Effect of Combination of Landslide Factors on the Prediction Accuracy of Landslide Susceptibility Maps: The Case of Goha Tsiyon-Dejen Transect in the Blue Nile Gorge of Central Ethiopia.

Matebie Meten, Netra P. Bhandary, Ryuichi Yatabe
Graduate School of Science and Engineering,
Ehime University

Landslide susceptibility, GIS, Frequency Ratio, combination, Prediction accuracy, Ethiopia

1. Introduction

Landslides in the Abay (Blue Nile) Gorge of Ethiopia are serious threat to the community and road infrastructure that connects Addis Ababa and Bahir Dar. In 1960, a terrible landslide at Gembechi village in upper Bechet valley killed 45 people (Ayalew, 1999). On September 2, 1993 a landslide incidence in the Blue Nile Gorge killed an ox and destroyed and crops resulting food scarcity for 700 households (Tadesse et al., 1994). The average annual rainfall of the area is 1400 mm while the minimum and maximum annual rainfalls are 1200 and 1800 mm respectively. Frequent road damage occurs at the middle or end of every rainy season (June 1 to September 30). The current study tried to prepare different landslide susceptibility maps from eight landslide causal factors (i.e. lithology, land use, distance from lineament, distance from river, slope, aspect, plan and profile curvatures) and landslide inventory with different combinations using the frequency ratio model in GIS and compare the prediction accuracies in order to select the best landslide susceptibility map. From this perspective, the following questions will be addressed in this paper. (1) How many combinations are possible in the frequency ratio model from a given number of landslide factors? (2) Which combination of landslide factors will give the best prediction accuracy?

2. Study Area

The study area is located in the Abay (Blue Nile) Gorge of Central Ethiopia and it is bounded by 38˚ 2' E to 38˚15" E longitudes and 10˚ 0′ N to 10˚ 15' N latitudes covering a total area of 391 km^2 (Fig. 1). From the top of plateau to the valley floor, the Abay Gorge has a depth of 1.5 km in the study area.

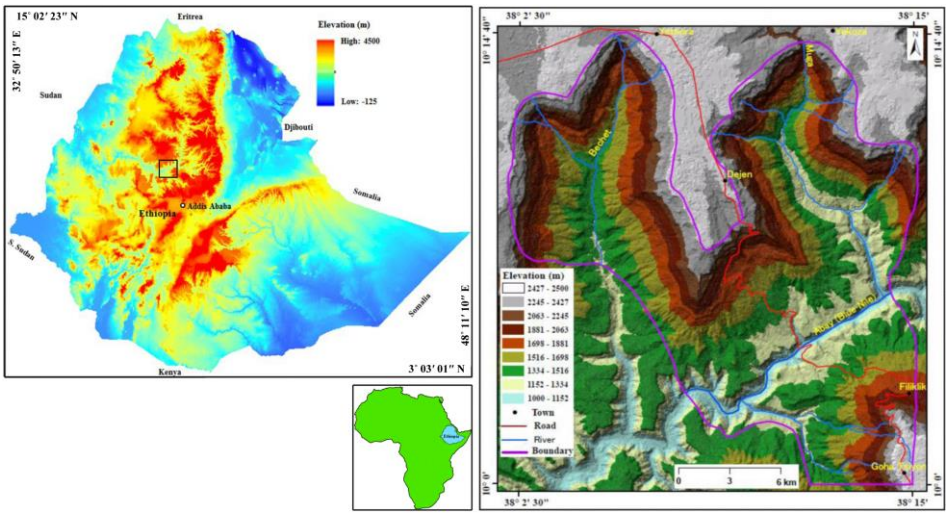

Figure 1 Location map of the study area.

3. Methodology

Frequency Ratio Model was chosen to analyze landslide susceptibility in the study area. This model works on the principle of assigning values derived from the percentage of landslides to the percentage of area for each landslide factor's class. Then, the derived frequency ratio maps of landslide factors will be combined by the mathematical combination theory. The prediction accuracy of selected landslide susceptibility maps were found from area under the curve (AUC) values of the receiver operating characteristics (ROC) curves in SPSS statistical software. For validation purpose, we overlaid the landslides used in the analysis and checked how much percentage of these landslides fall in each landslide susceptibility class.

4. Results and Discussion

In the frequency ratio model, we can have a total of 247 landslide susceptibility maps from eight landslide factors using the mathematical combination theory. We can combine 8, 7, 6, 5, 4, 3 and 2 frequency ratio factor maps into 1, 8, 28, 56,70, 56 and 28 number of ways respectively. However, for simplicity, a total of 28 combinations were selected in this analysis. One landslide susceptibility map was selected from each combination group based on the highest prediction accuracy and higher difference values between minimum and maximum landslide susceptibility index. Hence, a total of seven best landslide susceptibility maps were selected from each combination group to show how AUC values vary for different combinations.

