Spatial Filters For Extracting Susceptibility Areas of Landslide-dam Formation In GIS

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1. INTRODUCTION

Some most significant hazards could occur since large landslide dams formed by earthquake induced landslides. It presents serious threats to both life and property due to possible upstream flooding as the impounded lake water level rises, possible dam failure and downstream flooding as rapid release of impounded water.

In order to prevent those secondary disasters, we presented spatial filters to extract the dangerous slopes as sources of earthquake induced landslide-dam formation in GIS based on the assumption that the landslide dam is only formed when a large amount of landslide deposits directly rush into a river with moderate or high-velocities . The Spatial filters consist of the following steps: (1) Identification of all the slopes using spatial statistics; (2) Extract slopes along a catchment for a certain distance through Buffering Filter. (3) Exclude the slope that could not reach to the river according to its direction to the river through Aspect Filter. (4) Exclude the slope that could not reach to the river according to the block height standing on the way to the river through Blockage Filter. (5) Production of susceptibility map by ranking the risk of the exacted slopes through 2D Stability Evaluation.

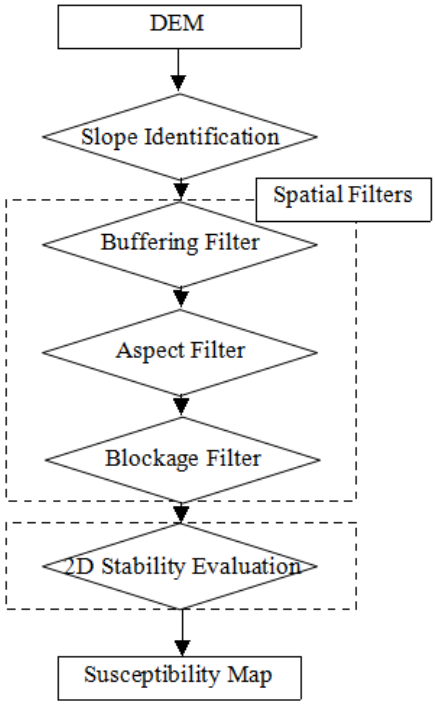

Fig. 1. Procedure flow

This method has been used to extract slopes those have potential to collapse and form landslide-dams in the catchment of Tongkou river based on the data from 2008 Wenchuan earthquake. The results show that the proposed method is very effective and efficient.

2. STUDY AREA AND DATA SOURCE

Out target catchment area is a 12×12 km^2 square field over the Basin of Tongkou River. A large number of landslides could be observed from satellite image. Consequently, five large-scale landslide-dams were reported in this area after WenChuan Earthquake, including the TangJiaShan Dam, the biggest dam induced by this Earthquake with a volume of 20.37 million m^3.

3. METHODOLOGIES

3.1. Slope Identification

For wide area slope stability analysis, a key problem is how to extract mapping units as study objects. Each mapping units, the portion of land surface that contains maximum internal homogeneity differing from adjacent units, should have relatively similar topographic and geological characteristics respectively. According to author's former researches, Arc Hydro tools is used to identified mapping units as "SlopeUnits" by ridge lines and valley lines and we controlled the size of SlopeUnits through adjusting threshold drainage value. At last we totally got 10186 SlopeUnits.

3.2. Buffer Filter

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To form a landslide-dam, the collapsed SlopeUnit should be close to the river channel. According to the filed investigation at the seismic area, the longest runout distance at Wenchuan Earthquake is 4.5 km, which was observed at Daguangbao landslide. Therefore, the buffer distance from the center of slide slope to the potential blocked channel is set as a constant distance 2 km. Thus, using buffer filter, the slopes along Tongkou River were extracted through a 2 km river buffer. As a result, 3996 SlopeUnits were extracted as potential risk area from total 10186 SlopeUnits.

3.3. Aspect Filter

To extract dangerous dam forming SlopeUnits, whether the slide runouts can reach the valley should be considered. It could be done by extending a runout path towards slide direction and then checking if it is conjoin with stream lines. In this research, the highest point was linked to the lowest point in each SlopeUnit to obtain the runout path and direction. And then, runout paths were extended 2 km towards downhill side. Spatial join tool of GIS was used here to obtain the spatial relationship between extended lines and stream lines. As a result, 1596 SlopeUnits were extracted as potential risk area from remained 3996 SlopeUnits.

3.4. Blockage Filter

The last spatial filter is the blockage height along the runout path towards river. The blockage is a risen topography on the runout path. When it is high enough, we considered it as a hill along the runout path and the landslide deposits would be blocked. So, the extended runout paths obtained above were cut off by the two side lines of river region, using Intersect tool of GIS. And then the elevations were extracted along cut lines as a cross section. The blockage height of each runout path was counted by SlopeWalker tool, which has developed by us, from top towards downhill direction. Basically, 5 m is considered to be high enough to hold back most landslide deposits along the path and used as a threshold value. As a result, 1136 SlopeUnits were extracted as potential risk area from remained 1596 SlopeUnits.

3.5. 2D Stability Evaluation

Among all the limit equilibrium methods, two dimensional (2D) models are the most widely used for engineered slopes. Especially in wide area assessment, the safety factor calculation is required to be simplified and easy to manage. In this research, a safety factor calculation tool has been developed based on GIS, using Bishop's simplified Method and taking no account of water pressure. The enumeration algorithm was performed to search an assumed circle critical slip surface. And then, the factor SF_{2D} can be derived according to Eq. 1:

$$SF_{2D} = \frac{\sum (W \cos\alpha \tan\phi) + \sum cL}{\sum W \sin\alpha} \quad (1)$$

4. Results

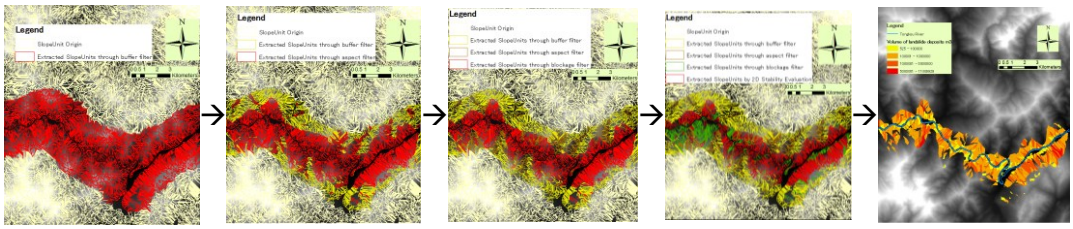

Fig. 2. The implement of Spatial Filters at the catchment of Tongkou river

As shown in Fig.2, Spatial Filters given effective and efficient procedures to located dangerous slopes of landslide-dam Formation.

References

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