on a scale of 1:50,000 published by the Survey of India were used as the baseline for the spatial data of glaciers and glacial lakes. The list of topographic maps used for the study is given in Chapter 4. Delineation of all the glaciers and glacial lakes was done on the topographic maps. All the glaciers and glacial lakes were numbered and their attributes were noted. The details of the methodology for the delineation and attributes are also given in Chapter 4.

The most common method of entering spatial data is by manual digitising using a digitiser board. Before starting digitisation one should know the map projection system. Map projection defines the relationship between the map coordinates and the geographic coordinates (latitude and longitude). Bhutan is situated between 88° 45' to 92° 10' E longitude and 26° 45' to 28° 10' N latitude. The coordinate system parameters for Bhutan are as follows.

- Projection: Polyconic
- Ellipsoid: Everest (India 1956)
- Datum: Indian (India, Nepal)
- False easting: 2 743 196.40
- False northing: 914 398.80
- Central meridian: 90° 0' 00" E
- Central parallel: 26° 0' 00" N
- Scale factor: 0.998786

The minimum and maximum X and Y values required in the above geo-reference system in the Bhutan area falling in Grid Zone IIB are:

- minimum X = 2,605,000
- maximum X = 2,950,000
- minimum Y = 985,000
- maximum Y = 1,185,000

It is always necessary to maintain the details, smoothness, and accuracy of the input spatial data of all the required information as in the maps of the given map scale. They are defined by the snap and tunnel tolerances in the system. The snap and tunnel tolerances in the system are defined by the extent of the minimum and maximum X and Y values. To increase the detail and accuracy, the coordinate system with the required X and Y extents for each one degree area was created to digitise all the topographic maps. These sub-coordinate systems were very useful and made the input and handling of the data easy.

After the delineation of the glaciers, glacial lakes, and ridges on the maps the segments were digitised using the following codes.

- 1 = lake boundary
- 2 = glacier boundary
- 3 = ridge line
- 5 = basin or international boundary
- 10 = dry lake
- 11 = drainage line
- 12 = lake attached to glacier common boundary
- 20 = rock glacier boundary only
- 23 = glacier attached to ridge line common boundary
- 25 = glacier attached to basin boundary common boundary
- 100 = tic points reference lines

The segment code values are necessary for data retrieval and analysis in GIS. All the polygons representing glaciers and glacial lakes are numbered as mentioned in Chapter 4. Points showing the location of glaciers and glacial lakes were digitised. They were used later for identification of the polygons of the glaciers and glacial lakes. After digitisation, the segments were checked and the glaciers and glacial lakes were numbered using point identifiers. Basin-wise polygon maps of glaciers and glacial lakes are presented in Chapters 7 and 8.

In an object oriented GIS, polygon maps with identifier domains of the objects have a related attribute table with the same domain. The domain defines the possible contents of a map, a table, or a column in a table (attribute). Some examples of 'domain' are class domain (a list of class names), value domain (measured, calculated, or interpolated values), image domain (reflectance values in a satellite image or scanned aerial photograph), identifier domain (a unique code for each item in the map), string domain

(columns in a table that contain text), bit domain (value 0 and 1), bool domain (yes or no) etc. An attribute table is linked to a map through its domain. An attribute table can only be linked to maps with a class or identifier domain. An attribute table may contain several columns.

Required attributes of the glaciers and glacial lakes as explained in Chapter 4 were derived or entered in the attribute database in the GIS. Most of the attributes were derived from the topographic maps, aerial photographs, satellite images, reports, field data, etc. Attributes such as area, location (latitude, longitude) etc were derived from the spatial database. If other necessary digital spatial data layers, such as digital elevation models (DEM), are available, it is possible to generate terrain parameters such as elevation, slope, length etc as measuring units for glaciers and glacial lakes. Other attributes such as aspect, mean length, elevation, map code, name, etc, were manually entered in the attribute database. Additional attributes, such as mean elevation, volume etc were derived using logical calculations. For each basin, attribute tables were developed for glaciers and glacial lakes. Some of the attributes were also derived from the results of an aggregation in the same table or from another table using the table joining operations, such as glaciers associated with the glacial lakes, etc.

The criteria for the identification of potentially dangerous glacial lakes are explained in Chapter 11. Using the logical calculation in the GIS, the potentially dangerous glacial lakes were determined. To study the geomorphic characteristics of these potentially dangerous lakes, the available time-series satellite images and topographic maps were also used.

