



# Climate Change Adaptation

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# Climate Change Adaptation

## Outline:

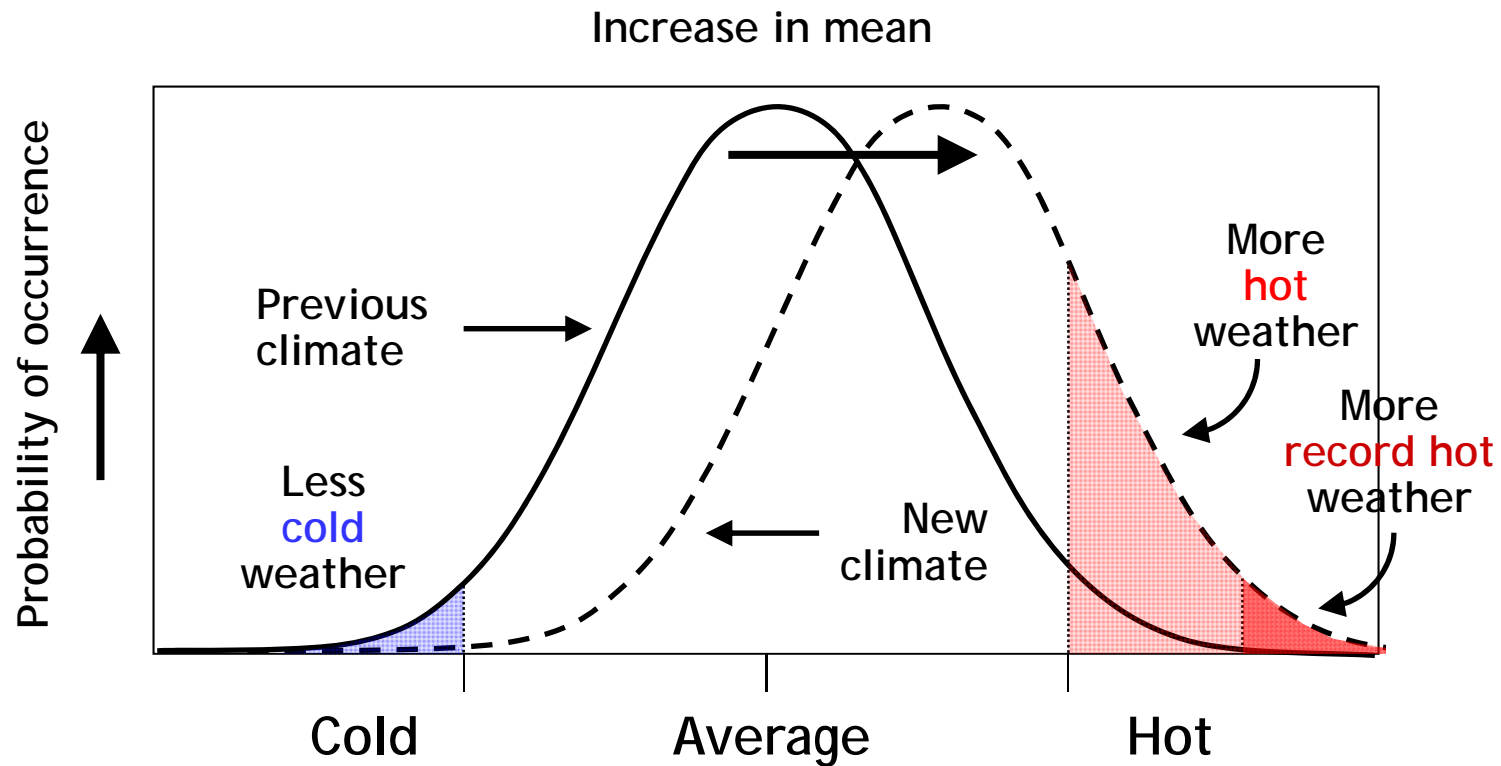
1. Background/global climate change
2. Climate change across the ROADEX areas
3. Predicted impacts
4. Questionnaire & analysis
5. Adaption & good practice measures
6. Summary



Climate Change Adaptation report, 2012

# Global climate change

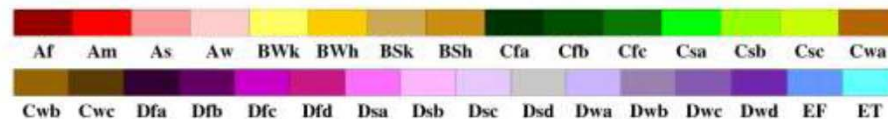
What could happen? The effect of a shift in climate:



# Global climate change

## World Map of Köppen–Geiger Climate Classification

projected using IPCC A1FI Tyndall SC 2.03 temperature and precipitation scenarios, period 2076 to 2100



