OPTIMISATION OF WINTER MAINTENANCE ON PEDESTRIAN AND CYCLING PATHS - CASE STUDY RR 110

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ABSTRACT

The Centres for Economic Development, Transport and the Environment and the Finnish Transport Infrastructure Agency have launched a pilot project to study the impacts of the traffic environment, the weather, road conditions and maintenance on walking and cycling conditions in winter. The focus of study in the project was the pedestrian and cycling paths adjacent to regional road 110 in an urban area. The study has been in two phases: prior to the study (2018) and follow-up and optimisation of winter maintenance (2021).

The recommended improvements prior to the study included route optimisation and real-time monitoring applications using experience and weather reports to conduct a daily planning process and the acquisition of more equipment and personnel. The conclusion is that more financial resources are essential for improving the quality of winter maintenance and achieving environmentally-friendly winter maintenance. For the maintenance process to be successful, the physical environment should also be suitable for maintenance. If the traffic environment is viable, this also improves the usability and safety of the route.

Pedestrian and cycling paths have now been rebuilt and the measures and quality of winter maintenance have been reviewed and improved in line with the recommendations. In the follow-up period we will repeat the study carried out in the first phase to obtain information on how we have managed to improve winter conditions for walking and cycling, by how much the number of pedestrians and cyclists has increased due to better path and winter maintenance, and how the recommendations work in real life.

To improve the efficiency and cost-effectiveness of maintenance, information systems should be considered. With automatic performance tracking systems resources could be allocated accordingly, but other areas could also be examined and improved. These systems can also be used for improved communication, and more detailed and effective reporting, which could then be used for quality monitoring. Information about real-time winter maintenance could also be made available to the public.

1. FINLAND

Finland is a sovereign state in Northern Europe. With The Gulf of Finland lies to the south and the Gulf of Bothnia to the west. The country has land borders with Sweden to the north-west, Norway to the north, and Russia to the east. Finland is a Nordic country situated in the geographical region of Fennoscandia, which also includes Scandinavia. Finland's population is 5.5 million, the majority of which are concentrated in the southern region. In terms of area, it is the eighth largest country in Europe and the most sparsely populated country in the European Union.

