The future of the Finnish national road network under changing climate

Introduction

National road network is an essential infrastructure for the society. The road network needs to be maintained on regular basis for optimal service. Weather and its variability affect the quality and sustainability of road durability in many ways. Climate change is expected to exacerbate the impacts. Costs of road maintenance are considerably high. Hence, it is important to optimize the maintenance to minimize the costs. Fig. 1 shows the relationships between maintenance costs and different factors affecting the costs.

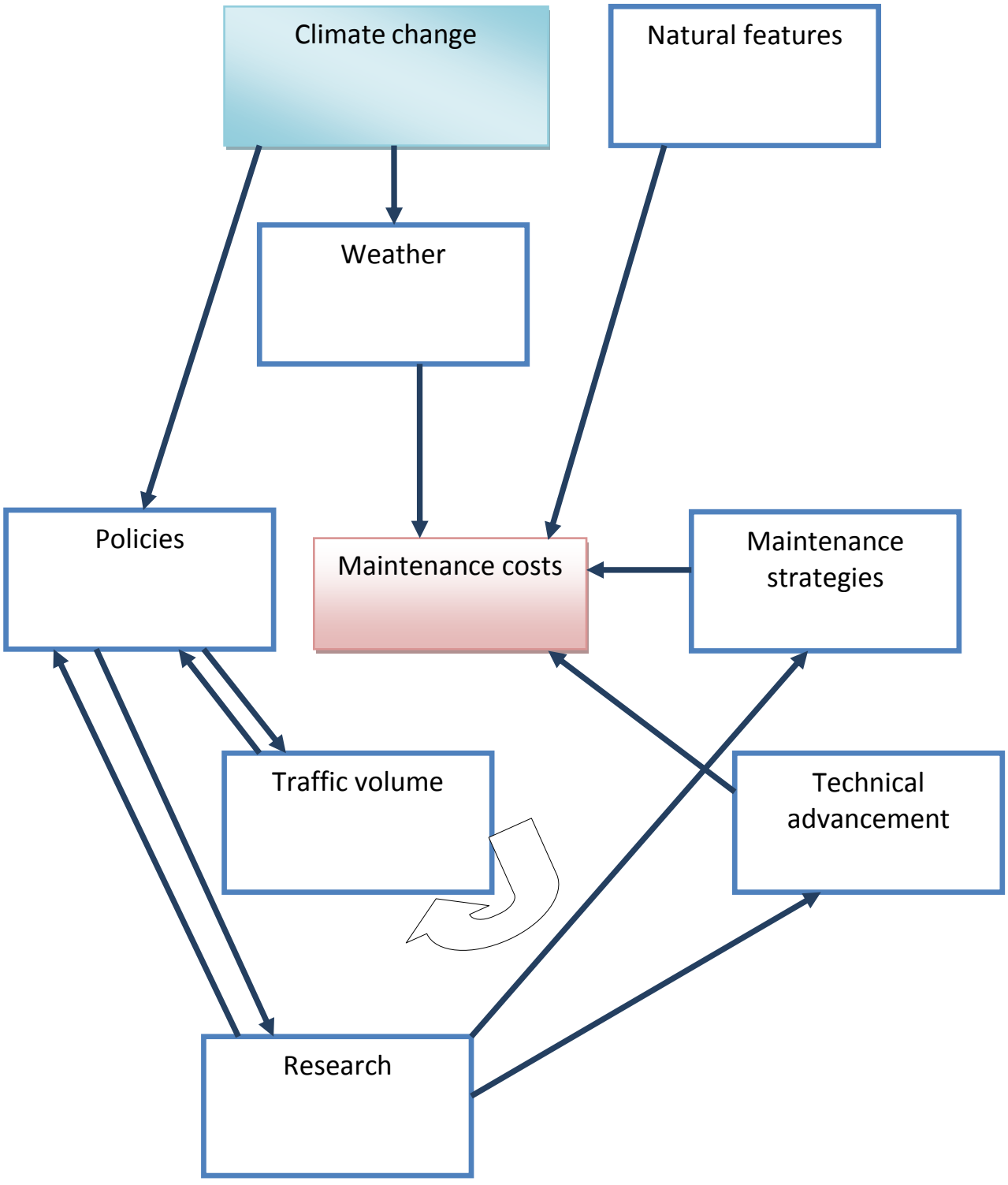


Fig. 1 .....
Who are we doing this for: National road administration
A technical issue, knowledge demanding, national roads are very important for the general society, national security issues etc.