### Main climates

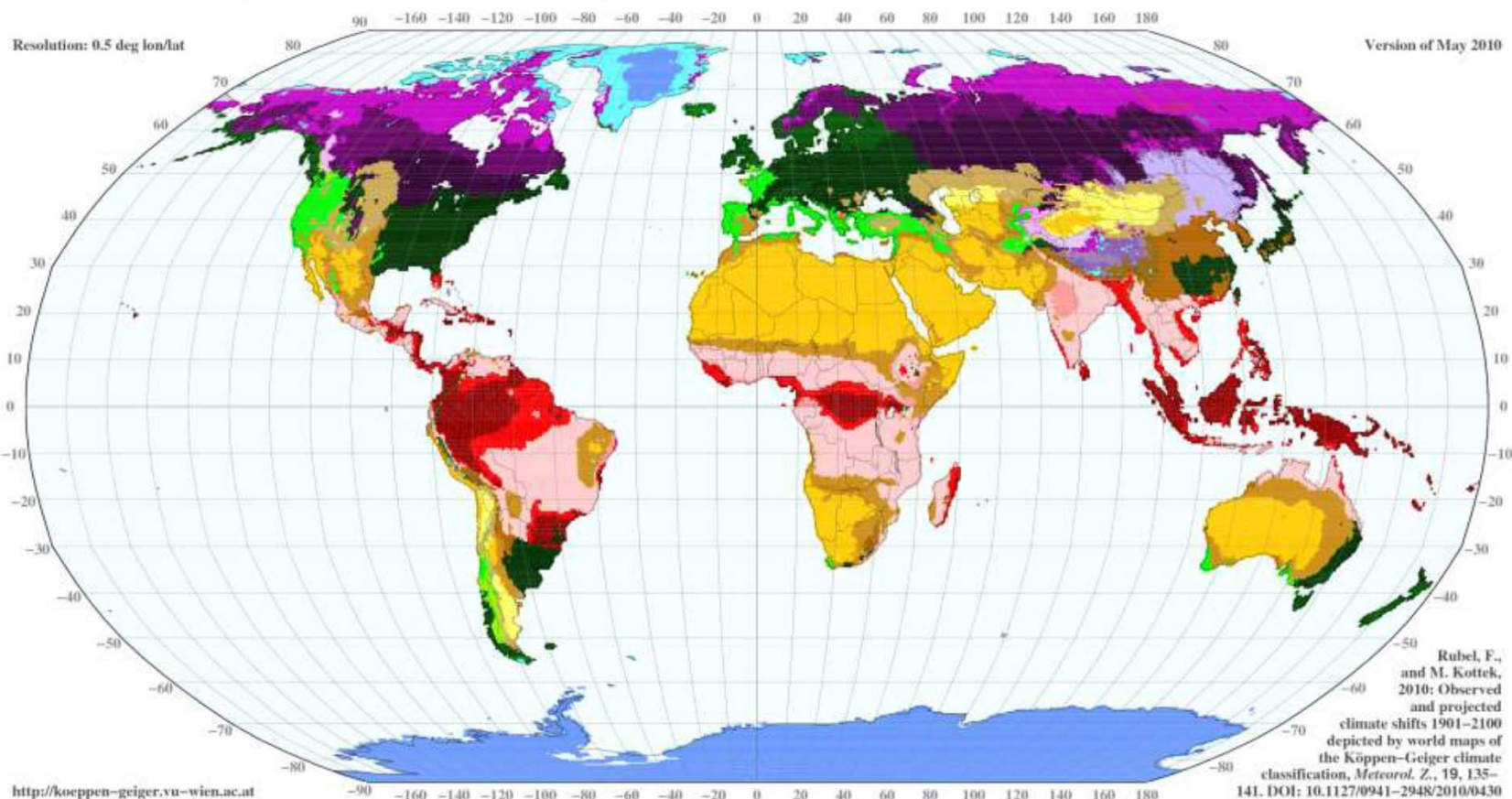
A: equatorial  
B: arid  
C: warm temperate  
D: snow  
E: polar

### Precipitation

W: desert  
S: steppe  
f: fully humid  
s: summer dry  
w: winter dry  
m: monsoonal

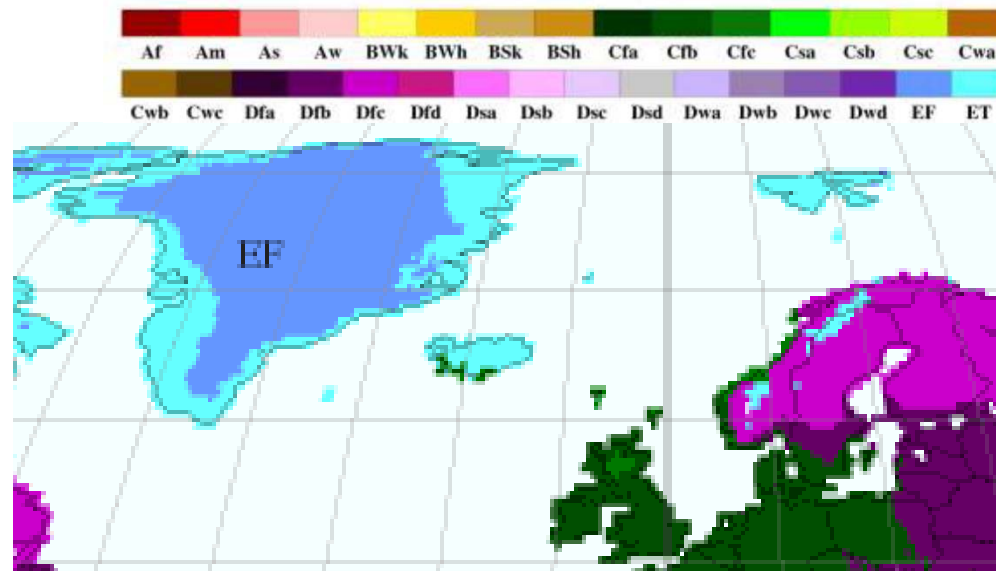
### Temperature

h: hot arid  
k: cold arid  
a: hot summer  
b: warm summer  
c: cool summer  
d: extremely continental  
F: polar frost  
T: polar tundra



