Climate Change – A Challenge for Norwegian Roads

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ABSTRACT

This short paper offers some preliminary information about the work on adaptation to climate change currently being carried out by the Norwegian Public Roads Administration."Climate and Transport", a 4-year R&D program initiated in 2007, addresses all the topics considered to be important for effective adaptation of planning, design, operation and maintenance of roads under changed climate conditions. The program consists of seven projects, the results of which will be formulated as amendments to Road Administration manuals and projects on the road network demonstrating necessary action for adaptation to climate change.

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CLIMATE CHANGE IN NORWAY

Norwegian climate will in the next 50 to 100 years be marked by a temperature rise of between 0,2°C to 0,5°C pr. decade, depending on region (RegClim 2005). This rise in temperature will bring higher precipitation - more frequent and at the same time more intense rainfall, milder winters, warmer summers, and an increase in storm frequency and intensity.

The change in precipitation will show regional and seasonal differences. The highest increase in precipitation (20 – 35%) is expected in areas that already have a lot of rainfall, the west coast and the high Arctic. Also, the increase will be higher during autumn than during summer months. The winter season will however be shorter, with a reduction in the amount of snow at lower altitudes (below 1000 m).

EFFECT OF CLIMATE CHANGE ON ROADS

The road network is influenced by climate conditions. Higher ground water levels will yield higher probability of floods and erosion. More rain will give a higher risk for slides, slides occurring at new locations and of new types, such as slush avalanches, debris slides and mud flow. The current choice of structural solutions and dimensioning of physical protection may be incorrect in the altered climate conditions and existing slide protection may not be sufficiently safe. Areas exposed to stable winter conditions may experience higher exposure to freezing and thawing in the future. All this requires improved emergency plans.

One should also prepare for challenges concerning reduced accessibility and regularity. Regularity on high mountain roads, railways, airports (especially small ones at the coast) and coastal boat/ship traffic is highly dependent on storm frequency, duration and intensity. Also the fishery at the coast is highly dependent on weather. Fishery together with fish farming, which is the second largest export industry in Norway, is dependant on open roads and railways to the market in Europe for swift delivery of their fresh products.

The most common events causing problems for traffic safety and operation are avalanches and rockfalls and floods (Figure 1).

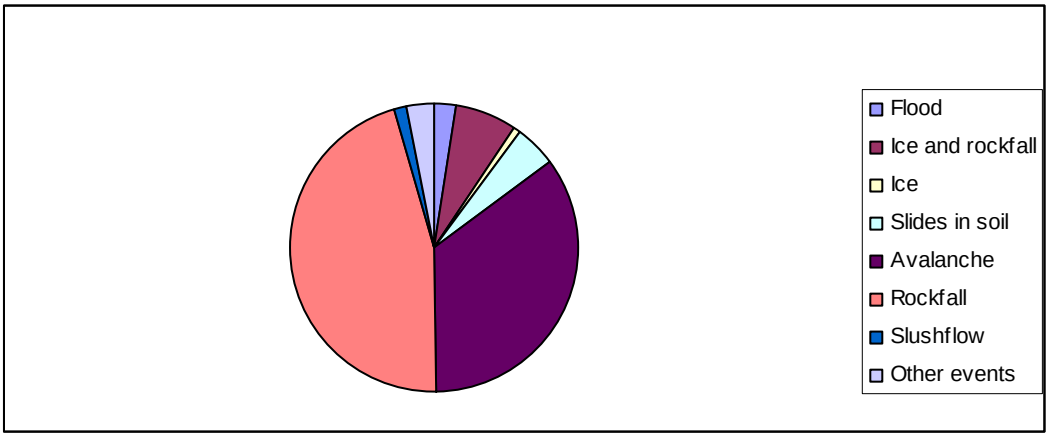

Figure 1. Registration of slides, avalanches and floods on highways and main roads 1975-2005

Most types of landslides are weather related, the main factors being precipitation, wind and temperature. Especially important are precipitation intensity, rapid change in temperatures from below freezing to above, and frequency and magnitude of storms/blizzards correlated to slide and avalanche activity. Floods and erosion are partly dependent on precipitation, and snow melt intensity, but is also related the grounds ability to absorb water, glacier water discharge, and erosion protection of river beds.

The Norwegian Road Administration is doing systematic registration of all landslide events causing closure and near closure of highways and roads under their responsibility. County roads and private roads are not included. On these highways there has been a registration of about 18 000 events in the period 1996 – 2004, or an average of more than 2000 events annularly (Figure 2).

