Local scale investigation and modelling of geohazards at the Derwent Valley Mills World Heritage Site

Novellino A.¹, Harrison A.M.², Hobbs P.R.N.², Wang L.², Bee E¹

THE SITE

The Derwent Valley Mills World Heritage Site (DVMWHS) is the birthplace of the modern factory system. The Derwent Valley and its associated mill complexes, infrastructure and housing features were included in the UNESCO World Heritage List in 2001.

In the 18th and 19th century, it saw the successful combination of the essential ingredients for factory production, with Water Power applied at a large scale for the first time. This led to the development of new technology for spinning cotton, and the first modern industrial settlements.

The DVMWHS is one of the PROTHEGO case study sites, allowing focused research on local scale monitoring, investigation and advanced modelling.

GEOLOGICAL SETTING and GEOHAZARDS

The DVMWHS is mostly overlain by fluvial and mass movement deposits with glacially-derived till deposits. The underlying bedrock geology predominantly consists of interbedded mudstone, siltstone and sandstone. The alternating permeable and impermeable rocks can frequently give rise to landslide susceptibility, especially so if the river undermines the toe of the steep-sided escarpments.

Analysis of the British Geological Survey GeoSure dataset demonstrates that, despite the majority of the DVMWHS area is attributed to very low to low susceptibility hazards, landslides and flooding susceptibilities for the area are slightly higher.

MONITORING

In order to monitor the current state of activity of the identified geohazards, Sentinel-1 spaceborne imagery acquired between 2015 and 2017 has been processed using the Interferometric Synthetic Aperture Radar (iSAR) technique.

The ground stability conditions reveal that, globally, the land is not moving apart from three areas: two of them correspond to active landslides in Stannhouses and Ambregate which might impact the World Heritage site, in Belper the radar data identified damage connected to a recent flooding event.

MODELLING

UKCP09 medium emissions scenario predicts the area will experience drier, warmer summers, wetter winters with higher intensity rainfall events, with similar overall annual rainfall. This could significantly increase both the landslide and flooding susceptibility.

Analysis shows that landslide events often coincide with an unusually low Soil Moisture Deficit, such as that which occurred in June 2015 within a wider and notably irregular summer pattern which is also reflected in a period of high summer rainfall. INSAR results confirm that the movement is still ongoing at a constant rate.

Based on the analysis of linkage of hydrological components to historical events, an index method was developed to generate flood susceptibility maps for the future.

CONCLUSIONS

- This study reveals that the principal geohazards within the DVMWHS are landslides and fluvial and groundwater flooding. The other shallow geohazards associated within the study area have a comparably lower susceptibility, and the consequences would potentially be smaller.
- Two landslide locations are identified that could impact the WHS in the future: Stannhouses and Ambregate. INSAR data confirms the landslide susceptibility data and the active state of the high susceptibility landslide hazard. In Belper, the radar data identified the damage connected to the recent flooding event.
- This work has highlighted the potential for future research to aid the protection of WHSs from sources of hazard within the site, but, there has been no suggestion of implementing specific mitigation measures or on the cost-benefit analysis of possible mitigation alternatives. However, modified drainage patterns, dependent on localised conditions (walls and drains), drainage maintenance, floodwalls and floodplains, raising community awareness (flood risk maps) to allow individuals to take action appears to the initial response to these shallow processes.
- Antecedent rainfall is a major driver of the occurrence of the principal geohazards, and therefore the frequency and magnitude of these geohazards will be affected by future climate change. With the release of UKCP09 projections imminent, this is also an opportunity to strengthen the resilience of UNESCO heritage sites to future climatic fluctuations.

REFERENCES