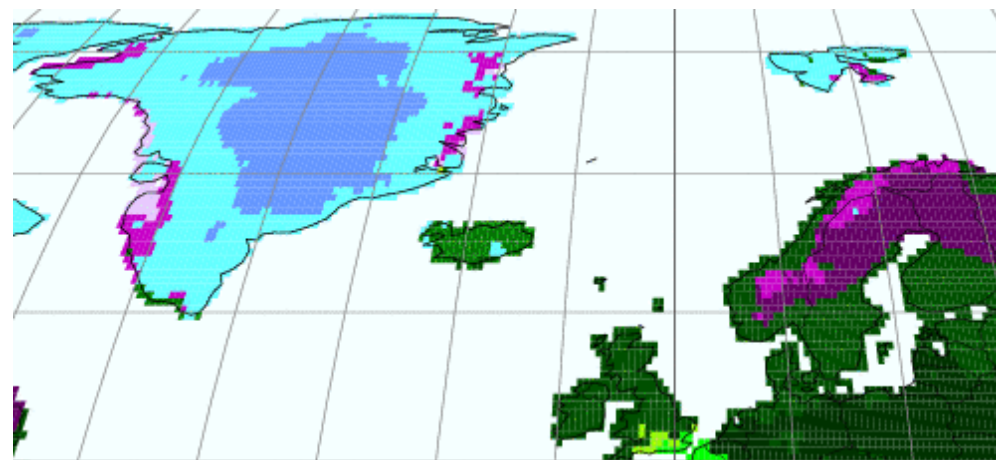
# Global climate change

Dfc - snow, fully humid, cool summer  
 Dfb - snow, fully humid, warm summer  
 EF - polar frost  
 ET - polar tundra  
 Cfb - warm, fully humid, warm summer  
 Cfc - warm, fully humid, cool summer



Climate classification for the period 1976 - 2000

Dfc - snow, fully humid, cool summer  
 Dfb - snow, fully humid, warm summer  
 Dsb - snow, steppe, warm summer  
 EF - polar frost  
 ET - polar tundra  
 Cfc - warm, fully humid, cool summer



Climate classification for the period 2076 - 2100



# Climate Change

*“Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and sea temperatures, widespread melting of snow and ice, and rising global average sea level”.*

**Intergovernmental Panel on Climate Change, 2007**

.... but the general population has yet to be convinced ....



# Natural weather variability or climate change?



ax County/Flickr (File)

- Uncertainty in climate projections
- Natural variability of weather patterns
- Is this climate change or natural variability?



Storm damage, northern Sweden, late September 2011



# Natural weather variability or climate change?





# Natural weather variability or climate change?

## Landslides in Scotland

A83 Cairndow



A9 Dunkeld



A85 Glen Ogle



# Climate Change

## The ROADEX position

- The scientific consensus believes that the world's climate is changing.
- Road networks, especially rural road networks, can be affected by weather conditions.
- The ROADEX Partner organisations consider it sensible to review what can be done now to modify current road construction and maintenance practices to meet the predicted changes

# Climate Change - possible impacts on roads:

- Disruption of the network by extreme weather events (rain, snow, high temperatures)
- Damage to roads through deterioration, deformation and subsidence
- Flooding from rivers, seas and inadequate land drainage
- Severance of routes by landslides and avalanches
- Damage to roadside infrastructure by high winds
- New road safety issues

*“The Changing Climate: Impact on the Department of Transport”, 2004*



# Climate Change - possible impacts on roads:

- **Temperature**

- Carriageway effects
- Frost damage (including freeze-thaw cycles and frost heave)
- Permafrost effects
- Winter maintenance
- Increase in sea level

- **Precipitation**

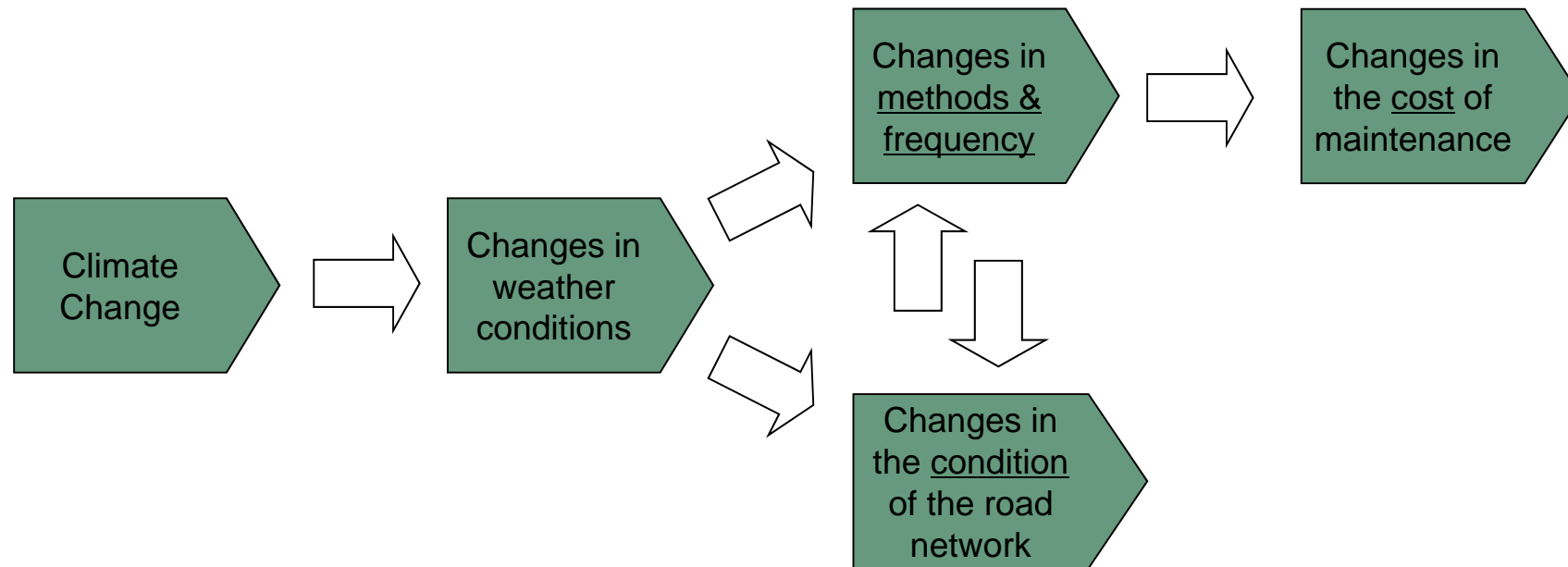
- Floods
- Erosion of roads and bridges
- Drainage problems
- Landslides



