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Consequences of Climate Change – Swedish Experience

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Swedish Commission on climate and vulnerability

Assignment by the Ministry of Environment

Bengt Holgersson, Chair

Tom Hedlund, Principal secretary

Final report 1th October 2007

Commission Directives - overview

- Map the vulnerability in society
- Estimate the costs of damages
- Propose actions to decrease vulnerability and estimate the costs
- Describe the needs for organisational changes and better preparations at authorities

Some supplementary tasks

- Identify key-actors
- Report about the insurance protection
- Analyse the need for more detailed climate scenarios
- Analyse the need for more research
- Propose legislation when needed
- Evaluate the mapping of risks for flooding and how these are used by municipalities

Consequences of climate change in Sweden

- Increase in air temperature, sea surface temperature, sea level
- Changes in precipitation
- More extreme weather conditions

Geotechnical consequences:

- Landslides, Flooding, Erosion, Ground pollutant behavior


Sweden 25 large road damages/year
25 % flooding
50 % severe erosion and flushing away of road embankment
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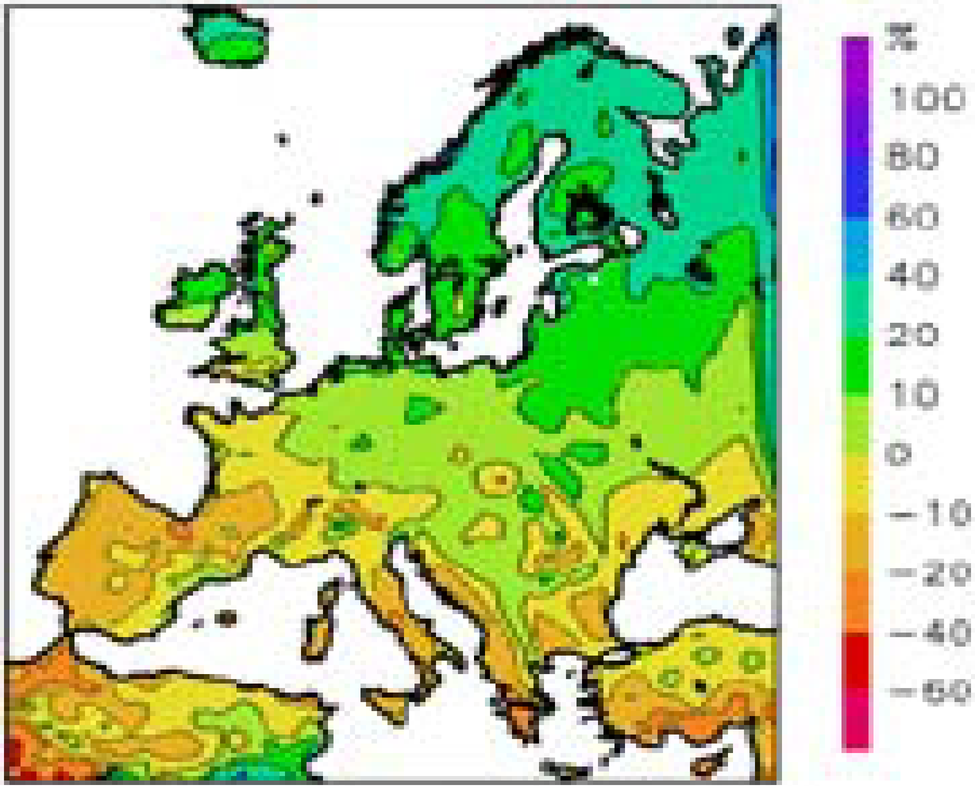
Ground stability

20 % landslides
5 % undermining of bridges

The climate change in Europe

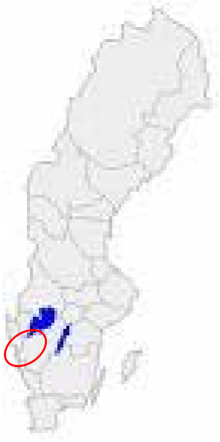


Climate scenarios

- Atmospheric model RCA3 Rossby Centre, Swedish Metrological and Hydrological Institute
- Global climate model ECHAM4/OPYC3 Max Planck Institute, Germany
- CO_2 discharge scenario B2 (IPCC, SRES)

