Use of today´s hydrogeological data to predict future landslide risk

A case study at the Ångermanälven river valley, Sweden

H. Blomén, M.S. Zetterlund, K. Bergdahl, K. Odén

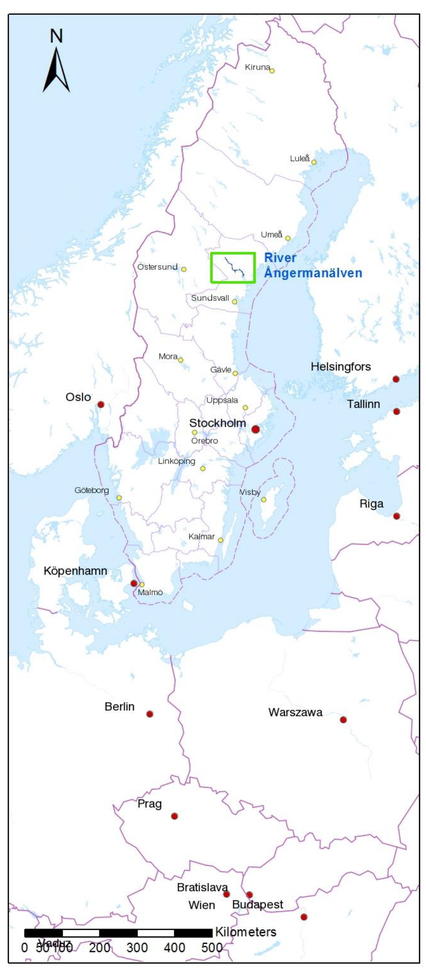
Landslide Risk Mapping

Many areas in Sweden are susceptible to landslides. In vulnerable areas, the effects of climate change can also be very tangible, e.g. a higher water flow that causes increased erosion and a deterioration in soil layer stability.

The aim of landslide risk mapping is to provide an overall picture of the landslide risks along each specific watercourse, under current conditions and from a long-term perspective in 2100.

Landslide Risk = Probability x Consequence

The presented study is in its initial phase and is part of an extensive landslide risk assessment along the Ångermanälven river in northern Sweden.



Geotechnical Conditions

The quaternary geology in the area consists of various layers of postglacial silt, sand and clay. The banks of the river are often 30 to 40 meters high and exposed to erosion in both the slope and at the toe. Negative pore pressures occur in the silt layers which has an impact on the slope stability, and thereby also the probability of landslide.

As part of the project methods of measuring the magnitude and fluctuations of ground water level, negative and positive pore pressures are under development. Methods of determining the shear strenght of silty soils are also developed both in field as well as in laboratory to give a realistic input to the stability calculations.

Field Measurements

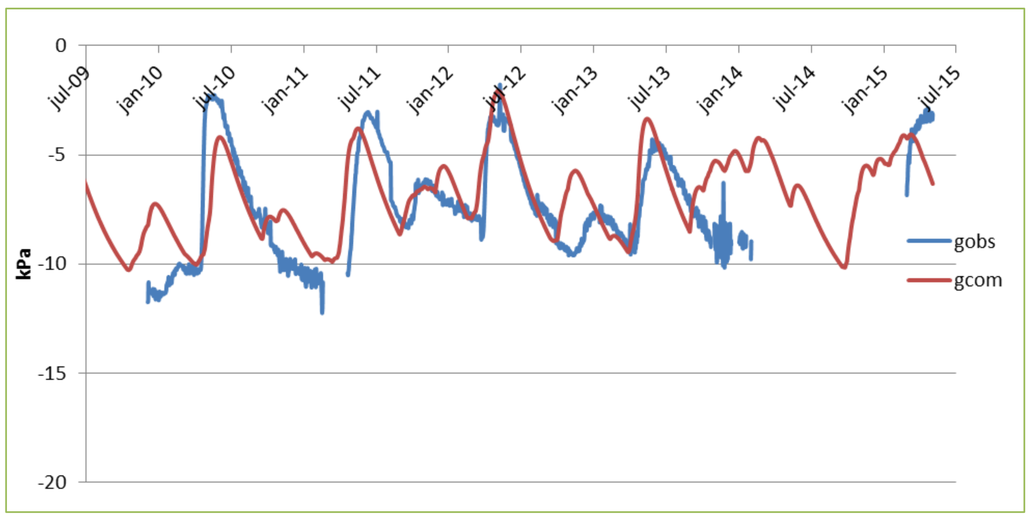
Ongoing pore pressure measurements at four sites along the river. Installations performed in 2016 and 2017. Four to six tensiometers at each site, at 2-11 m depth.