High Bridge, Struie, Scotland

# Climate Change

## Impacts on road maintenance



*“Impact of climate change on road maintenance”, Finnish Road & Traffic, 2009*



**Freeze-thaw damage**



**Flooding**



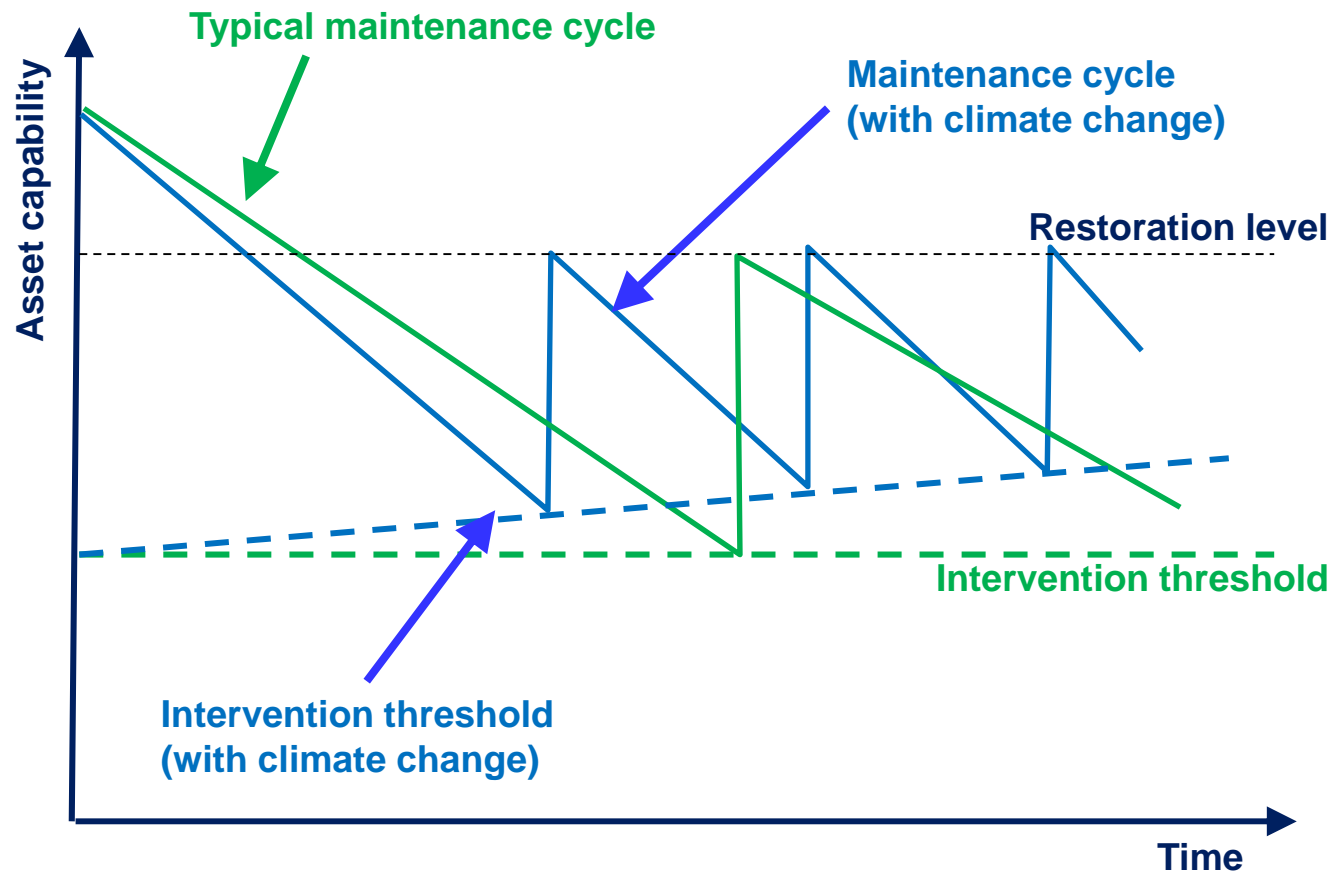
**Winter conditions**



**Rutting**

# Climate Change Adaptation


## Influence of climate change on maintenance cycles




# ROADEX climate change adaptation: questionnaire

## Contents:

- Introduction
- What are the most important changes and problems?
  - Drainage
  - Freeze-thaw
  - Rutting
  - Erosion
  - Stability
  - Winter
- Organisational strategy?
- Organisation working group or person?
- National strategy/guidance?