Increase of the <u>annual precipitation</u> until 2071-2100

Case studie Göta river valley (South West of Sweden)



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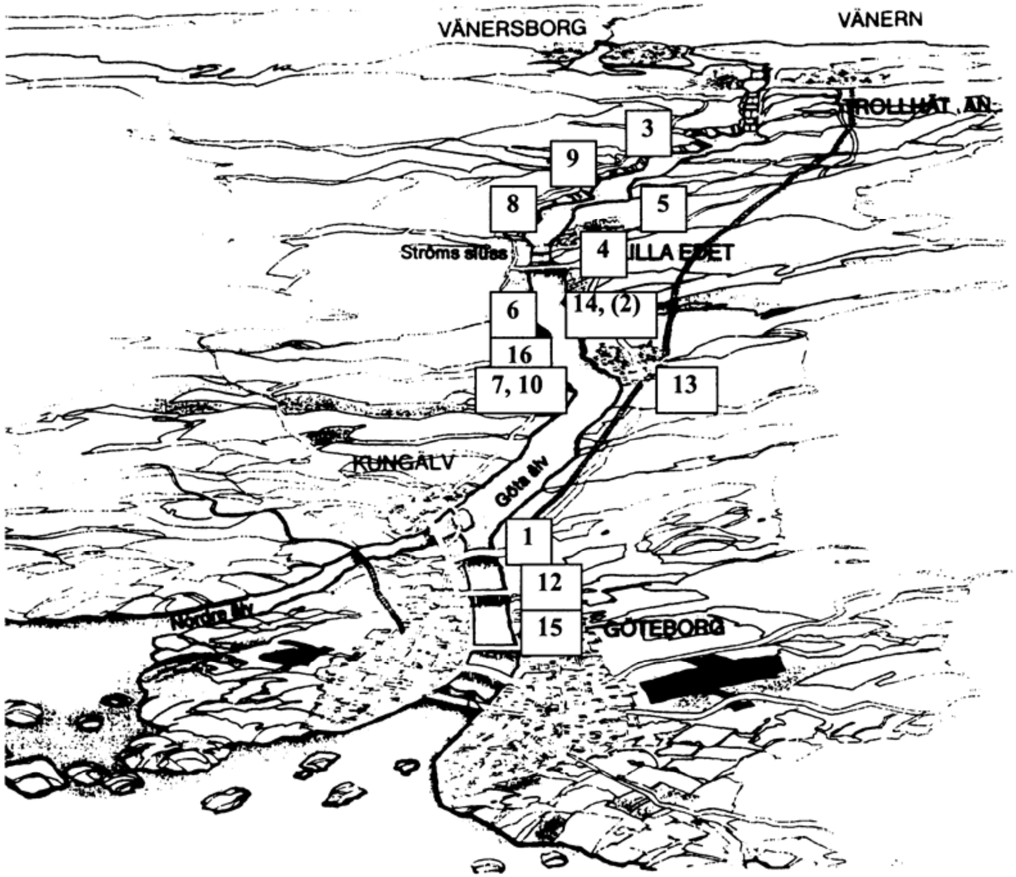
Case studie Göta river valley



Map of documented landslides since 1150

Case studie Göta river valley – climate change

Expected climate change effects:

- Increasing precipitation
- Rising groundwater level and pore pressure in the ground
- Need of more tapping from lake Vänern (from max 1030 m^3/s to 1400 m^3/s)
- Increased water flow will result in increased erosion

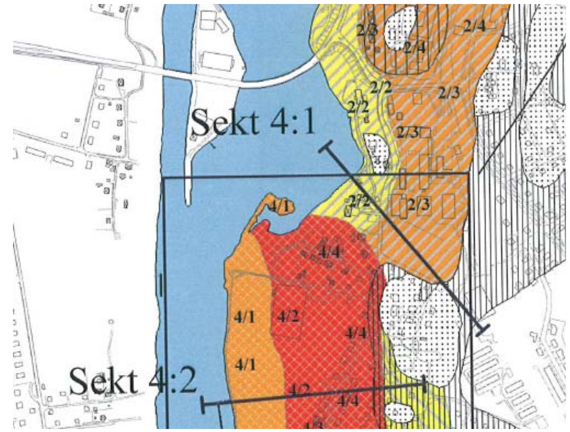
Case studie Göta river valley – risk analyses