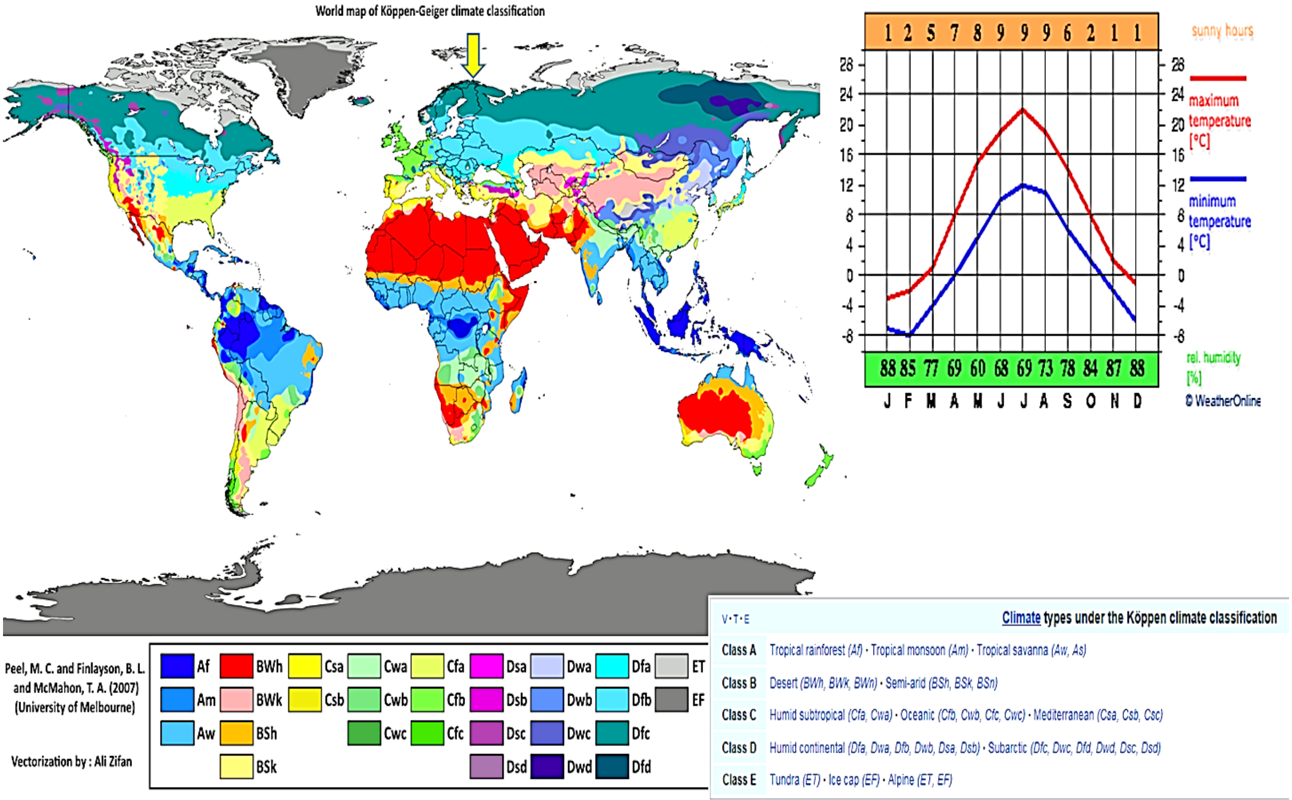


Figure 1 - In Köppen-Geiger climate classification [11] Finland belongs to the (Df) continental subarctic or boreal climates. The climate of Finland has characteristics of both maritime and continental climate. The yellow arrow at the top indicates Finland.

The climate in Finland is influenced most by latitude. Due to Finland's northern location, winter is the longest season. Only the south coast has equally long summer season. On average, winter lasts from early December to mid-March in the archipelago and the south-western coast and from early October to early May in the northern part of the country. This means that the southern parts of the country are snow-covered for about three to four months of the year and northern part for about seven months. Due to the long winter, about half of the annual 700 millimetres of precipitation falls as snow in the north.

Finnish road network comprises highways, municipal street networks and private roads. Together with the regional ELY Centres, the Finnish Transport Infrastructure Agency is responsible for the maintenance and development of the state-owned road network. There are 78,000 kilometres of highways maintained by the state in Finland. Approximately 65% of highways are paved. More than half of the total highway network with low traffic volumes are in the lowest maintenance category. It is impossible to maintain all roads in such condition that, during the most challenging weather conditions, no problems will occur anywhere on the road network.

2. STARTING POINTS FOR THE RESEARCH AND ITS OBJECTIVES

Walking and cycling are modes of transport that have a positive impact on the health and wellbeing of individuals as well as the environment. They are inexpensive and emission-free ways to travel that are available to most people. Despite these obvious benefits, car travel is more popular than walking and cycling, except when it is a case of a short journey (less than 1km).

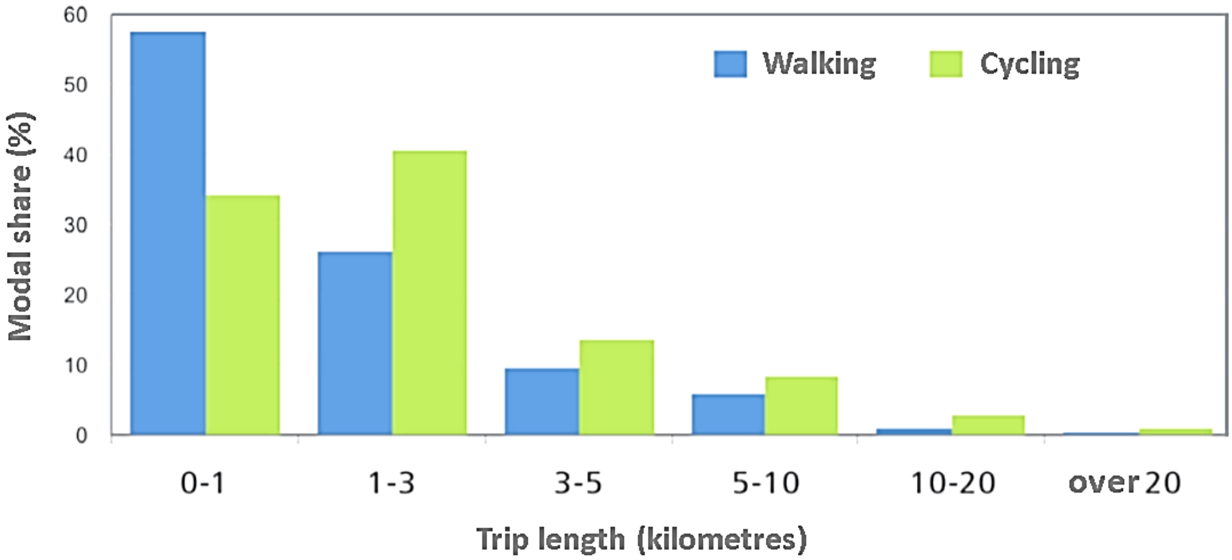


Figure 2 - Modal share of walking and cycling per trip length in Finland [13].