H. Sheet ice problems	
Might significantly increase	Additional comments:
Might slightly increase	
No change	
Might slightly decrease	
Might significantly decrease	
Are you aware of any documentation, guidelines or strategy was produced to help engineers to deal with this problems?	



I. Winter maintenance problems due to drifting snow	
Might significantly increase	Additional comments:
Might slightly increase	
No change	
Might slightly decrease	
Might significantly decrease	
Are you aware of any documentation, guidelines or strategy was produced to help engineers to deal with this problems?	

Questionnaire in WORD

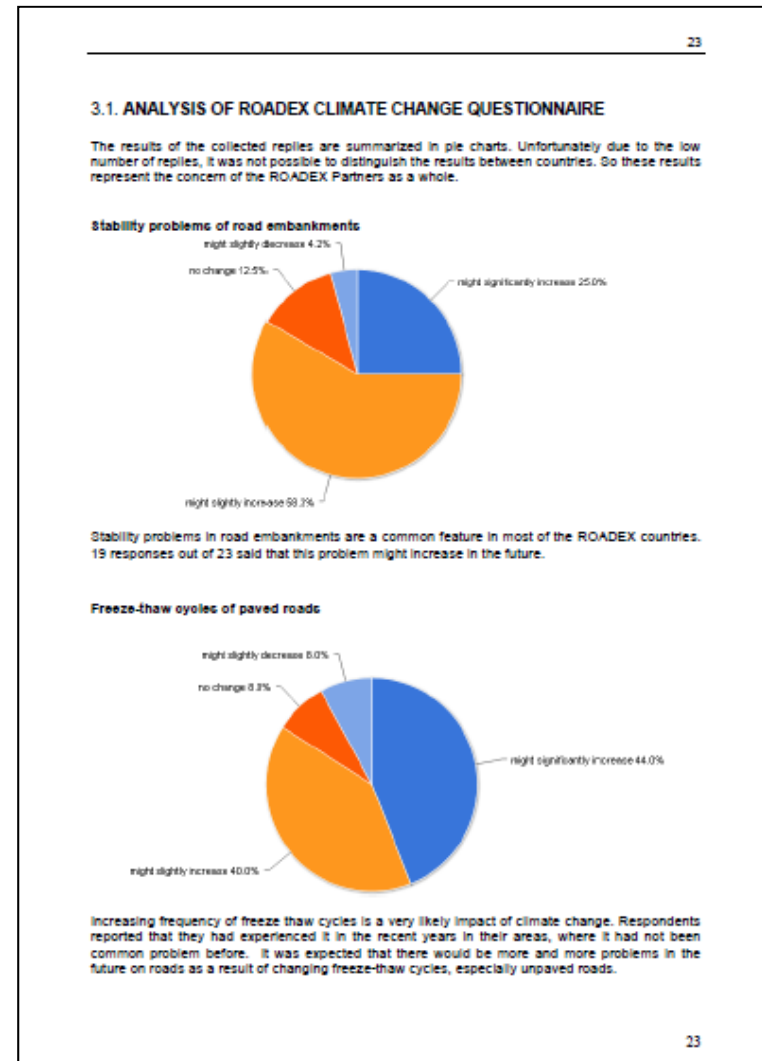


# Climate Change Adaptation: questionnaire

## Questionnaire & Analysis:

### ■ Analysed by topic

- Stability problems of road embankments
- Freeze-thaw cycles of paved roads
- Freeze-thaw cycles of unpaved roads
- Rutting due to spring thaw weakening of paved roads
- Rutting due to spring thaw weakening of unpaved roads
- Differential frost heave
- Settlement due to permafrost
- Sheet ice problems
- Winter maintenance problems due to drifting snow
- Winter maintenance problems due to icing
- Winter maintenance problems due to salt
- Avalanches
- Erosion of paved roads due to heavy rains
- Erosion of unpaved roads due to heavy rains
- Flooding
- Landslides
- Rise of sea level



