CHAPTER V
LANDSLIDE HAZARD ZONATION MAPPING
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5.1 General

The natural disasters are generally of two major types such as the hazards caused by the natural morphodynamic and morphotectonic processes of the planet Earth like earthquakes, volcanic eruptions, etc. and disasters induced by human interaction with the nature (or) extraneous sources like landslides, soil erosion, reservoir siltation, salt water intrusion, land subsidence, etc.

Amongst, all natural disasters, landslides are most difficult to predict as the causes, inherent in the terrain, vary from place to place. But, forecasting the danger prone areas rendered possible through application of zonation in a broad sense implies division of land surface into zones of existing (or) potential hazard from landslides with different degrees of susceptibility.

Landslide hazard zonation is a division of the land surface into areas, and the relative ranking of these areas according to degree of actual or potential hazards from landslides. This is a method to evaluate the risk where there is the potential for landslides and an important tool for designers, field engineers and geologists to classify the area into zones of varying degree of hazards. Many workers have used different type of approaches to study and integrate the various terrain parameters in different parts of the world to generate landslide hazard zonation maps.

In the present study, various thematic maps were generated on different landslide influencing terrain parameters and landslide susceptibility ranges were identified in each terrain parameter on the basis of landslide frequencies maxima
falling in different classes of each variable. Buffered raster images were generated by buffering out landslide vulnerable zones of each parameter. Such buffered images were integrated using overlay function of ArcGIS by assigning suitable weightage factors, and landslide hazard zonation mapping was done for the study area on the basis of number of landslide influencing variable loaded.

5.2 Generation of Threshold maps

Various thresholds (or) susceptibility ranges were developed for all the landslide influencing variables namely

- Lineament density
- Lithology
- Drainage density
- Regolith cover
- Soil types
- Slope
- Relief
- Tectonic geomorphology
- Rainfall
- Landuse/landcover

The said parameter thresholds were developed by duly analyzing different classes in the dynamic range of the above variables and more number of frequency of landslides falling in each class. Then, those classes are identified as threshold for the individual variables. The landslide susceptibility range or the threshold so fixed up for the 10 variables for the study area as shown in Table 5.1.
Table 5.1 Variable wise Threshold/Susceptibility range

<table>
<thead>
<tr>
<th>Variables</th>
<th>Threshold / Susceptibility range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lineament density</td>
<td>Low and moderate density</td>
</tr>
<tr>
<td>Lithology</td>
<td>Charnockite</td>
</tr>
<tr>
<td>Drainage density</td>
<td>Low and Moderate</td>
</tr>
<tr>
<td>Regolith cover</td>
<td>1 – 3 mts.</td>
</tr>
<tr>
<td>Soil types</td>
<td>Hill and Ooty soil types</td>
</tr>
<tr>
<td>Relief</td>
<td>400 – 600m</td>
</tr>
<tr>
<td>Tectonic geomorphology</td>
<td>Structural hill</td>
</tr>
<tr>
<td>Rainfall</td>
<td>500 – 1500 mts.</td>
</tr>
<tr>
<td>Landuse/Landcover</td>
<td>Huts, Coffee plantation, and Forest plantation</td>
</tr>
</tbody>
</table>

The above said established thresholds for each variable, the individual thematic maps of these variables were analysed and such threshold zones were buffered out in each thematic map such as Lithology (Fig. 3.1), Lineament density (Fig. 3.4), Tectonic geomorphology (Fig. 3.5), Tectonic slopes (Fig. 3.16), Regolith cover (Fig. 3.20), Drainage density (Fig. 3.22), Landuse/Landcover (Fig. 3.24), Relief (Fig. 3.25), Soil types (Fig. 3.26), and Rainfall (Fig. 3.27).
5.3 GIS overlay and Landslide Hazard Zonation Mapping

Such GIS images, were finally integrated using overlay function of ArcGIS by assigning suitable weightage factors. Thus, all the GIS images generated for the above mentioned parameters were added one over the other and the final integrated image was generated cumulating all the 10 variables.