Probability of landslide

Stability class

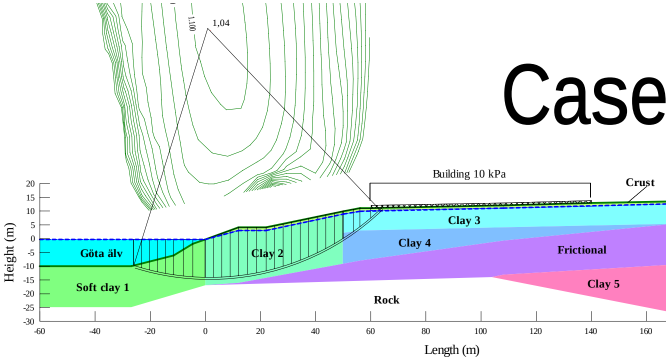
Stability class	1	2	3	4
4	4/1	4/2	4/3	4/4
3	3/1	3/2	3/3	3/4
2	2/1	2/2	2/3	2/4
1	1/1	1/2	1/3	1/4

Consequence class



Consequense of landslide

- Acceptable slide risk (yellow)
- Need for further investigations (orange)
- Unacceptable slide risk (red)



Case studie Göta river valley – stability analyses

Present stability class	*Estimated future stability class*	*Estimated need for reinforcements due to expected tapping and water flows in the future.*	
		Flow 1,030 m^3/s	*Flow 1,400 m^3/s*
4	>4	Approx. 30-50% of the area	Approx. 50-70% of the area
3	3 -4	Approx.20-40% of the area	Aprox.40-60% of the area
2	2 -3	Approx. 5-15% of the area	Approx. 10-20% of the area
1	1 -2	Less/little reinforcement to increase the slope stability is needed	Less/little reinforcement to increase the slope stability is needed

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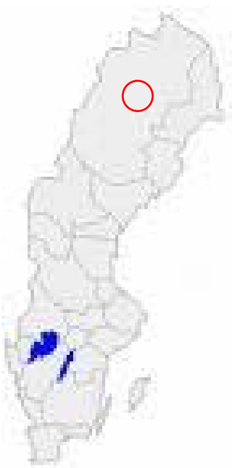
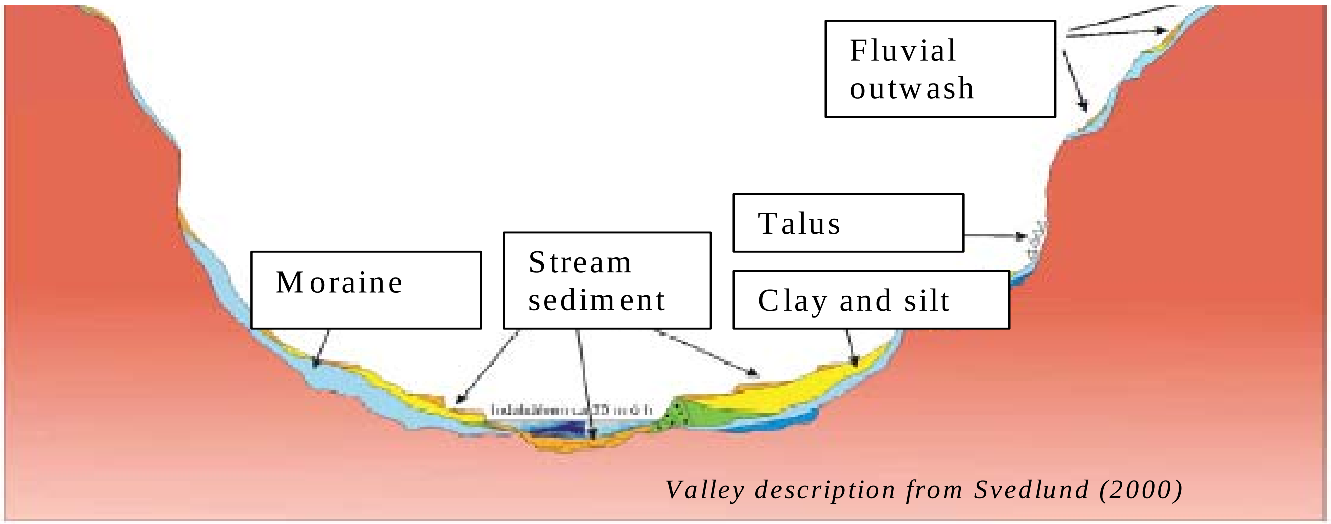
Case study Krokvåg (North East of Sweden)