The number of cyclists and pedestrians varies from one season to another. The biggest fluctuations in numbers are the result of the winter conditions in Finland, such as the cold, slippery surfaces, snow and rainfall, and a lack of winter maintenance. There is, however, the potential to promote winter cycling if the conditions are right throughout the year.

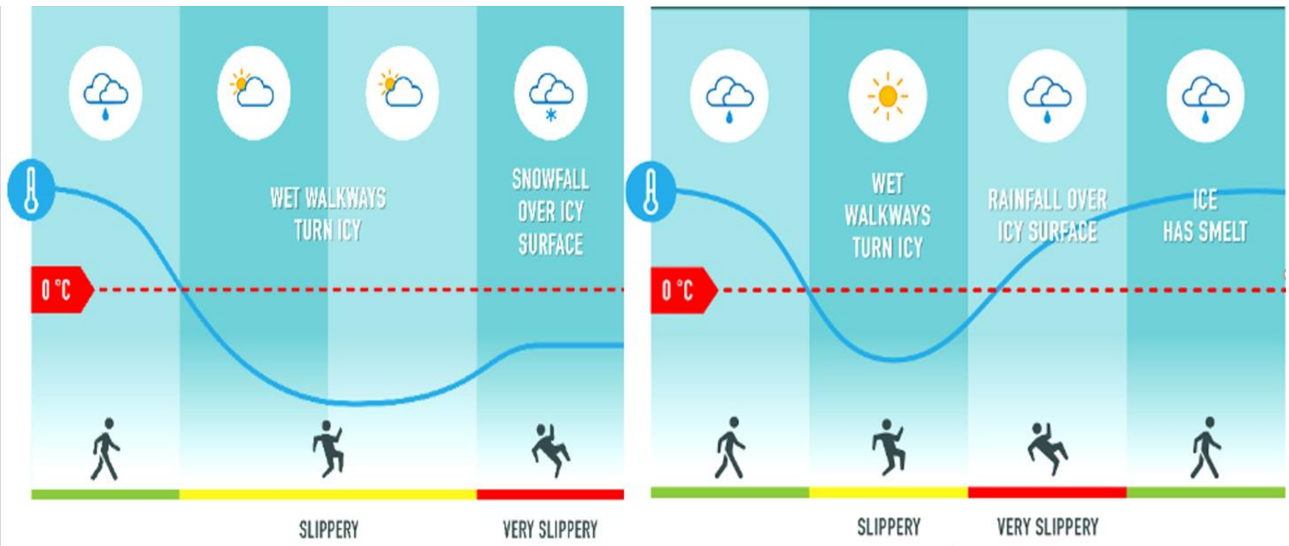


Figure 3 - Slippery road conditions pose a significant risk of falls for cyclists and pedestrians [3].

Figure 3 shows two extremely slippery scenarios for pedestrians. The first scenario (on the left) depicts a situation, where at night the temperature is above zero degrees Celsius, and during the daytime, drops below zero. Before the temperature drops below zero degrees Celsius, the weather is wet; either from rain or the streets are wet from melting snow and/or ice. The water then turns into a slippery icy surface. Additionally, a layer of fallen snow on the ice further reduces the grip levels of the surface. The second scenario (on the right) depicts extreme slipperiness, when the temperature falls below zero degrees Celsius for a short period of time, usually between morning and midday, turning the water on the paths into ice. As the temperature increases further, the ice starts to melt, creating a layer of water on top of the ice, which further reduces the level of grip. Additional rainfall on the ice makes the surface even more slippery.

In winter, the most common cycling accident is a crash where the main risk factor is a slippery surface or the unevenness of the cycle path. The period when surfaces are slippery in the Turku region is from November to April. Temperatures hovering around zero and ice under the snow can make a road surface more slippery. Many municipalities have plans that promote walking and cycling, but inadequate winter maintenance of pedestrian and cycle paths poses a safety risk and is a key obstacle to any increase in walking and cycling.

3. RURAL ROAD 110 CASE STUDY

A case study was carried out on the pedestrian and cycle paths of Road 110 between Turku and Kaarina. On a 5 km stretch of road, the combined pedestrian and cycling paths are separated from the highways.