Such an added image has shown the following various classes:

1. Lineaments (Lineament density) induced landslide vulnerable zones
2. Tectonic geomorphology induced landslide vulnerable zones
3. Denudational geomorphology (Regolith cover) induced landslide vulnerable zones
4. Fluvial geomorphology (Drainage density) induced landslide vulnerable zones
5. Slope induced landslide vulnerable zones
6. LU/LC induced landslide vulnerable zones
7. Relief induced landslide vulnerable zones
8. Soil type induced landslide vulnerable zones
9. Lithology induced landslide vulnerable zones
10. Rainfall induced landslide vulnerable zones

After preparing the buffered raster images for landslide vulnerable and non-vulnerable zones for the above 10 variables. Subsequently, the buffered GIS images generated for the above mentioned parameters were added one over the other. For example in the buffered raster image of lithology data which was showing the landslide susceptibility zones, there were two classes namely vulnerable zone and unvulnerable zone. The class threshold vulnerable zone landslide can occur due to lithology. The vulnerable weightage 1, unvulnerable weightage 0.
Similarly, the other GIS raster images of other variables overlaid, which obviously has innumerable number of polygons of land loaded with number of various influencing variables loaded in various permutations and combinations such as Combined zone of 1 & 2; combined zone of 1 & 3; combined zone of 1 & 4; Combined zone of 1 & 5; combined zone of 1 & 6; combined zone of 1 & 7; Combined zone of 1 & 8; combined zone of 1 & 9; combined zone of 1 & 10; Combined zone of 1, 2, 3; combined zone of 2, 3, 4; combined zone of 3, 4, 5; Combined zone of 4, 5, 6; combined zone of 5, 6, 7; combined zone of 6, 7, 8; Combined zone of 7, 8, 9; combined zone of 8, 9, 10; combined zone of 9, 10, 1; Combined zone of 10, 1, 2; combined zone of 2, 3, 4, 5; combined zone of 3, 4, 5, 6; Combined zone of 4, 5, 6, 7; combined zone of 5, 6, 7, 8; combined zone of 6, 7, 8, 9; Combined zone of 7, 8, 9, 10; combined zone of 8, 9, 10, 1; combined zone of 9, 10, 1, 2; Combined zone of 10, 1, 2, 3; combined zone of 1, 2, 3, 4; Combined zone of 1, 2, 3, 4, 5; combined zone of 2, 3, 4, 5, 6; Combined zone of 3, 4, 5, 6, 7; combined zone of 4, 5, 6, 7, 8; Combined zone of 5, 6, 7, 8, 9; combined zone of 6, 7, 8, 9, 10; Combined zone of 7, 8, 9, 10, 1; combined zone of 8, 9, 10, 1, 2; Combined zone of 9, 10, 1, 2, 3; combined zone of 10, 1, 2, 3, 4; Combined zone of 1, 2, 3, 4, 5, 6; combined zone of 2, 3, 4, 5, 6, 7; Combined zone of 3, 4, 5, 6, 7, 8; combined zone of 4, 5, 6, 7, 8, 9; Combined zone of 5, 6, 7, 8, 9, 10; combined zone of 6, 7, 8, 9, 10, 1; Combined zone of 7, 8, 9, 10, 1, 2; combined zone of 8, 9, 10, 1, 2, 3; Combined zone of 9, 10, 1, 2, 3, 4; combined zone of 10, 1, 2, 3, 4, 5; Combined zone of 1, 2, 3, 4, 5, 6, 7; combined zone of 2, 3, 4, 5, 6, 7, 8; Combined zone of 3, 4, 5, 6, 7, 8, 9; combined zone of 4, 5, 6, 7, 8, 9, 10; Combined zone of 5, 6, 7, 8, 9, 10, 1; combined zone of 6, 7, 8, 9, 10, 1, 2; Combined zone of 7, 8, 9, 10, 1, 2, 3; combined zone of 8, 9, 10, 1, 2, 3, 4;
Combined zone of 9, 10, 1, 2, 3, 4, 5; combined zone of 10, 1, 2, 3, 4, 5, 6;
Combined zone of 1, 2, 3, 4, 5, 6, 7, 8; combined zone of 2, 3, 4, 5, 6, 7, 8, 9;
Combined zone of 3, 4, 5, 6, 7, 8, 9, 10; combined zone of 4, 5, 6, 7, 8, 9, 10, 1;
Combined zone of 5, 6, 7, 8, 9, 10, 1, 2; combined zone of 6, 7, 8, 9, 10, 1, 2, 3;
Combined zone of 7, 8, 9, 10, 1, 2, 3, 4; combined zone of 8, 9, 10, 1, 2, 3, 4, 5;
Combined zone of 9, 10, 1, 2, 3, 4, 5, 6; combined zone of 10, 1, 2, 3, 4, 5, 6, 7;
Combined zone of 1, 2, 3, 4, 5, 6, 7, 8, 9; combined zone of 2, 3, 4, 5, 6, 7, 8, 9;
10; Combined zone of 3, 4, 5, 6, 7, 8, 9, 10, 1; combined zone of 4, 5, 6, 7, 8, 9;
10, 1, 2; Combined zone of 5, 6, 7, 8, 9, 10, 1, 2, 3; combined zone of 6, 7, 8, 9;
10, 1, 2, 3, 4; Combined zone of 7, 8, 9, 10, 1, 2, 3, 4, 5; combined zone of 8, 9;
10, 1, 2, 3, 4, 5, 6; Combined zone of 9, 10, 1, 2, 3, 4, 5, 6, 7; combined zone of
10, 1, 2, 3, 4, 5, 6, 7, 8; Combined zone of 1, 2, 3, 4, 5, 6, 7, 8, 9, 10.