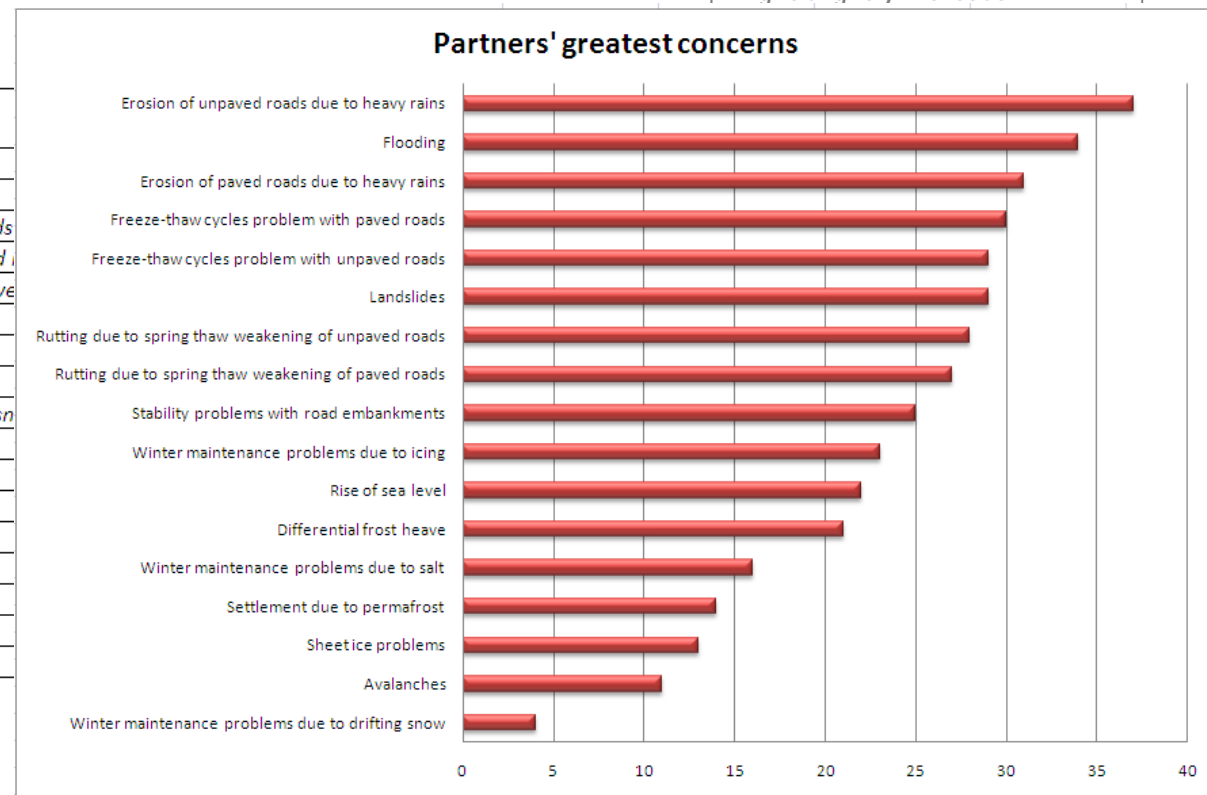
# Climate Change Adaptation: questionnaire

## Questionnaire & Analysis:

- By Partner concern: prioritised

Might significantly decrease: -2  
 Might slightly decrease: -1  
 No change: 0  
 Might slightly increase: 1

Impacts
Stability problems with road embankments
Freeze-thaw cycles problem with paved roads
Freeze-thaw cycles problem with unpaved roads
Rutting due to spring thaw weakening of paved roads
Rutting due to spring thaw weakening of unpaved roads
Differential frost heave
Settlement due to permafrost
Sheet ice problems
Winter maintenance problems due to drifting snow
Winter maintenance problems due to icing
Winter maintenance problems due to salt
Avalanches
Erosion of paved roads due to heavy rains
Erosion of unpaved roads due to heavy rains
Flooding
Landslides
Rise of sea level



# Typical impacts:



Greenland (photo Arctic Technology Centre)



Norway (photo Norwegian Public Roads Administration)

E10 Lofoten



Finland



Raattama, Finland (photo J. Leskinen)



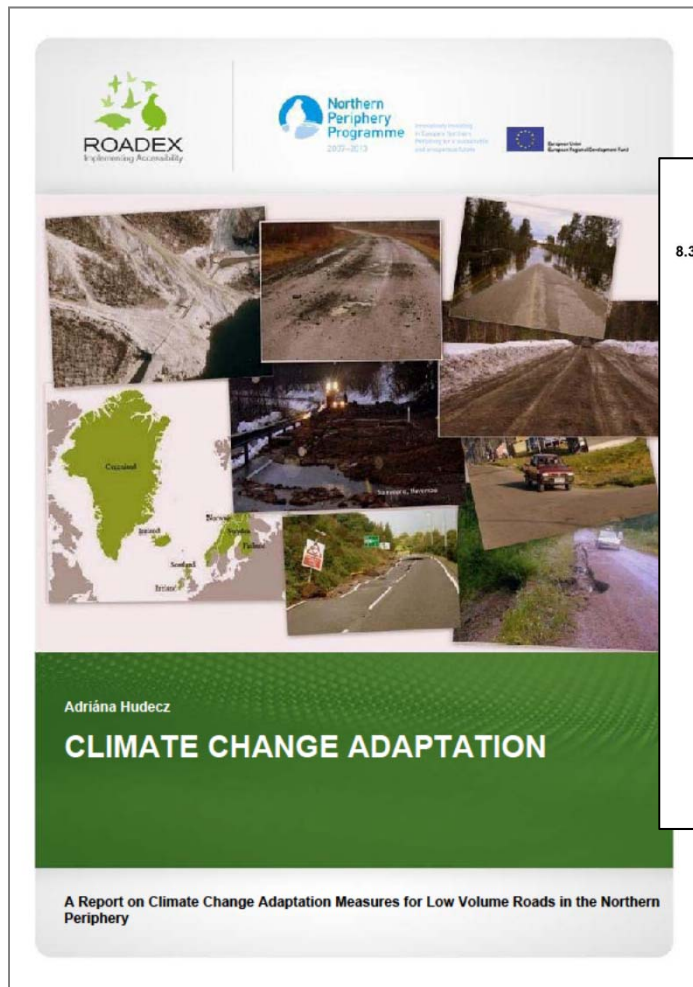
Møre and Romsdal, Norway (photo Norwegian Public Roads Administration)



A9 Raigmore Slip Road, Inverness (photo BEAR Scotland Ltd)



# Adaptation & Good Practice Measures



Climate Change Adaptation report, 2012

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### 8.3 SUMMARY OF GOOD PRACTICE AND ADAPTATION MEASURES

This Appendix summarises the good practice and adaptation measures listed in the boxes at the end of each subsection and chapter in the report.