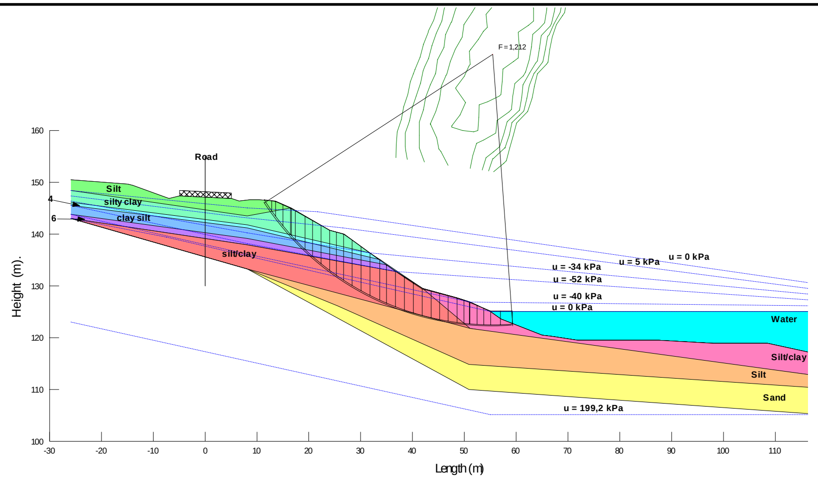
Valley description from Svedlund (2000)

Slope north of Sweden, Krokvåg.

The scales differ on the horizontal and vertical axes

Case study Krokvåg

Expected climate change effects	*Changes of safetyfactor*
Increasing precipitation Rising groundwater level Porepressures changing from negative to positive	→ - 20%
Increased erosion	→ - 25%



Effects: The slope can not be regarded as safe

Debris flows (mountain areas)

- Debris flows are common on hillsides, restarted with moraine landslides
- Increasing annual precipitation and heavy rain shown in climate scenarios will result in increasing risk for debris flows in the mountain areas.

Detecting unstable slopes

The Vagnhärad landslide 1997

The Swedish investigation programme:

1a Overview landslide mapping
("to finding the needles in the haystack") *)