Groundwater measurements at two sites. Installation in 2017 at 24 and 35 m depth, respectively.

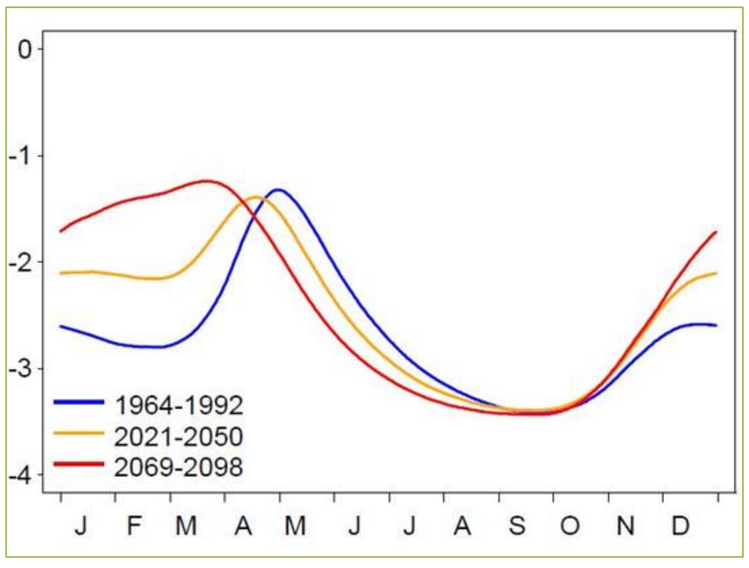
Groundwater - year 2100

Future groundwater levels are modelled with the GRV-model (e.g. Rodhe et al., 2009).

Input data is values of temperature, precipitation and measured levels of pore pressure or groundwater. Climate scenarios for temperature and precipitation for the years 1961-2099 are used (Strandberg et al., 2014; Yang et al., 2010), in addition to RCP 8.5 together with nine global climate models (Sjökvist et al., 2015).



Example of model of measuring point R3-6m. Blue line represents measured pore pressure, and red line represents modelled values of pore pressure.



Example of modelled values of pore pressure (kPa) for the measuring point R3-2m, with climate scenario RCP8.5.

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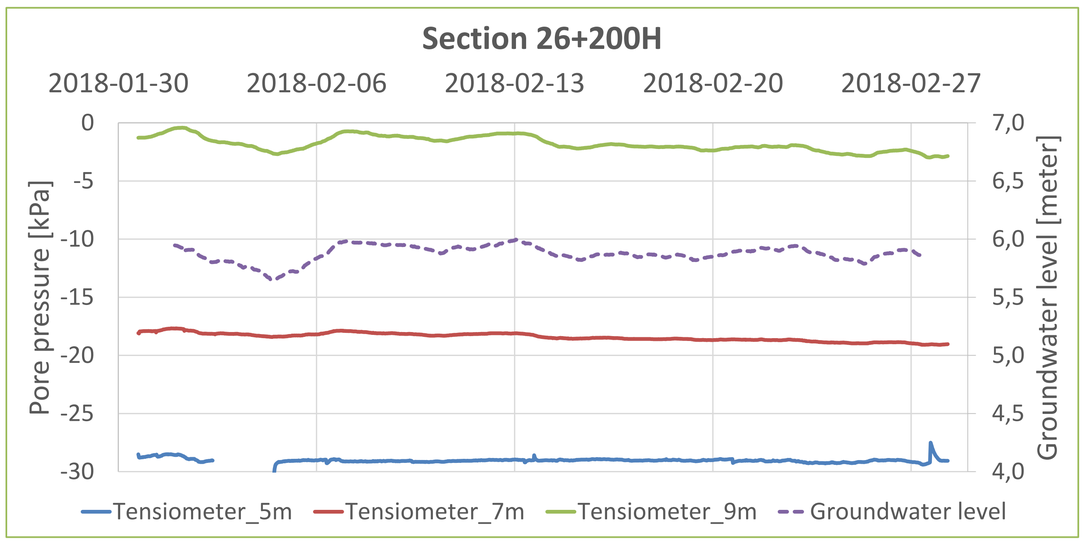
Ongoing work

A refined model for the Ångermanälven river requires investigations of the present situation, and hence geotechnical field and laboratory tests are conducted in addition to installation of groundwater loggers and tensiometers at different levels in the soil profile at several locations along the river.