Effect	Impact	Good practice and adaptation measures
Temperature	Higher summer Temperatures	<p><u>Good practice measures</u></p> <ul style="list-style-type: none"> <li>keeping the road drainage in good condition by implementing the ROADEx drainage maintenance strategies and guidelines [63]</li> <li>sealing of cracked and distressed areas</li> <li>removal of roadside vegetation</li> <li>Increase frequency of grass cutting, etc</li> </ul> <p><u>Adaptation measures</u></p> <ul style="list-style-type: none"> <li>reviewing pavement material compositions at the next rehabilitation/reconstruction event</li> <li>building on well-working practices from areas with warmer temperatures</li> <li>using more rut-resistant and/or stripping-resistant resurfacings</li> <li>surface dressing and microsurfacings, especially with chippings with high reflectivity</li> <li>pervious wearing course</li> <li>improving surface and sub-surface drainage systems</li> <li>stabilisation of unsealed pavements</li> </ul>
	Increased freeze-thaw cycles, frost heaves and frost damage	<p><u>Good practice measures</u></p> <ul style="list-style-type: none"> <li>keeping the road drainage in good condition by implementing the ROADEx drainage maintenance strategies and guidelines [63]</li> <li>Keeping ditches and culverts free of snow and ice by means of good winter maintenance practices</li> <li>Managing the vehicle numbers using the road</li> <li>Applying axle load restrictions where necessary</li> <li>Surfacing and/or regrading gravel roads to provide good crossfalls</li> </ul>

Table of good practice and adaptation measures



# Climate Change Adaptation

Examples of adaptations in the Partner areas:

**Norwegian Public Roads Administration**

“Climate and transport” project

The need for increased drainage capacity:



Climate factor  
dependant on  
the storm return  
period

$$Q = C \times I \times A \times K_f$$

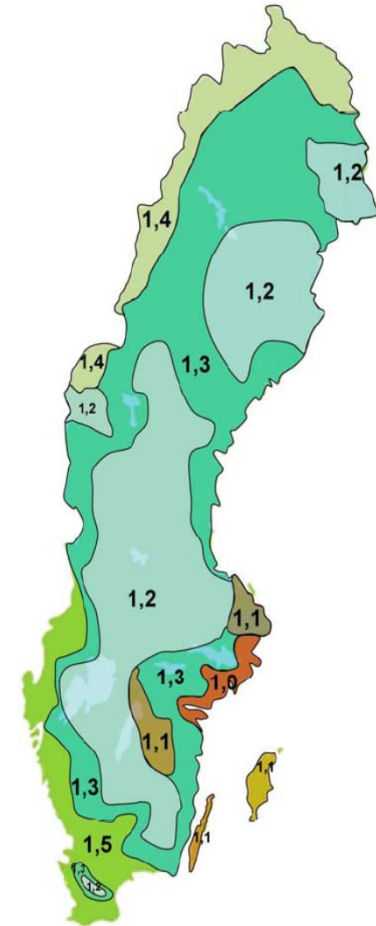
# Climate Change Adaptation: example

## Drainage design - Sweden

Regional drainage factors for climate change :



Ånn 2006



**(Scotland climate change factor for drainage = + 20%, or 1.2)**



# Climate Change Adaptation: ERA-NET ROAD SWAMP

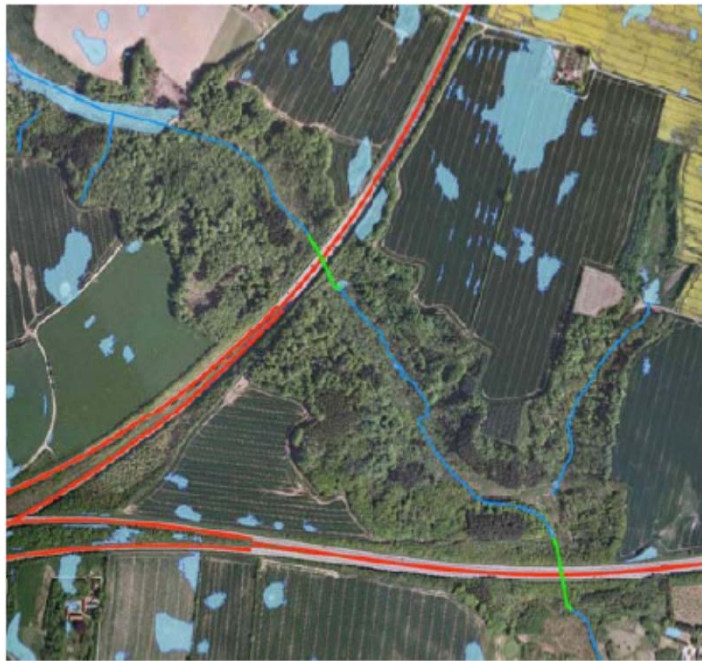
## Blue Spot screening:

"A part of a road that is vulnerable to flooding, either by precipitation, catchment water or sea level rise"