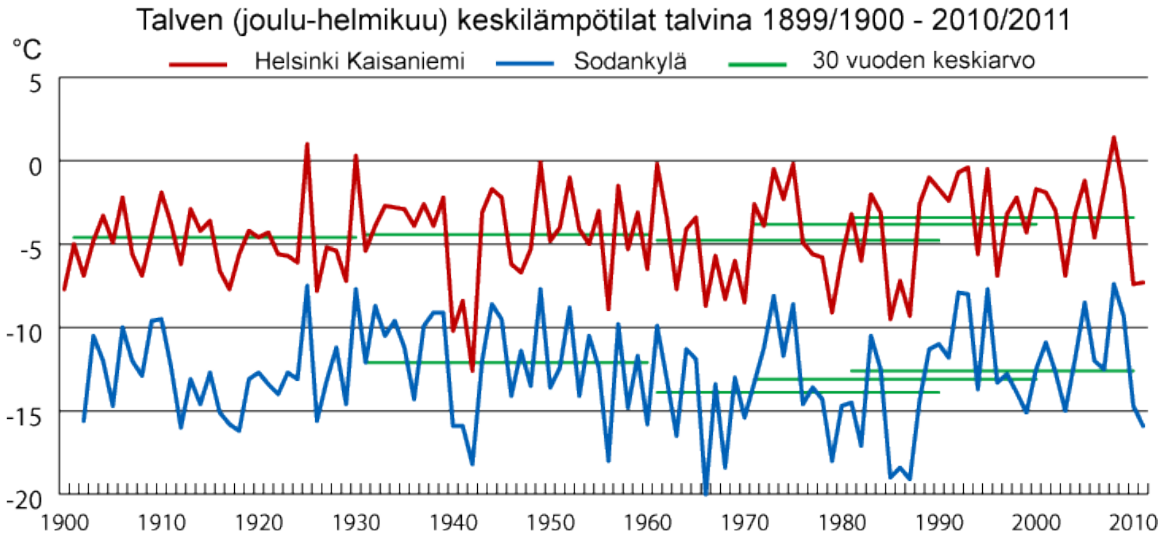


Fig. 2: Historical climate records in Finland

Maintenance and operational tasks: Maintenance encompasses smaller repairs, larger refurbishments, and adding new lanes. Operational tasks: Salting, removing of snow

Stakeholder involvement:
What is manageable cost level?
What is the reasonable level of road quality and the level of service
Information and knowledge: frequency of freeze-thaw cycle,

Stakeholders: road authority and users (how to define?)
Time frame: until 2050
The reason for choosing this time horizon is because we are working with maintenance of roads
Frequency of extreme weather

- Climate data
  - Increase in precipitation
  - Change in road deterioration
  - Frequency of high and low temperatures
  - Heavy rainfall
  - Increase in average temperature

Technical state of the roads – state of the Finnish road network: data available from Road administration
Data on past events about climate related damage on roads

Technical development of e.g. asphalt – more durable

Knowledge gaps

When to do maintenance

First we should start by identifying the problems by including relevant stakeholders and what are the key vulnerabilities.