A refined model needs longer series of data of pore pressure and groundwater level. Monitoring will continue during 2018 and data will be used as input to an updated model at the end of the year.

A model of Svensson & Sällfors (1985) will be used for comparison.



Example of pore pressure and groundwater measurements in one of the sections.

The results from the groundwater modelling will be used in stability calculations and in analyses of the probability of landslides.

References:

Rodhe, A., Lindström, G., & Dahné, J. (2009). *Slutrapport FoU-projekt Grundvattennivåer i ett förändrat klimat*. Uppsala: Sveriges geologiska undersökning, SGU.

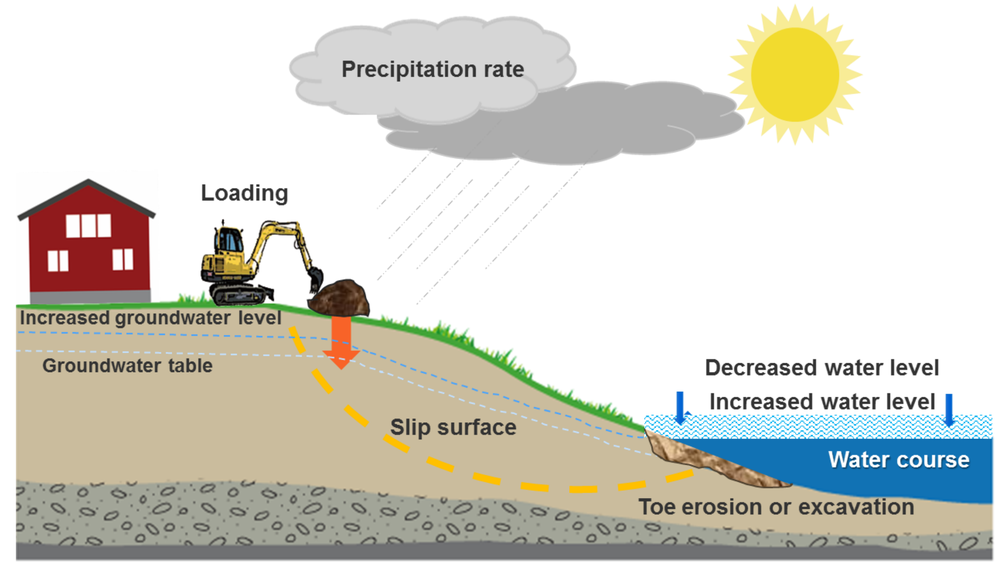
Sjökvist, E., Axén Mårtensson, J., Dahné, J., Köplin, N., Björck, E., Nylén, L., Berggreen Clausen, S. (2015). *SMHI Klimatologi Nr 15, Klimatscenarier för Sverige - Bearbetning av RCP-scenarier för meteorologiska och hydrologiska effektstudier*. Norrköping, Sweden.

Strandberg, G., Bärring, L., Hansson, U., Jansson, C., Jones, C., Kjellström, E., Wang, S. (2014). *SMHI Report Meteorology and Climatology No. 116, CORDEX scenarios for Europe from the Rossby Centre regional climate model RCA4*. Norrköping, Sweden.

