Quantitative Assessment of Temporal/Spatial Relevance in Landslide Prediction Models

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1. Introduction

Landslide prediction models for mathematical representation and integration of spatial data have been studied since 1990s (Van Westen, 1993; Chung and Fabbri, 1998). These approaches with their own mathematical backgrounds have provided powerful schemes for decision-supporting information, through several case studies for future landslide prediction (Carrara *et al.*, 1999; Chung and Fabbri, 1999; Lee and Min, 2001). However, proper interpretation and quantitative evaluation of prediction result have not been fully considered in landslide hazard mapping, and is in the development stage.

This contribution discusses the problem of providing measures of significance of predictions results when the predictions were generated from spatial databases for landslide hazard mapping. A core point of measuring the significance of a prediction is that it allows interpreting the results. We illustrate the analytical procedure using two case studies, one from the Fabriano area in central Italy, and the other from the Boeun area in Korea.

2. Temporal/Spatial validation of the prediction models

1) Analytical procedure for validation

After a prediction image is obtained, we need to consider the supporting evidence and the confirmation of reliability of the prediction result. All predictions related to future events are always subject to the uncertainties. So the uncertainty should be estimated by some analytical procedures. Such confirmation is not only to convince us of the degree of success in predicting, but also to communicate to non-specialists the significance of the predictions so that decisions can be taken about safer land uses as a consequence of the prediction results.

To validate the prediction results, we should restrict the use of all the data of the past landslides in the study area. Because we don't know the future events, the next best thing to do is to mimic the comparison by using a part of the past events as if it represents the future landslides. By partitioning the data, one subset is used for obtaining a prediction map; the other subset is compared with the prediction results for validation. In this contribution, we consider examples of time and space partitions of the past landslides.

Key Words: validation, landslide hazard

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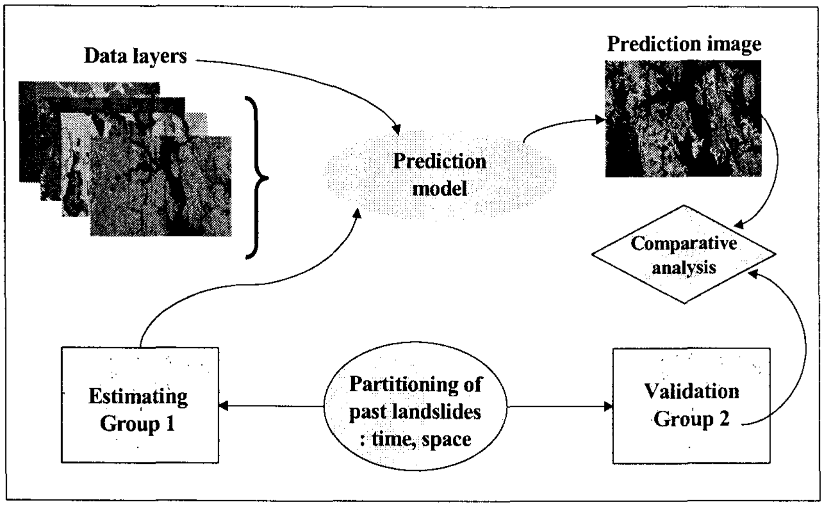

Fig. 1 Diagram for illustrating the validation procedure.

2) Temporal relevance of predictions

To illustrate the procedure for assessing temporal relevance of predictions, a case study from the Fabriano area in central Italy is carried out. For spatial databases, the following six are used: (1) slope map, (2) aspect map, (3) engineering geology map, (4) distances from drainage, (5) distances from fault, and (6) land-use map. The landslides are classified into two temporal groups: before 1955, and during 1955-1993. In the spatial databases, it was pretended that the time of the study was the year 1955. All the seven layers available in 1955 were compiled in addition to the distribution of the landslides which had occurred prior to that year. These were used as the training data set to construct probabilistic relationships between the landslides and the remainder of the input data set. The predictions based on those relationships were then evaluated by comparing the map pattern of the predicted hazard classes with the distribution of the landslides which had occurred during 1956-1993.

The prediction image was obtained using the likelihood ratio model (Chung and Fabbri, 1998). To evaluate the temporal relevance of predictions, the prediction rate curve was computed. The prediction rate is the measurements of how well the prediction model predict the distribution of future landslides. To calculate the prediction rate, we first count the number of the future landslides whose values are larger than (100-certain value) %. Then the number was divided by the total number of future landslide to obtain the corresponding value in the vertical axis.

When we use this time-partition technique, then we are able to estimate the probability of the occurrences of future landslides within a certain time constrain such as for the next 38 years.

3) Spatial relevance of predictions

To illustrate the procedure for assessing spatial relevance of predictions, a case study from the Boeun area in Korea is carried out. For spatial databases, slope map, aspect map, geology map, soil data sets and forest data sets are used. As for the prediction model, the likelihood ratio model is applied.

To establish whether and to what extent a prediction can be extended, in space, to neighboring areas with similar geology, we divided the entire study area into two separated sub-areas. The study area has been subdivided into a northern sub-area and a southern sub-area. This was because the geological trend runs in the north-south direction so that greater similarity exists between north-south than east-west sub-areas, and the corresponding database subdivisions. We selected one of two sub-areas to construct a prediction model and the other to validate the prediction.

When we use this space-partition technique, then we are able to extend the current prediction model in the study area to the surrounding areas or similar geology.

3. Conclusions

In this contribution, we discussed analytical procedures for validating the prediction results. Owing to the temporal/spatial partitioning of the past landslide distributions, the validation strategy provides some empirical measures of support in the prediction of when and where the future landslides are likely to occur. We should notice that reliability of the prediction is only within the validation results or degree of satisfaction for the temporal/spatial matching of hazard ranges and the relative distribution of validation landslides.

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