A case study series published by the UNISDR Scientific and Technical Advisory Group

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The United Nations Office for Disaster Risk Reduction

UNISDR Scientific and Technical Advisory Group Case Studies - 2014

Using Multi-Temporal Satellite Imagery to Better Understand the History of the Ab Barak Landslide and Predict Future Landslides in the Region

The Problem

Landslides are one of the most destructive geo-hazards that pose serious threats to people and property, destroying houses and other structures, blocking roads and rivers, severing pipelines and other utility lifelines as well as smothering agricultural lands and the natural environment (Fan et al., 2012). A recent catastrophic landslide example includes the Ab Barak landslide, which occurred on 2 May 2014 in Badakshan, Afghanistan. It was induced by heavy rainfall in the period between 25 to 29 April and has drawn a lot of international attention due to its large magnitude and devastating damage. The number of fatalities remains uncertain, ranging from 300 to more than 2000, making it the worst landslide of 2014 to date (Witze, 2014). The UN Operational Satellite Application Programme's (UNOSAT) mapping of the landslide impacts shows that a total of 87 structures were almost certainly buried by the landslide. The landslide also blocked the Barik Aab valley, forming a landslide dam and a barrier lake. In order to prevent and predict similar landslides in the future, scientists must understand: what had happened in the past, what are the causal factors and failure mechanism of such type of landslides.

The Science

Due to the complexity of landslide failure mechanisms that involve various geo-environmental factors (i.e. geological, terrain and hydrological, etc.), the accurate prediction of landslide occurrence is still difficult, especially the prediction of individual landslides (van Westen et al., 2003). The prediction of landslides is often based on the assumption that the past is the key to the future, and therefore inventories of past landslides and their causal relationships can be used to predict future landslides as well as studying of landslide characteristics and evaluating slope profiles. Remote Sensing (RS) and Geographic Information System (GIS) technologies are useful tools for landslide mapping as well as understanding pre- and post-event situations. These techniques were applied to the Ab Barak landslide; based on the WorldView-2 satellite image (50 cm resolution) from 5 May 2014, the landslide is divided into source zone and deposition zone (Figure 1). Knowing the size of deposition area is important for rapid damage assessment and landslide volume estimation.

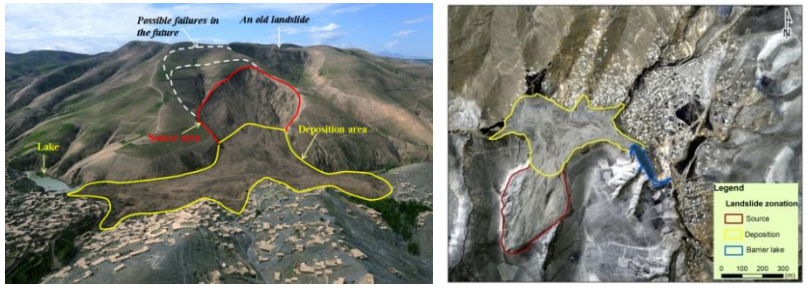

Figure 1. Left: An overview picture. There is an old landslide (with unknown age) next to the recent one, indicating that this region is prone to landslide hazards. The white dashed lines show the possible failure scarps in the future (Source and Copyright: The Atlantic). Right: Visual interpretation of the Ab Barak landslide (Source: WorldView-2; Copyright: DigitalGlobe Inc.)

The images from 2004 (Google Earth image) and 2013 (WorldView-2 satellite) show that the landslide area had been active prior to 2004. The high-resolution image from 2013 clearly shows geomorphic evidence of previous deformations, such as the dense erosion gullies along the flow path direction, accurate scarps and ridges.

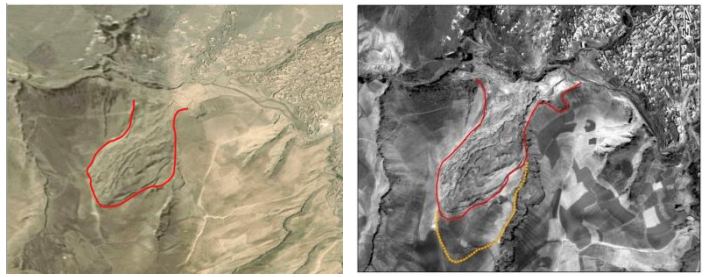

Figure 2. Left: Google Earth image from 2004; Right: WorldView-2 satellite image acquired on 7 June 2013. The red line indicates the active area, while the yellow dashed line indicates the sub-active region. (Source: Google Earth and WorldView-2; Copyright: Google Earth and DigitalGlobe Inc.)

The landslide failure mechanism is thought to be loess due to the colour and fine grain size of the deposits and high mobility of the landslide (Witze, 2014). Badakhshan is situated in the loess region where 34 similar landslides have been reported by Shroder et al. (2011), who analysed the failure mechanism of loess landslides and noted that farming practices specifically irrigation could increase the likelihood of landslides in these materials.

The Application to Policy and Practice

The Ab Barak landslide is a representative case of loess failures in Afghanistan. It is likely to be reactivated in the future, possibly due to retrogressive failures along the dashed lines as seen in Figure 1, and because the recent failure steepened the slope. The landslide might fail retrogressively to the ridge in the worst scenario or fail tracing the irrigation channels or track ruts.

Based on the above finding, local authorities have started to consider taking some simple early warning (EW) measures and mitigation work such as investing in hazard mapping programmes to prevent any future landslides from causing major damage. They are also planning to put more effort in identification and mapping of similar landsides in the loess region. Loess landslides are very sensitive to water (rainfall) therefore constructing drainage systems will be one effective way to stabilize the slopes.

Did it make a Difference?

This case study concludes that Ab Barak landslide will definitely not be the last landslide in the Ab Barak area, Afghanistan. Many movements have already happened in the past, and there will likely be similar landslides in the future. Fortunately, local authorities have recognized from this case that RS and GIS are useful tools for investigating, emergent damage mapping and disaster management. In addition, local authorities agree that carrying out the preventive measures including early warning and landslide hazard mapping is the most cost effective way to reduce landslide risk in such a highly landslide prone area. The landslide hazard mapping will be considered as an important factor for urban planning. These will certainly make a difference in decision making in the future. Local people also learned their lesson from this catastrophic case that the loess region is prone to landslide occurrence during heavy rainfalls, so they will pay more attentions to the potential unstable slopes. Furthermore, they will take landslides into account for site selection and construction of new houses.

References

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