Figure 4 - The target research area of Rural road 110 is highlighted in blue. Map [6].

In phase 1 of the study a literature review was undertaken, a user survey conducted and the first measurements were taken on the pedestrian and cycling path included in the study. This resulted in the creation of a matrix of the effects of various factors on pedestrian and cycling conditions and traffic volumes. This led to suggestions being made to improve path conditions [9].

In phase 2 of the study in 2021 follow-up measurements were taken and a user survey conducted. These results were compared to those for phase 1 of the study. This report sets out the results for phase 2 and the conclusions drawn for the entire research project.

The aim of the research project was to discover how the traffic environment, the weather, path conditions and maintenance affect pedestrian and cycling conditions in winter. The purpose of phase 2 of the study was to examine how the phase 1 proposals for improvements were implemented and their impact. The study ended with various development proposals being drawn up to make further improvements to pedestrian and cycling paths.

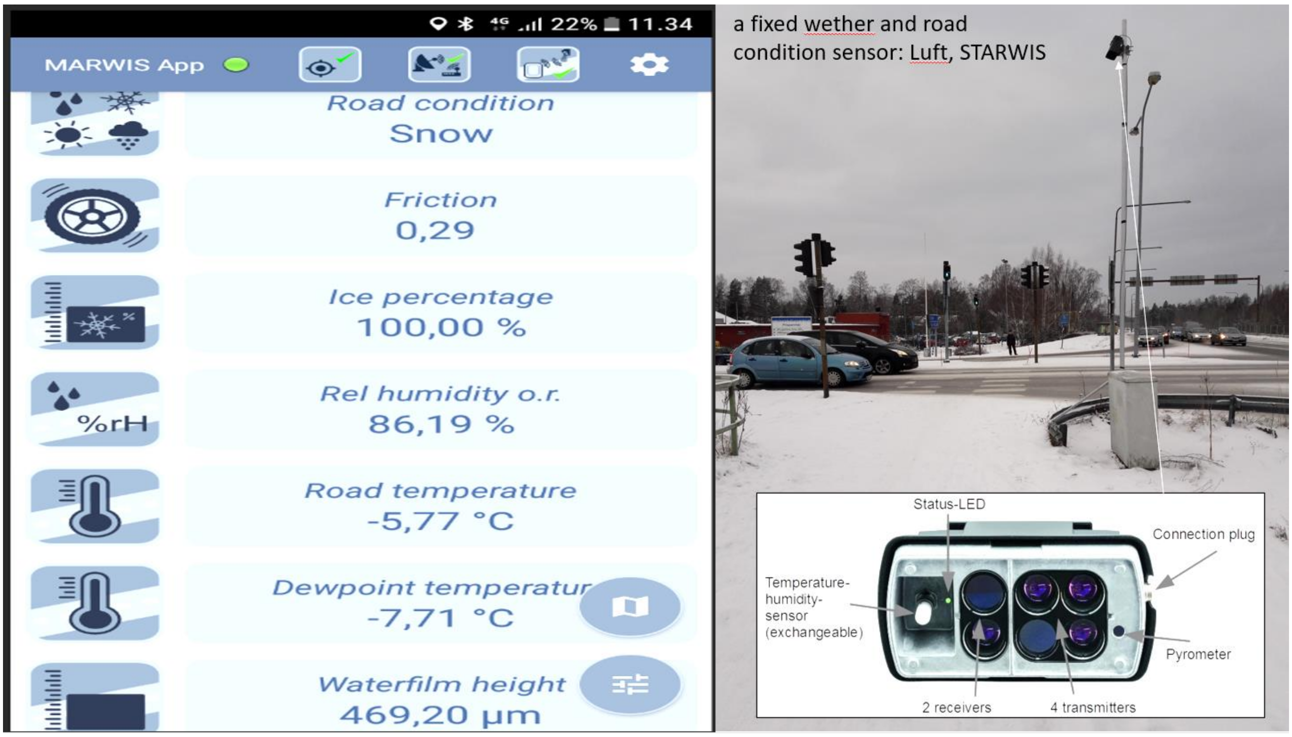


Figure 5 - The Starwis device [12], which is a fixed, mains connected sensor, was installed at the junction between Road 110 and Kairiskulmantie.