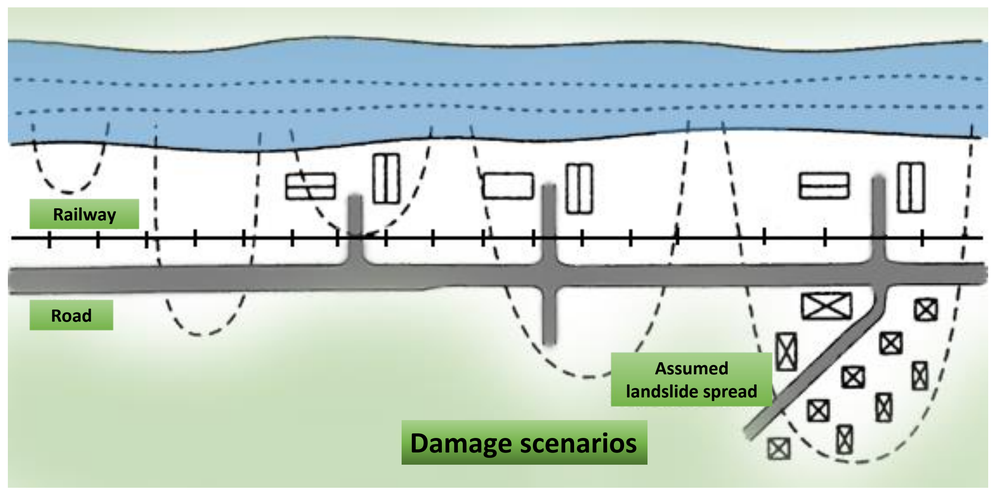
Svensson, C., & Sällfors, G. (1985). *Beräkning av dimensionerande grundvattentryck - 1. Göteborgsregionen. Meddelande nr 78*. Göteborg, Sweden.

Yang, W., Andréasson, J., Graham, L. P., Olsson, J., Rosberg, J., & Wetterhall, F. (2010). Distribution based scaling to improve usability of RCM projections for hydrological climate change impacts studies. *Hydrology Research*, *41*(3–4), 211–229.

Probability of Landslide

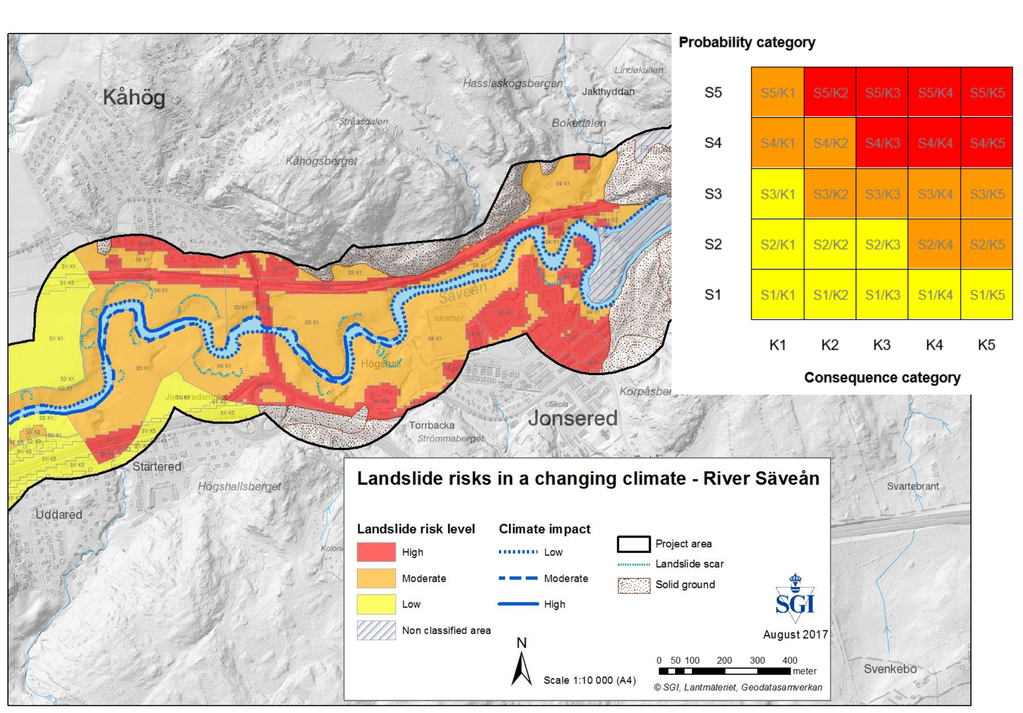


Consequences of Landslide



Landslide Risk Assessment

The final landslide risk analysis is an important basis for municipal decision regarding risk reduction measures and sustainable spatial planning in today's climate as well as in the future.



hanna.blomen@swedgeo.se
karin.bergdahl@swedgeo.se

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