**Figure 4.10**     Soil classification map for south east Viti Levu (43 classes based on Ministry of Primary Industries survey).
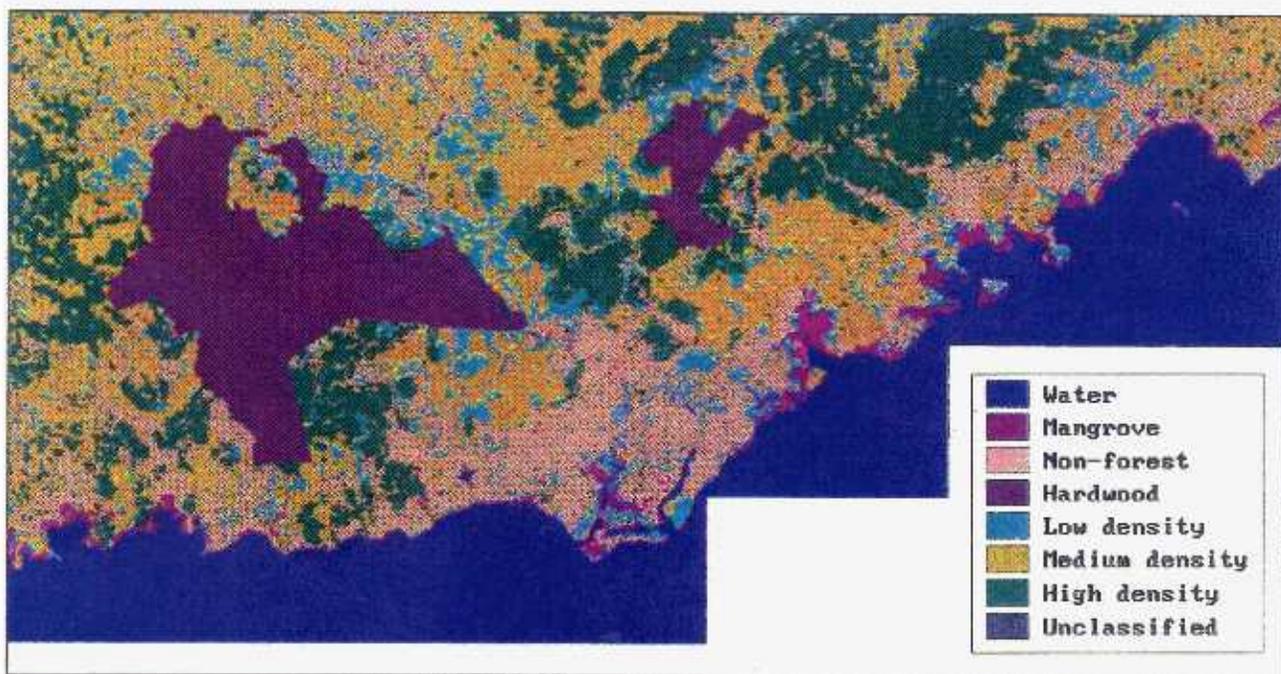


Water
Mangrove
Non-forest
Hardwood
Low density
Medium density
High density
Unclassified

**Figure 4.11**     Forestry land classification map for south east Viti Levu (provided by Fiji-German Inventory Project).

**Forest:** A forestry/land-use digital data set divided into 8 classes was provided by the FGIP. This is shown in Figure 4.11.

**Rivers:** These were digitised from the 1:50 000 topographic maps. They were used only for geographical reference.

**Roads:** Again, these were digitised from the 1:50 000 topographic maps, and used for reference in relation to risks and contingency planning.

**Coastline:** This was also digitised from the 1:50 000 topographic sheets.

## 4.5 Description, derivation and use of a digital elevation model (DEM)

Although in the present study, the DEM was supplied to the project by the FGIP, some general information on DEM production is nevertheless appropriate. It is important to note that creating a DEM is a major, time-consuming task requiring specific computer hardware and sophisticated software. It may not be possible to achieve using a standard PC.

A DEM is a representation of the land surface stored on computer. Digitized spot heights and contours do not in themselves form a DEM since these relate to individual points or lines and provide no information about locations in between, whereas a DEM is continuous over an area. For this reason, DEMs are often held in a grid or raster format with a height value assigned to each cell.

Clearly, topographic survey information, usually in the form of spot heights and contours, is fundamental to the creation of a DEM. The major work involves the transference of survey data from maps to the digital form before the DEM can be calculated. This usually involves raster scanning a map of the contours and the use of line-following software to convert them to attributed vectors (i.e x-y-z strings). Once digitized, the height information can be interpolated onto a regular grid using a variety of computer algorithms.

The simplest procedure calculates the average of all the height points within a circle of specified radius centred on each of the grid nodes. Since the moving average technique is easy to calculate, it is often the interpolation algorithm implemented in PC-based GISs. Its advantage is that the calculated height values are restricted to the range of the observed data. Choosing the correct search radius, however, can be difficult. Too small a radius will result in the DEM not having a value at each grid node. This is a particular problem in flat lying areas where the data points are widely spaced. Conversely, too large a radius will result in an overly smooth surface which does not accurately represent the terrain.

Other, more sophisticated, interpolation procedures are available but usually in software packages external to the GIS. The least squares algorithm best fits a plane to the observed data within a specified distance of the grid node accounting for local surface trends, by reducing the significance of the more distant points. Projection algorithms use surface gradients and trends calculated at each observed point and then determines the height values at the grid node positions by projection and averaging. This procedure yields smooth surfaces and satisfactorily interpolates into areas of sparse data but can give unrealistic highs or lows for some data sets. The minimum curvature method can be compared to the flexing of a thin

metal plate to the surface. This procedure produces the smoothest possible surface whilst attempting accurately to fit the observed data.

An alternative technique for creating a surface model is 'triangulation', in which a set of facets spanning the area are created by fitting a plane between each group of three data points which form the vertices of a triangle. The regular grid of height values is then determined by projection to the facets. The advantage of this procedure is that the surface is closely tied to the observed data and can never exceed the limits of the data. However, in areas of sparse data, the calculated surface can contain artificial plateaux.

Irrespective of the method used to create a DEM, it must be recognized that the result is a mathematical model; there is no guarantee that the height at a grid node is close to the actual elevation that would be measured on the ground. The calculated surface depends on many factors, some examples of which are: the chosen algorithm and parameters; the distribution of the observed data; and the required spacing between grid nodes. With contour data the distance between observed points is generally much smaller along the contour lines than between them, and this may lead to artifacts being produced parallel to the contours.

An alternative method of deriving a DEM is directly from remote sensing data using the parallax differences present in stereoscopic aerial photography or satellite imagery. Parallax is essentially a measure of apparent displacement of ground points, due to their relative elevation, when viewed from two different positions (e.g. successive aerial photographs along a flight line). Since parallax shift is proportional to height and can be calculated, such measurements can be used to derive a DEM. Modern computer systems such as the Intergraph ImageStation use sophisticated pattern matching software to correlate pixel groups across a pair of images (or scanned photograph pair), and use this to determine parallax on a regular grid.

Once the DEM has been calculated it is a relatively simple procedure to create secondary (derived) data sets such as slope and aspect using readily available GIS functions. The local slope and aspect at each grid node is determined from the results of simple filtering operations in the x and y directions. The slope can be given either as a percentage gradient or as an angle between 0° and 90°. Aspect, the direction of maximum slope, is given as an angle from 0° through 360°.