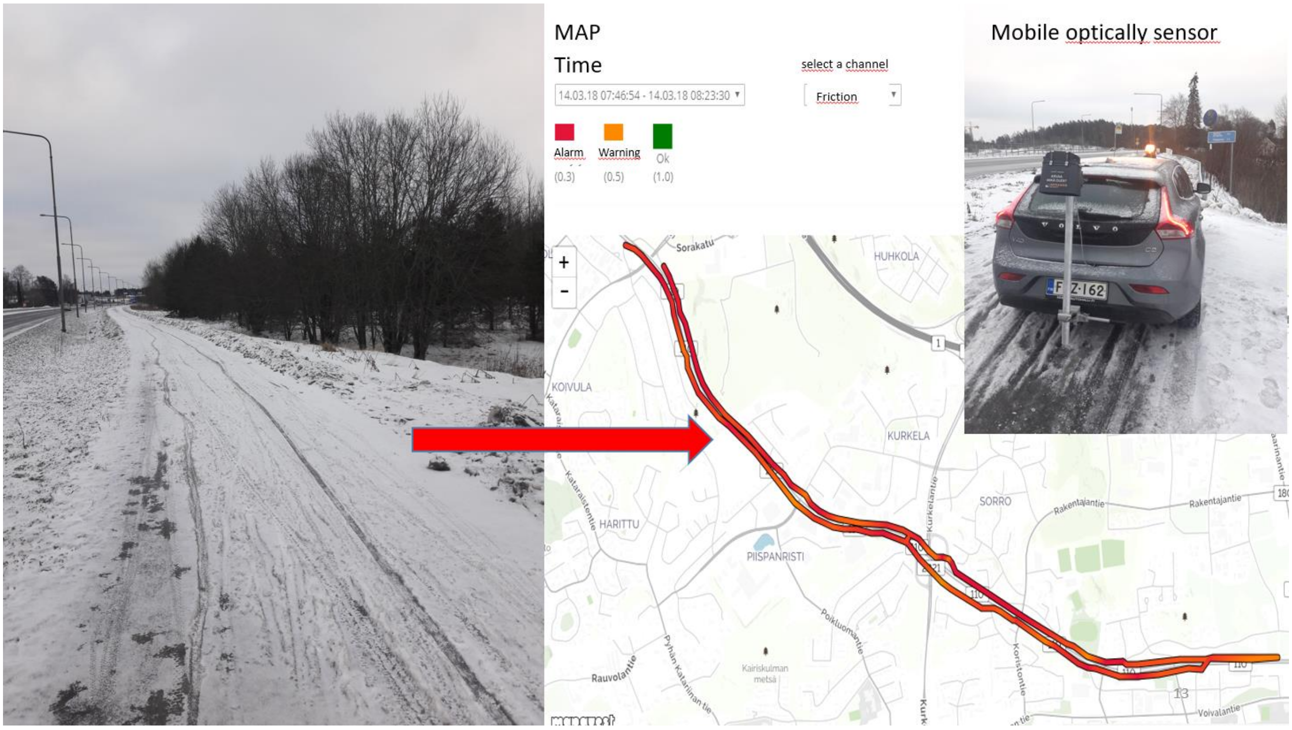


Figure 6 - The mobile Marwis device [12], which was mounted in a car, collected the same road conditions data as the Starwis device, but its data collection targets were also the pedestrian and cycling paths across the research area (5 km).

4. WHAT DEVELOPMENT PROPOSALS HAVE BEEN IMPLEMENTED SINCE PHASE 1?

The following improvements to the traffic environment on the route covered in the study were made between 2018 and 2020:

- it was completely resurfaced and the northern path was widened from three to five metres
- incomplete or inadequate sections of the route were improved and extended to improve route continuity
- directions on the northern path were shown by means of road markings
- handrails for cyclists were introduced on the route
- underpasses and interchanges were made safer and easier to maintain
- more space was made available for the snow cleared off the path by snowploughs
- signposts for cyclists were introduced on the section.

The total costs of the measures to improve the traffic environment on the section of the route was EUR 2.74, of which EUR 1.7 million was spent on pedestrian and cycling path improvements, EUR 0.51 million on the relocation of cables and transfer of equipment, and EUR 0.53 million on improvements to bus stop connections and road junctions.

Figure 7 - Before 2018 and after 2021. Walking and cycling paths have now rebuilt in line with the pace 1. recommendations. Photo [7].