1b Coarse stability investigations

2 Detailed stability investigations

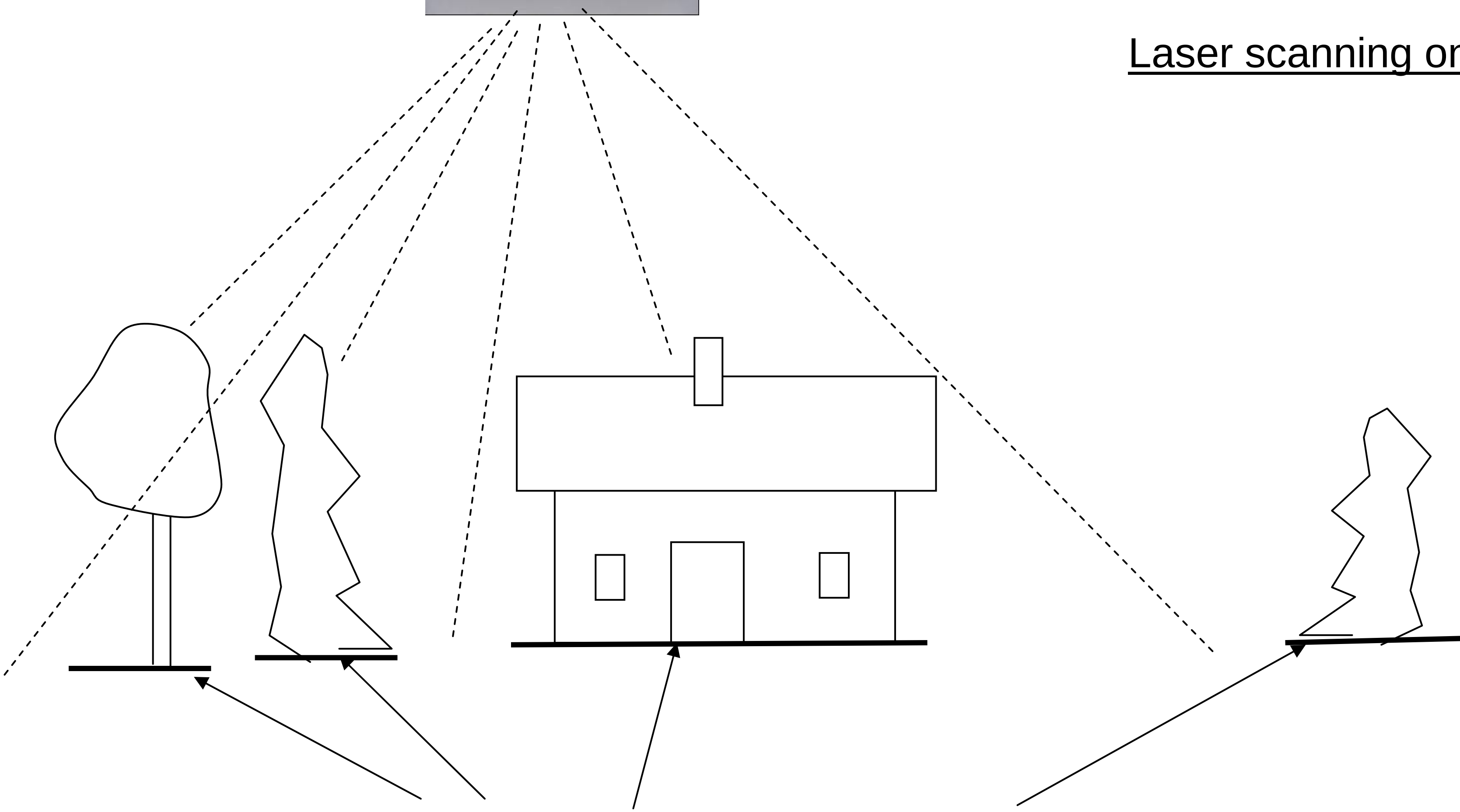
3 Complementary stability investigations