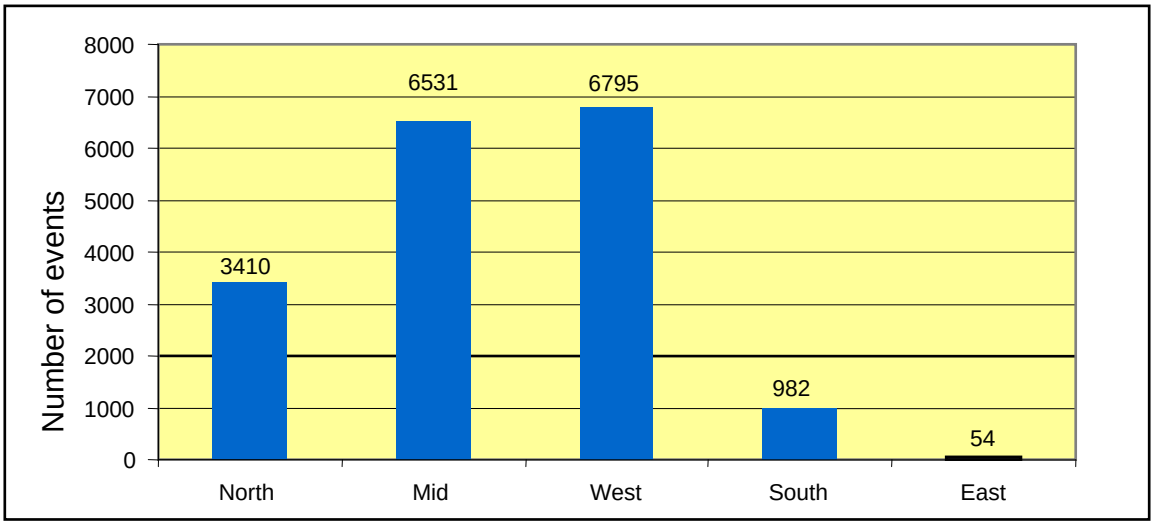

Figure 2. Slide events on Norwegian highways and roads between 1996 and 2004 divides on five regions (Harila 2006).

The threat from more severe or more frequent floods requires a study of the performance and design of drainage, a survey of bridges including erosion protection and development of efficient emergency plans.

Figure 3.

Floods threaten bridge operation and safety, example from the 2007 flood in Buskerud, South-East of Norway.

R&D PROGRAM "CLIMATE AND TRANSPORT"

A 4-year R&D program for climate change adaptation was initiated by Norwegian Public Roads Administration in January 2007. The main objectives of the program are to evaluate the effect of climate change on the road network and recommend remedial action concerning planning, design, construction and maintenance of the road network. Both safety and accessibility should be maintained. The contents of the program are formulated mostly from the point of the need of NPRA. However, the results are expected to be used by the all program cooperation partners and also Norwegian municipalities.

The following topics were considered to be crucial for adaptation to climate change and are organized as individual project activities:

1. Program conditions and demonstration projects
2. Data: collection, processing and storage
3. Flood and erosion prevention
4. Avalanches: snow-, soil-, flood slides, rock fall
5. Bearing capacity of roads
6. Consequences for winter operation
7. Susceptibility and emergency plans

Project 1 'Program Conditions and Demonstration Projects' is a work package that incorporates topics of general importance, such as monitoring the results of new climate research and updating of design values for floods, sea level etc. The main report that sets the conditions for the wok on climate adaptation is developed in cooperation between the Meteorological Institute in Norway and representatives from the transport sector (roads, railways, air traffic and shipping) in 2007. This part of the R&D program includes in addition full scale projects that test or demonstrate the results of all the program activities.

Project 2 'Data: Collection, Processing and Storage' has the aim to improve accessibility and coordinated utilisation of data relevant for climate adaptation. In addition, new methods and tools for dynamic presentation of weather and climate data, combined with data concerning ground conditions, road network and climate related events, will be developed, tested and evaluated.

Project 3 'Flood and Erosion Prevention' focuses on principles for the choice of structural solutions and design and maintenance methods for drainage and erosion protection measures. The work includes drainage, erosion of slopes, bridge foundations, erosion from waves, ensuring flood proof road levels and other environmental aspects of climate change.

Project 4 'Avalanches and Landslides' deals with all types of avalanches and how their frequency and triggering factors can be influenced by climate change. The main topics are: risk assessment (methods for probability and risk description) and risk acceptance criteria; mitigation and protection plans, methods of physical protection. Special attention is given to types of landslides that are influenced by the presence of water, such as slush and debris slides.

Project 5 'Bearing Capacity of Roads' studies the impact of climate factors on deterioration of roads and aims at calculating the maintenance costs for the present road standard. In addition to roads with asphalt pavements, gravel roads are included in the study, due to their

importance for the county and forest road network and their susceptibility to climatic conditions.

Project 6 ‘Consequences for Winter Operation’ investigates necessary measures for maintaining traffic safety and regularity in extreme winter conditions concerning snow, wind, and temperature changes. Important topics are maintaining acceptable friction conditions and adapting strategies for winter operation in zones with shifting climatic conditions.

Project 7 ‘Susceptibility and Emergency Plans’ includes development and application of suitable risk- and susceptibility analyses, adaptation of emergency systems to more variable weather conditions and implementing relevant changes in operation and maintenance contracts.

The program group consist of managers of each of the 7 projects and a program secretary (all employees of the NPRA), and a representative of the Norwegian National Rail Administration. The program will be carried out with the help of a large number of cooperating partners (in addition to Norwegian National Rail Administration), such as: Norwegian Coastal Administration, Avinor (responsible for air traffic control and services), Norwegian Meteorological Institute (met.no), Norwegian Water Resources and Energy Directorate (NVE), Norwegian Geotechnical Institute (NGI), Norwegian Geological Survey (NGU), Norwegian University of Science and Technology (NTNU), Centre for International Climate and Environmental Research (CICERO), Directorate for Civil Protection and Emergency Planning (DSB), Norwegian University of Science and Technology NTNU /SINTEF and Norwegian Institute for Agricultural and Environmental Research (Bioforsk).

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