Winter maintenance has been improved since phase 1 of the study, as follows:

- winter maintenance has been scheduled for times before commuter traffic starts

- the content of the maintenance contract and cooperation between the customer and the contractor have improved - the quality requirements will be reviewed with the contractor before the winter starts and the contractor will be contacted before any difficult winter road conditions appear
- it has been agreed that the equipment for maintaining the route should be optimal and depots will be located close to the area undergoing maintenance
- the maintenance budget has been increased to cover the additional costs incurred in the way in which commuter traffic is taken more into consideration
- the contract model has been updated and is now a road maintenance contract model.

The costs of the winter maintenance of the pedestrian/cycling path prior to the improvements were EUR 12 000 per annum and, with the widening of the route and a better standard of maintenance, the cost is now EUR 37 000 per annum.

Figure 8 - The measures and quality level of winter maintenance renewed in line with the pace 1. recommendations.

5. HOW HAVE PEDESTRIANS AND CYCLISTS REACTED TO THE CHANGES?

Both pedestrians and cyclists think that all aspects of the traffic environment are better in phase 2 of the study than they were in phase 1. Cyclists gave the route higher scores than pedestrians in both phases.

It was felt that lighting had not improved substantially, which was only to be expected as no improvements had been made to lighting since phase 1. The improved ratings compared to phase 1 may have been due to the fact that trees and bushes had been cleared along the route, with the result that the current lighting covers a wider area of the route. The route has also been widened in places in the direction of the carriageway, and now the carriageway lighting extends more in the direction of the pedestrian/cycle path.

Both user groups think that all aspects of winter maintenance are better in phase 2 than in phase 1. It is the timing of the snow removal, thought in phase 1 to be the poorest aspect of the work, that has improved most between the phases.

Figure 9 - Scores given by pedestrians and cyclists for different aspects of the research site prior to the improvements in 2018 and since then in 2021.

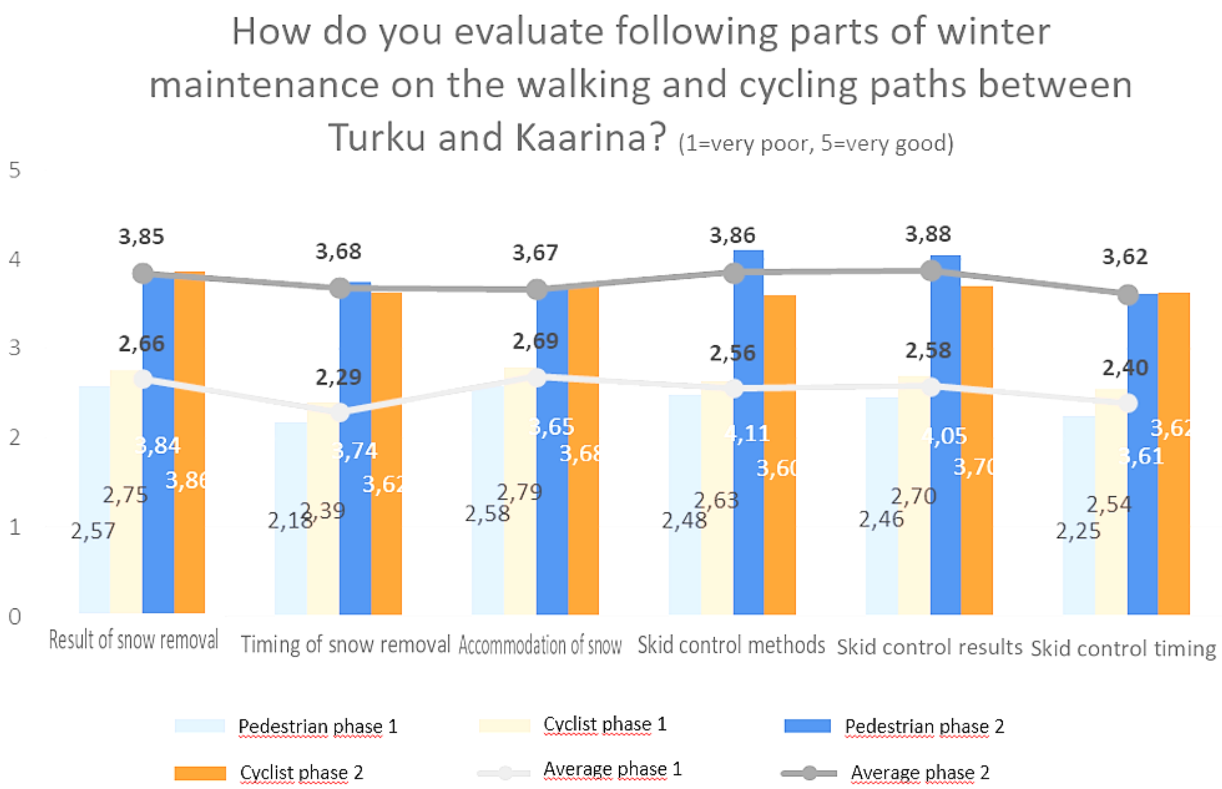


Figure 10 - Scores given by pedestrians and cyclists for different aspects of the winter maintenance of the research site prior to the improvements in 2018 and since then in 2021.