The prediction accuracy using seven factors excluding distance from river (FR_wo_dr) and four factors including slope, lithology, land use and distance from lineament (FR_slliludl) was found to be 87.7% while using all factors (FR_all_data) and six factors excluding profile and plan curvatures (FR_wo_prpl) resulted 87.6%. A combination of five factors excluding distance from lineament, profile and plan curvatures (FR_wo_dlprp), three factors including slope, lithology and land use only (FR_sllilu) and two factors with lithology and slope only (FR_lisl) have resulted a prediction accuracy of 87%, 86.9% and 85% respectively (Figure 2b). Among these seven maps, FR_wo_dr was selected for the final landslide susceptibility map and when a landslide inventory map was overlaid, 0.39%, 1.84%, 9.1%, 32.04% and 56.63% fall in very low, low, medium, high and very high landslide susceptibility classes respectively.

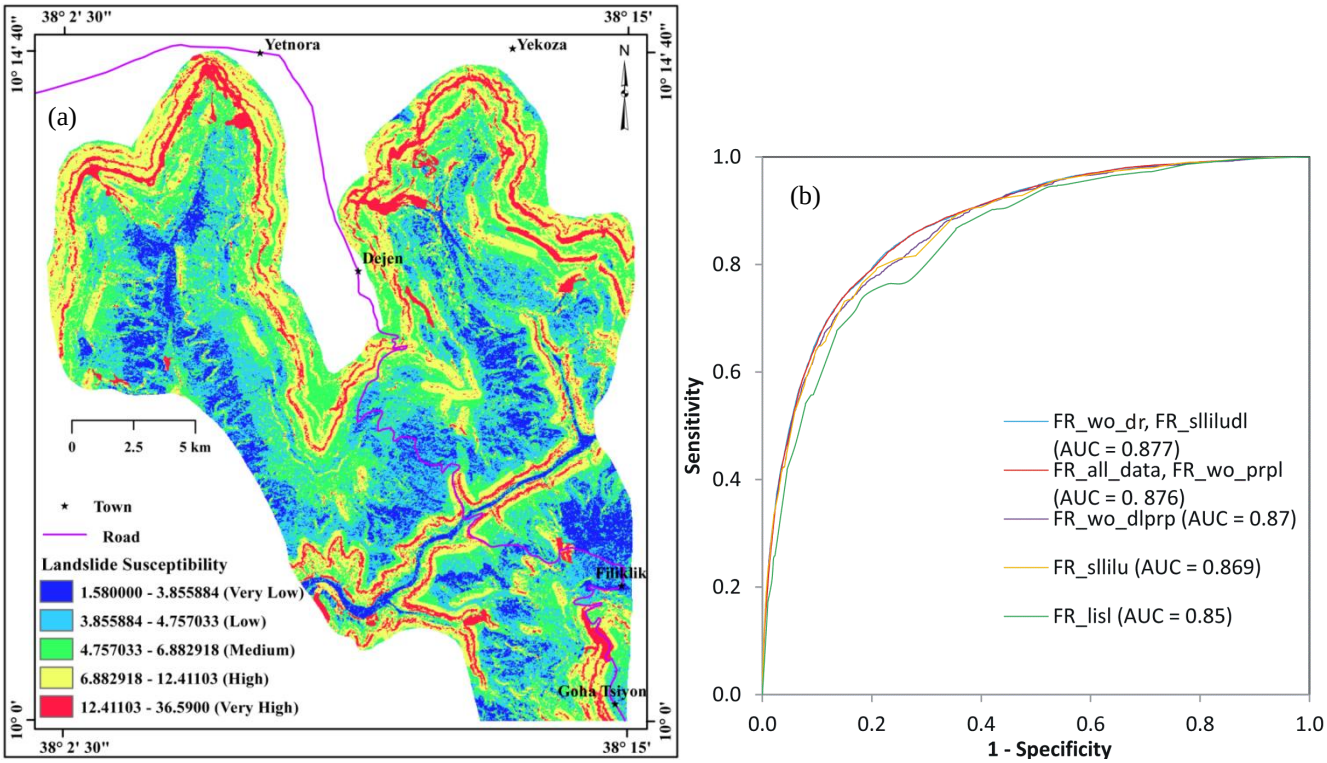

Figure 2 (a) Landslide susceptibility map using seven factors excluding distance from river (FR_wo_dr)
(b) AUC Values of ROC curves for the seven best combinations from each combination group.

5. Conclusion

From this study we have found that the mathematical combination theory is an important technique to identify the possible number of combinations in the frequency ratio model. This paper showed that using all or nearly all landslide factors in the frequency ratio model combination may not always result in higher prediction accuracies even though the range of values in the susceptibility index map is higher. However, limited number of landslide factors with a major degree of influence in land sliding, when combined can bring about the same level of prediction like using too many factors. Once the most important landslide factors are determined in a smaller area, then these can be used to scale up the investigation at the regional level using these factors. When landslide inventory map is overlaid over the landslide susceptibility map, most of landslides fell in the high and very high susceptibility classes accounting about 86.6% of landslides. The fact that the prediction accuracy of the best landslide susceptibility map is being 87.7% shows that the landslide susceptibility map is quite acceptable.

References

Ayalew L and Yamagishi H (2004) Slope failures in the Blue Nile basin, as seen from landscape evolution perspective. Geomorphology 57 (2004) 95–116.

Tadesse T, Dessie T, Deresa K (1994) Landslide incidence in the Blue Nile Gorge of East Gojam, Ethiopia, Geological Survey of Ethiopia, unpublished report, 830-301-01.