Modeling studies – are the models capable of doing what we want them to do
The role of public transport

Including stakeholders in the scenario process

Relevant stakeholders: ministry of finance (€€€), ministry of transport, national road administration, road users, people living next to the big roads (noise reduction vs. durability of asphalt), scientists in road technology, firms

Important to inform general public about forthcoming maintenance; stakeholders have different agendas: essential to get the stakeholders to cooperate and find a compromise between agendas

Meetings not feasible/possible due to busy schedules → communication and discussion difficult → needs a lot of effort during the planning process

Scenarios descriptions

Key characteristics:

i. **CLIMATE CHANGE:**

Change in average temperature in winter-- > frequency of freeze/thaw cycles will increase in the south
Emission scenarios are not important because of the time horizon (2050) : differences between scenarios are very small, but the uncertainty range is large. We are looking two cases: worst case (+4 C degrees increase) and best case (1.5 C increase). Increase in prec: more rain in the winter

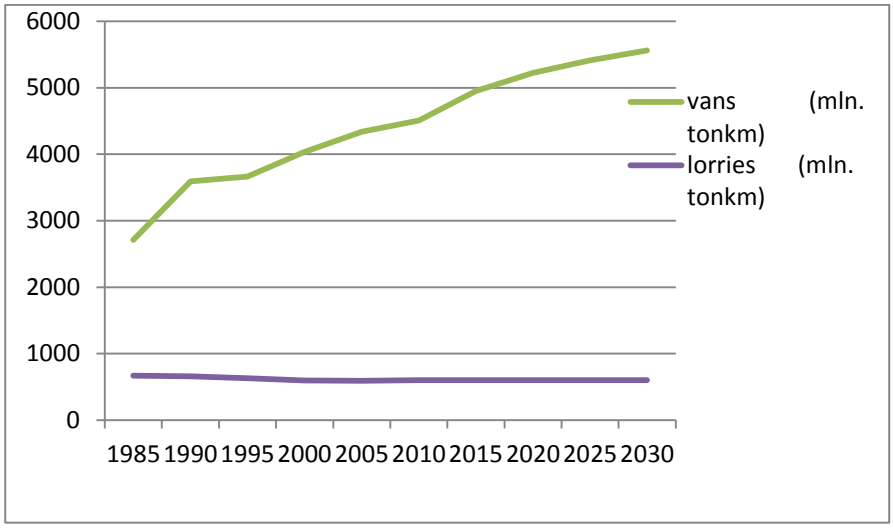
Decrease in the predictability of weather
Natural variability

ii. Socioeconomics

a. Change in traffic volume

b. BAU

- Ten-year time steps
- National main roads
- Geographic area: The whole country



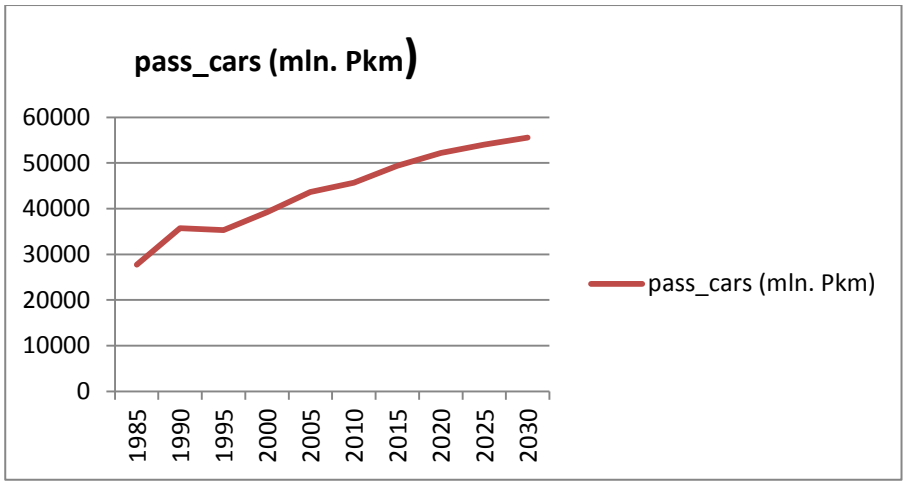


Fig. 3... Projected changes in traffic volume

No change in the structure of transport (railroad…)
Slow technological development in road maintenance and operational tasks