6. HOW DOES THE WINTER AFFECT PATH CONDITIONS AND TRAFFIC VOLUMES?

The removal of snow and sludge on the paths was mainly carried out before 6 a.m. Additional snowploughing was introduced at later times if it also snowed during the day. The findings show that the maximum depth of loose snow (3 cm) during snowfall seemed to work well in the main and triggered snowploughing operations. The analysed data suggest that the intervention period (ploughing starting within three hours of the time it stops snowing) worked well.

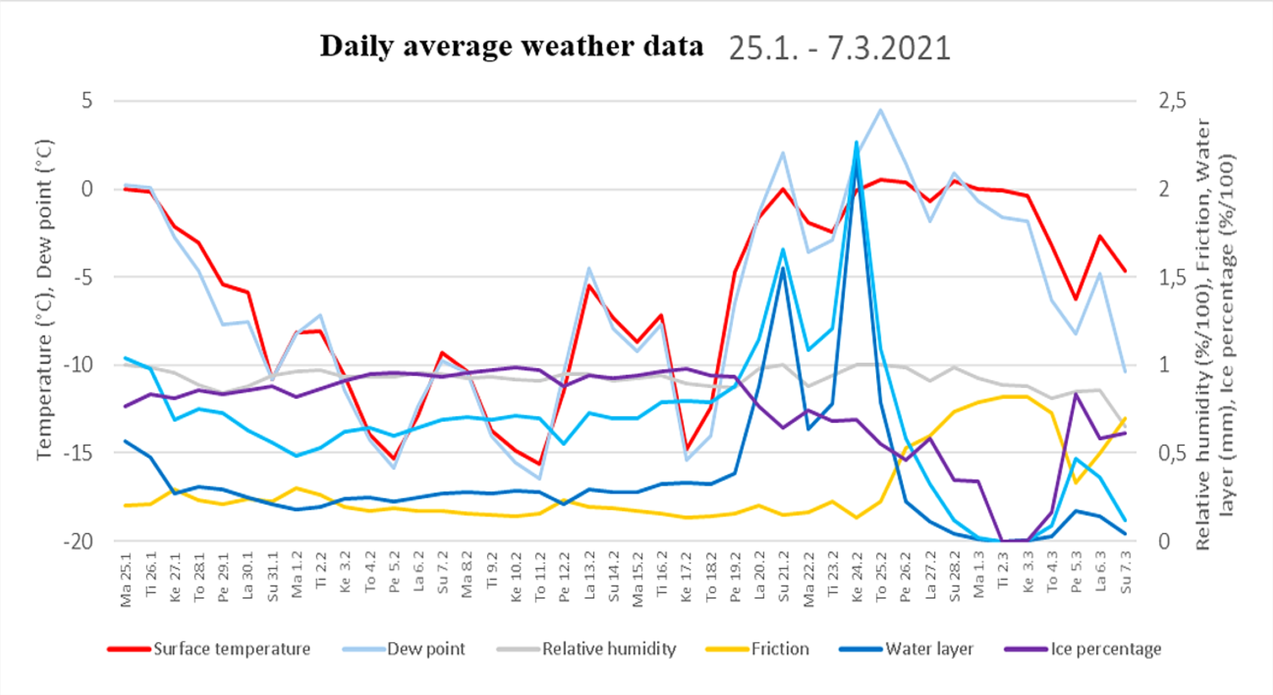


Figure 11 - Daily average weather data.

The users of the route were also satisfied with the snow and sludge clearing work, although they also thought there was room for improvement. The survey results suggest that the areas that need improving most are the timing of the snow removal, the achievement of a better outcome overall and better coordination with adjacent carriageways.

Table 1 - Quality requirements of pedestrian and cycling paths in maintenance categories 1 and 2 [4]. The walking and cycling path included in this study belongs to winter maintenance class K1.