*) Performed manually – time consuming and imprecise

LESSLOSS - Achievement of a detailed topographical database

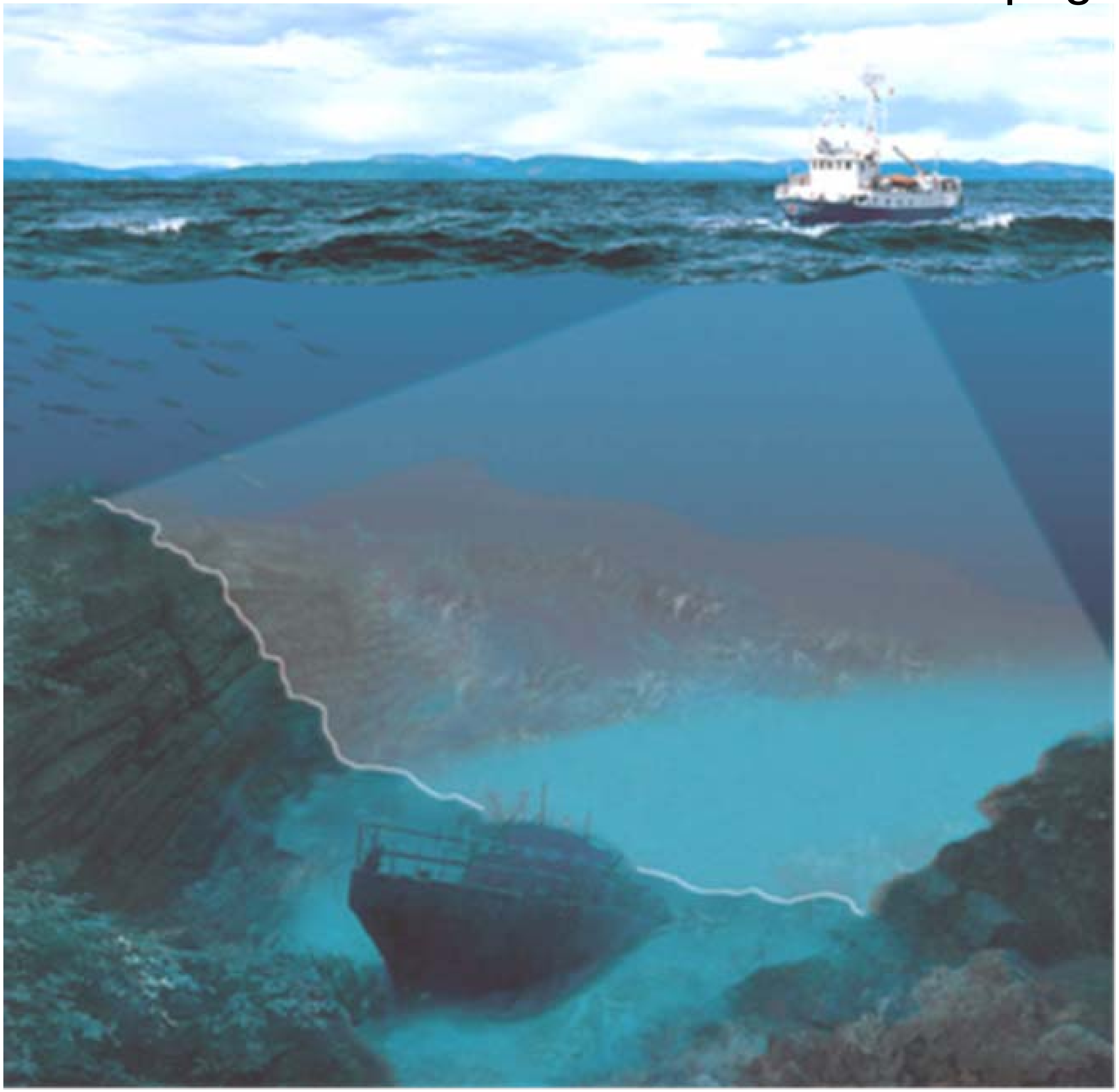
EU 6th frame programme

Laser scanning on land



Hidden ground surface replaced with a virtual new ground surface

LESSLOSS - Achievement of a detailed topographical database



Muli-beam echo sounding of the river bottom

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Stage 1a: Overview landslide hazard mapping in clay and silt areas