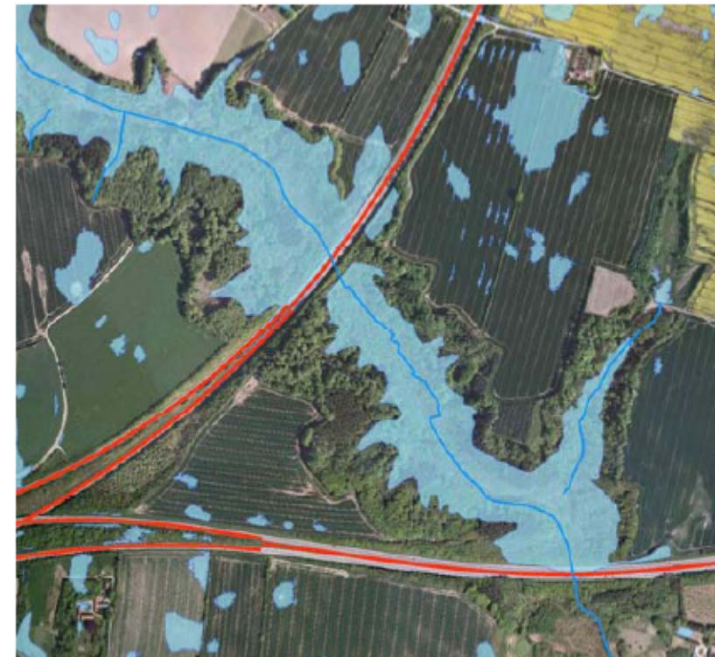


# Climate Change Adaptation: ERA-NET ROAD SWAMP

“Blue Spot” - Modelling restrictions in stream flow and river flows:



Free flow system - unrestricted



Blocked waterway - flooding



# Summary

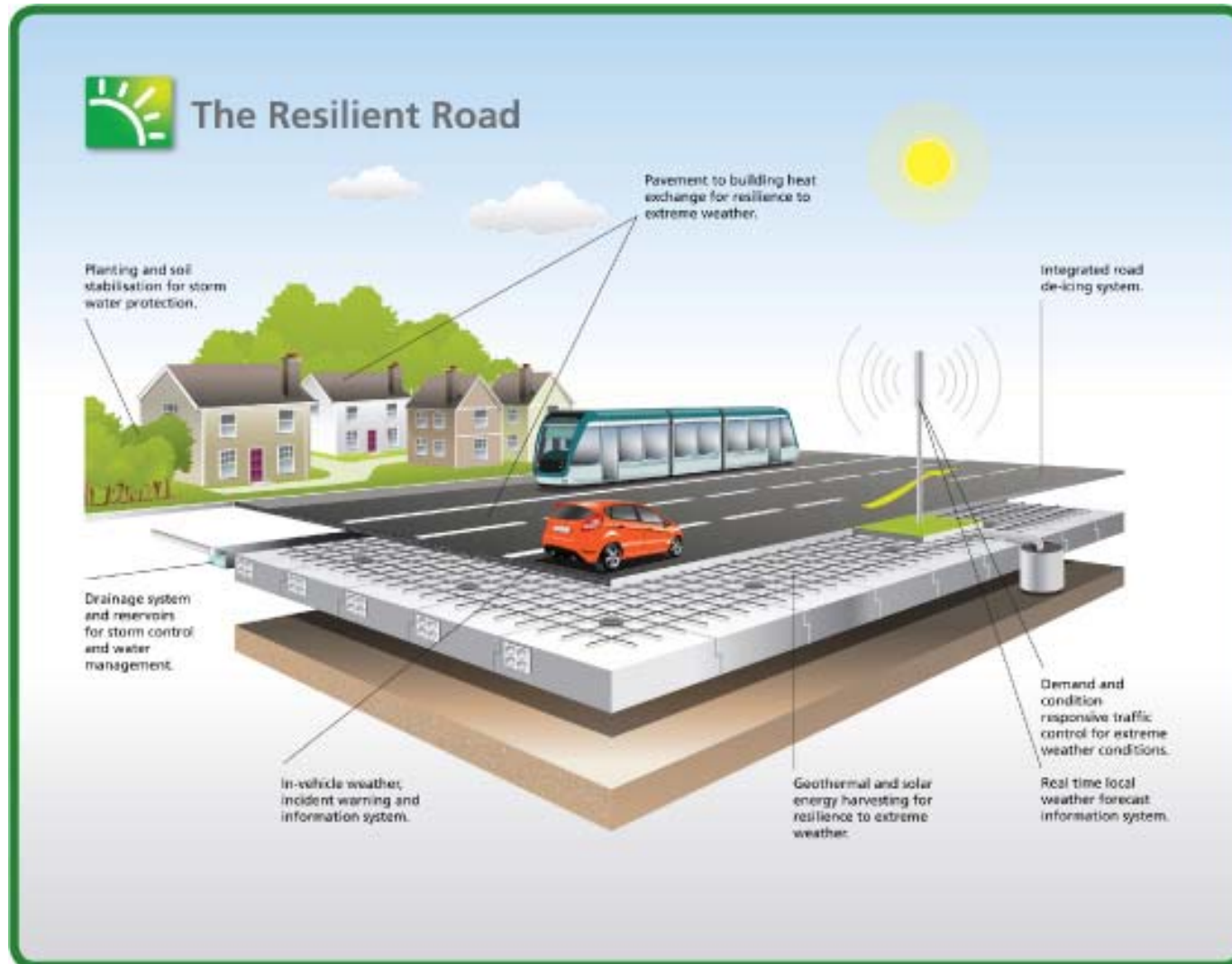
## Key points:

- Climate change is stated to be happening
- More frequent extreme weather events are likely
- More frequent freeze-thaw cycles
- Uncertainty in projections
- Road owners need to consider their positions
- Maintenance operations, a step at a time
- Solutions may be available in other countries
- Need to share information
- Good road drainage will be a key
- New construction will be different
- The ROADEx report offers a number of recommendations for best practice and adaptation measures



# The future?

## “The climate change resilient road”



But for the present”





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Thank you

[www.roadex.org](http://www.roadex.org)



# The ROADEx Network in the Highlands

