

Impacts of extreme weather events on transport infrastructure in Norway

Regula Frauenfelder (1), Anders Solheim (1), Ketil Isaksen (2), Bård Romstad (3), Anita V. Dyrødal (2), Kristine H. H. Ekseth (1), Reidun Gangstø Skaland (2), Alf Harbitz (4), Carl B. Harbitz (1), Jan E. Haugen (2), Hans O. Hygen (2), Hilde Haakenstad (2), Christian Jaedicke (1), Árni Jónsson (1), Ronny Klæboe (5), Johanna Ludvigsen (5), Nele K. Meyer (1,6), Trude Rauken (3), and Kjetil Sverdrup-Thygesen (1)

(1) Norwegian Geotechnical Institute, Oslo, Norway (regula.frauenfelder@ngi.no), (2) Norwegian Meteorological Institute, Oslo, Norway, (3) Center for International Climate and Environmental Research (CICERO), Oslo, Norway, (4) Institute of Marine Research, Tromsø, Norway, (5) Institute of Transport Economics, Oslo, Norway, (6) International Centre for Geohazards (ICG), Oslo, Norway

With the latest results on expected future increase in air temperature and precipitation changes reported by the Intergovernmental Panel on Climate Change (IPCC), the climate robustness of important infrastructure is of raising concern in Norway, as well as in the rest of Europe. Economic consequences of natural disasters have increased considerably since 1950. In addition to the effect of demographic changes such as population growth, urbanization and more and more concentration of valuable assets, this increase is also related to an augmenting frequency of extreme events, such as storms, flooding, drought, and landslides. This change is also observable in Norway, where the increased frequency of strong precipitation has led to frequent flooding and landslide events during the last 20 years. A number of studies show that climate change causes an increase in both frequency and intensity of several types of extreme weather, especially when it comes to precipitation. Such extreme weather events greatly affect the transport infrastructure, with numerous and long closures of roads and railroads, in addition to damage and repair costs. Frequent closures of railroad and roads lead to delay or failure in delivery of goods, which again may lead to a loss of customers and/or – eventually – markets. Much of the Norwegian transport infrastructure is more than 50 years old and therefore not adequately dimensioned, even for present climatic conditions.

In order to assess these problems and challenges posed to the Norwegian transport infrastructure from present-day and future extreme weather events, the project "Impacts of extreme weather events on infrastructure in Norway (InfraRisk)" was performed under the research Council of Norway program 'NORKKLIMA', between 2009 and 2013. The main results of the project are:

- Moderate to strong precipitation events have become more frequent and more intense in Norway over the last 50 years, and this trend continues throughout the 21st century. The increase, both in total precipitation, and in the frequency and intensity of extreme events, is greatest in the west and southwest, and in parts of northern Norway, areas with the highest present precipitation.
- Snowfall will increase due to increased precipitation in cold areas inland and at high elevations. In lower lying parts of the country, and along the coast, more precipitation as rain will replace snowfall.
- The frequency of near-zero events, with freeze-thaw cycles, which can trigger rock falls, will decrease due to the generally increased temperatures.
- The greatest uncertainties in the weather trends are linked to uncertainties in climate and emission scenarios, and to the downscaling.
- More than 30% of the total length of road and railroads in Norway is exposed to snow avalanche and rock fall/slide hazard. As an example, one of the most exposed railroads, Raumabanen, has an annual probability of 1/3 to be hit by snow avalanches.
- Total costs of geohazard impact on the road infrastructure (major roads only) were estimated to be roughly 100 mill. NOK per year, of which the costs of road closures comprise 70%. The numbers are unevenly distributed throughout the country, reflecting the topographic and climatic variability in Norway.