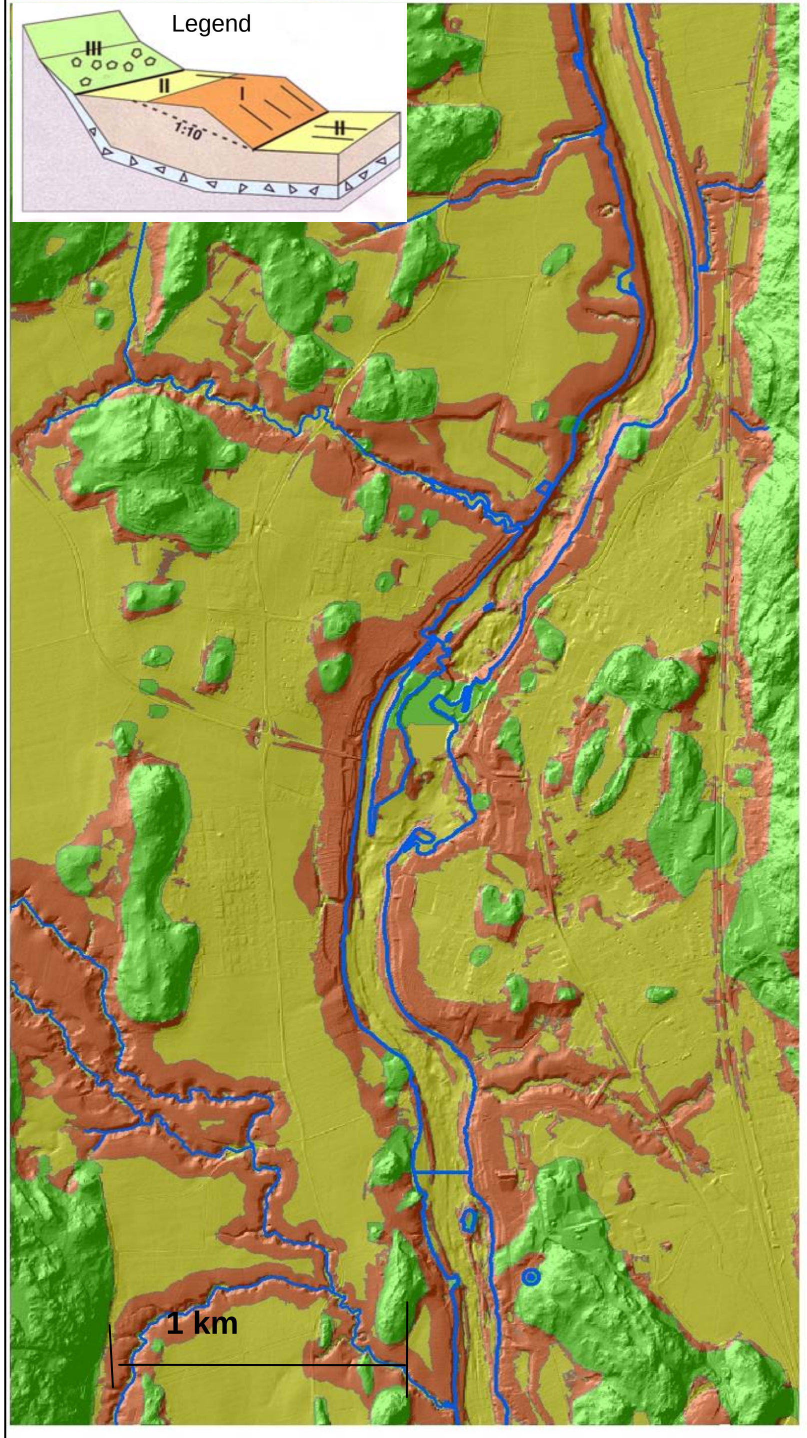
GIS processing based on the digital database

Stability Zone I (red)
- Slopes in clay/silt (>1:10)
- Prerequisites for sliding.

Stability Zone II (yellow)
- Flat areas in clay/silt (<1:10)
- No prerequisites for sliding.