Change
Change in the composition of means of transport: more from trucks to railroads
Rapid development in technology
More maintenance cost

Adaptation measures

- To try different kinds of asphalt and evaluate the performance of them in five-year basis
- Current state of the road network affects the possible decisions to be made at the moment

Political adaptation

Management structures have to be more flexible and ready to apply adaptive management

Technological adaptation

Scenario development:
Climate change scenarios: Emission scenarios - GCM – regional downscaling to Finland
Socio-Economic scenarios:
BAU: Statistical study about the projected growth in transport volume
Estimates about the technological development in asphalt, road maintenace
Change: 30% more than BAU

	Climate scenario	
Socio-economic scenario	**Worst case (4.4 C increase; 17 % increase in prec)**	**Best case (1.5 C increase; 2% increase in prec)**
BAU	A	B
Change +30 %	C	D

Spatial analogues:

- regions which today have a similar climate to the expected future one the study region (IPCC TAR, 2001)
- limited by possible lack of correspondence with other important features at study site
- easy to communicate

The idea here is to look for a place similar in climatic conditions to what is expected in Fnland within the next 40 years and study the maintenance work/strategies at that place. The problem of lack of correspondence might not be so severe in this case as cars need kind of the same conditions to operate on when we talk of highway structures – so the difference of what is an acceptable level of maintenance might not very that much from region to region (of course depending on the given regions).

Uncertainty:

The short time horizon of the problem reduces uncertainty on emission scenario (especially important for temperature change), which is determined by economic growth/global policy measures (qualitative uncertainty). On the other hand the importance of climate variability is larger giving more weight to onthological uncertainty (but also statistical uncertainty if we assume that this variability can be described by historic data). Still according to Hawkins and Sutton (2009) model uncertainty (epistemic uncertainty) will remain the largest source of uncertainty regarding climate change – this is reducible by doing more modeling studies. Looking at traffic volume development qualitative uncertainty is also important here as shocks might happen in society, policy measures will be implemented etc. On the other hand the development in Finland over the last 40 years shows a rather continuous increase so it might be possible to do useful modeling studies. Short of a war/large-scale natural disaster one would expect that people would abandon their cars from one day to another.
Political uncertainty – budget uncertainty

Scenario combination	Impact		Adaptation measures	
	North	**South**	**North**	**South**
A	* CC: Possible increase in the amount of snow → more snow clearing → increase in operational costs S-E: increase in traffic volume → increased wear of roads → increase in maintenance cost.	** CC: Possibly less snow, more rain Increase in freeze/thaw cycles → less snow clearing, more salting needed, increase in frequency of extreme weather events (flooding)	Better road services, increase capacity to clear/salt roads	Better road services, increase capacity to clear/salt roads Adjustment of maintenance cycles Flexible system for idle costs
B	* **CC: No change** S-E: increase in traffic volume → increased wear of roads→ increase in maintenance cost	** Possibly more snow → increase in operational costs		
C	**	*** CC: Less snow, more rain Increase in freeze/thaw cycles → less snow clearing, more salting needed, increase in frequency of extreme weather events (flooding)		
D	**	** CC: Increase in freeze/thaw cycles → less snow clearing, more salting needed, increase in frequency of extreme weather events (flooding) S-E: a large increase in traffic volume → increased wear of roads → increase in maintenance cost.		

Baseline computation: evaluation of BAU-maintenance policies under CC-scenarios

Adaptive management plan

More flexible management, learning by using experience from past events already happening and use that in future planning

Reactive vs. proactive management → stakeholder participation to find out what the client is able to do

Several options to adapt to future conditions: The roads need continuous maintenance → several options to adjust → low irreversibility of decisions

→ Option value: wait for better information. Whether to invest on maintenance now or wait for either technological development or information on climate change (reduced uncertainty) → possibility to save costs but also to have a lot higher costs. Depends on the current state of the world