After such final integration, general landslide hazard zonation was done by
grouping these polygons into 9 variables from 2 to 10 variable combinations
depending upon the number of variables loaded in them (Fig. 5.1 to 5.9).

The GIS overlay of landslide susceptibility zones of all 10 landslide influencing
variables has led into number of polygons of land with 2 variables, some with 3
variables and some with 4, 5, 6, 7, 8, 9, 10 variables as shown in Fig. 5.1 to 5.9.

So, in such an analysis, many classes were resulted with the loading of one
variable, two variables (Fig.5.1), three variables (Fig.5.2) and up to 10 variables (Fig.
5.1 to 5.9). Such final integrated image was regrouped, and grouping the classes or
the polygons having 1 to 3 variables, 4 to 6 variables and more than 6 variables
loaded in them and the zones where 1 to 3 variables loaded were documented as
least landslide vulnerable zones, 4 to 6 variables loaded zones as moderately
DOMAINS OF TWO VARIABLE COMBINATIONS INDUCING LANDSLIDES

Fig 5.1

Legend
- Lineament/Weathered zone

DOMAINS OF THREE VARIABLE COMBINATIONS INDUCING LANDSLIDES

Fig 5.2

Legend
- Lineament Weathered Zone
- Relief
- Lithology Lineament Weathered zone
- Drainage density / Lineament Weathered zone
- Drainage density / Lithology Weathered zone
- Lithology Lineament Weathered zone
DOMAINS OF FOUR VARIABLE COMBINATIONS INDUCING LANDSLIDES

Legend
1. Slope
2. Drainage Density
3. Lithology
4. Lineament Density
5. Landuse/Landcover
6. Geomorphology
7. Soil Type
8. Weathered Zone
9. Rainfall
10. Relief

Fig 5.3

DOMAINS OF FIVE VARIABLE COMBINATIONS INDUCING LANDSLIDES

Legend
1. Slope
2. Drainage Density
3. Lithology
4. Lineament Density
5. Landuse/Landcover
6. Geomorphology
7. Soil Type
8. Weathered Zone
9. Rainfall
10. Relief

Fig 5.4
DOMAINS OF SIX VARIABLE COMBINATIONS INDUCING LANDSLIDES

Legend
1. Slope
2. Drainage Density
3. Elevation
4. Rainfall
5. Landuse and Landcover
6. Geomorphology
7. Soil type
8. Weathered zone
9. Rainfall
10. Relief

Fig 5.5

DOMAINS OF SEVEN VARIABLE COMBINATIONS INDUCING LANDSLIDES

Legend
1. Slope
2. Drainage density
3. Elevation
4. Rainfall
5. Landuse and Landcover
6. Geomorphology
7. Soil type
8. Weathered zone
9. Rainfall
10. Relief

Fig 5.6
DOMAINS OF TEN VARIABLE COMBINATIONS INDUCING LANDSLIDES

Legend
1. Slope
2. Drainage Density
3. Lithology
4. Lineament Density
5. Landuse and Landcover
6. Geomorphology
7. Soil Type
8. Weathered Zone
9. Rainfall
10. Relief

Semmanattam
Nagalur
Maramangalam
Valavandi
Yercaud

Fig 5.9
vulnerable and more than 6 variables loaded polygons as the most vulnerable zones. And thus, the landslide hazard zonation map was done (Fig.5.10).

The above GIS overlay function technique has shown a number of polygons along with a number of variables loaded in them. But as weightages were given at each and every stage of addition, these polygons were not only capable of giving the number of variables that were loaded in them but also the type of variables.

5.4 Synthesis

Thus, the present study has evolved a newer technology for landslide hazard zonation mapping using geology/terrain systems with the help of remote sensing and geographic information system.

The landslide susceptibility zones in each 10 variables were buffered out using GIS and raster images were generated. Those raster images of 10 variables on integrated image was generated. Such an integrated image has shown innumerable number of polygons within 2 to 10 variables. In the same, the polygons with zones of more than 6 variables loaded has been classified as most vulnerable, then 4-6 variables loaded as moderate vulnerable zone and less than 3 variables marked as least vulnerable zone having the landslide hazard zonation of the study area.
LANDSLIDE VULNERABILITY ZONATION MAP

Legend
- Green: Least Vulnerable
- Yellow: Moderately Vulnerable
- Red: Most Vulnerable

Fig 5.10