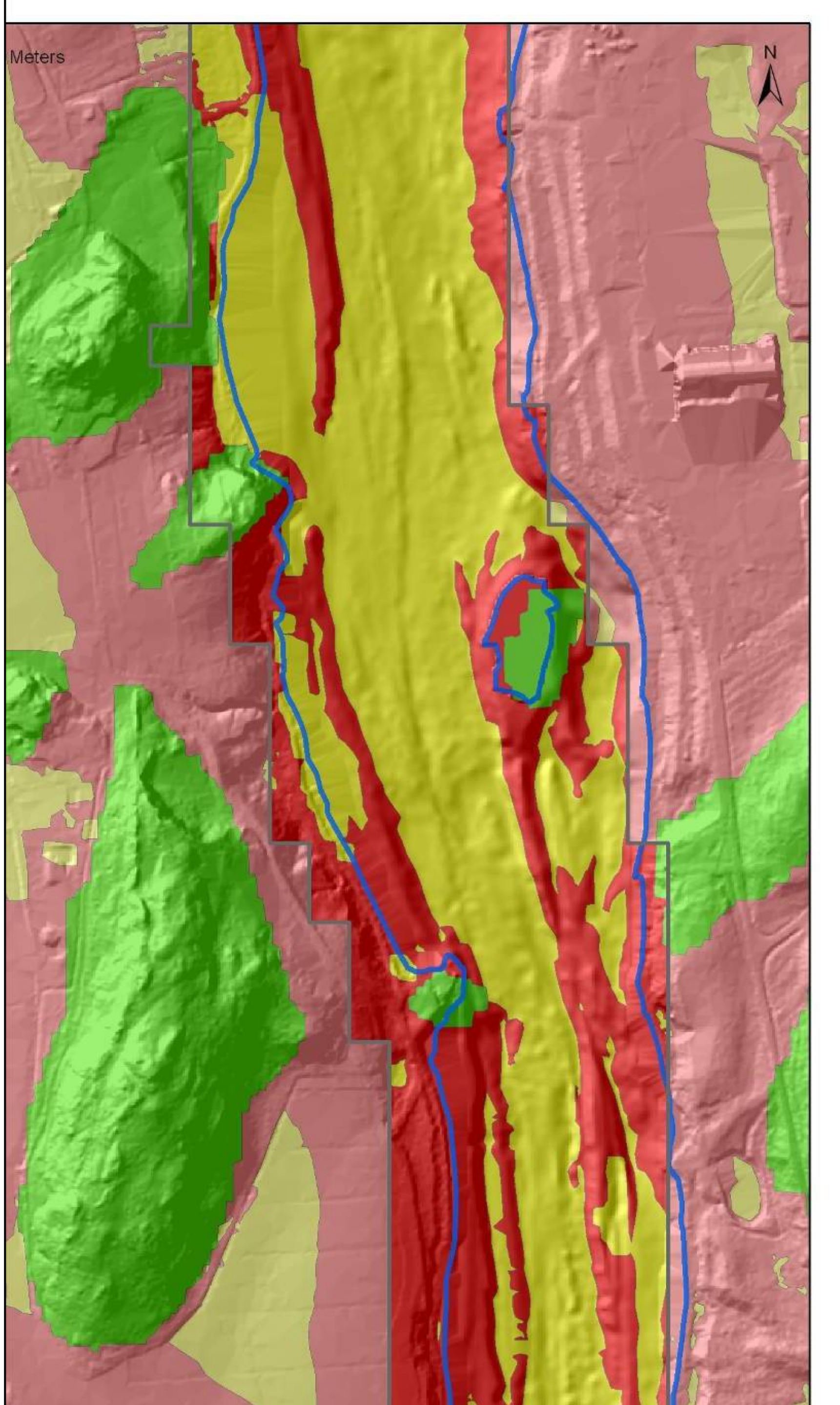
Stability Zone III (grey)
- Outcrops of firm rock
- Coarse soil layers
- No prerequisites for sliding (in clay or silt)

LESSLOSS



The LESSLOSS digital landslide hazard database combined with a flooding scenario

Zone I: Clay slope, with prerequisites for both landslides and flooding	(red)
Zone I: Clay slope, with prerequisites for landslides, but not flooding	(pink)
Zone II: Clay area, with no prerequisites for landslides, but for flooding	(yellow)
Zone II: Clay area, which prerequisites for neither landslides nor flooding	(olive)
Zone III: Areas with outcrops of firm rock or coarser soil layers.	(green)



Potential cause of increased risks - ground pollutants

- Increased annual precipitation
- More frequent storms and higher water flows
- Increased fluctuation of groundwater level
- Changed chemical (e.g. redox) and biological conditions
- Increased risks for erosion and landslides of contaminated sites
- In total, increased risk for more mobile and bio available contaminants

Conclusions

- Increased risks for flooding and erosion
- For the stability case studies the safety factors were reduced up to 30 % decrease - safety factor will be critical, soil improvement and reconstruction are needed
- New methods will improve the risk analysis and identify critical areas
- Increased risks for spreading of pollutants

SGI References (papers in English)

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