Class	Quality requirements K1 06.00-22.00 and K2 07.00-22.00.
K1 (winter mainte-nance class 1)	• To be undertaken by 6 a.m. before the traffic starts • Adjacent paths to be ploughed immediately after the main route • Maximum depth of loose snow 3 cm whilst snowing • Intervention period allowed for snow clearing three hours • There may not be steep or otherwise hazardous areas of unevenness over 2 cm deep • Adequate friction for safe walking and cycling • Intervention period allowed for antislip and antiskid treatment two hours • Bus stop connections to be treated the same way as the rest of the pedestrian/cycle route • Surfaces of pedestrian crossings to be made safe
K2 (winter mainte-nance class 2)	• To be undertaken by 7 a.m. before the traffic starts • Maximum depth of loose snow 4 cm whilst snowing • Intervention period allowed for antislip and antiskid treatment three hours • Intervention period allowed for snow clearing four hours • The other quality requirements are the same as for class K1.

Rural road 110 between Turku and Kaarina is fairly busy throughout the year. Turku, which in winter is a cold and snowy coastal area in Finland, also tracks year-round walking and cycling. It is harder to assess how successful the antislip/antiskid treatment was as the quality requirements were open to interpretation (Adequate friction allowing for safe walking and cycling). On the basis of the study findings and measurements, antislip/antiskid treatment could be regarded as a success and the quality requirements could be considered met.

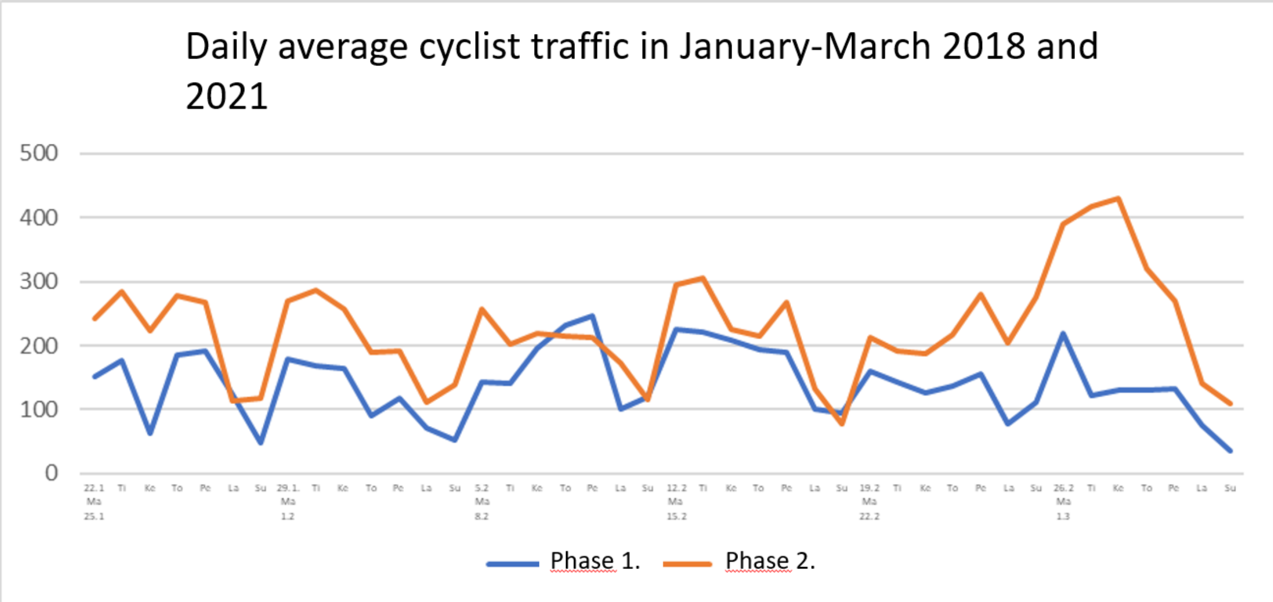


Figure 12 - Comparison of the volumes of bicycle traffic in phases 1 and 2.

The data in the pilot project 2018-2021 revealed the following:

- cycling decreased by as much as 85% in winter compared to the busiest summer months
- the results of the study support those obtained in previous studies, where improved winter maintenance was seen to have the effect of increasing commuting by bicycle in winter by up to 18% and reducing commuting by car by 6%
- The coronavirus pandemic did not discourage walkers and cyclists in the research site in winter 2021. The pandemic has had an effect, in particular, on the distribution of weekday and weekend journeys.

Table 2 - Summary of the results of the different phases of the study [10].

Variable	Follow-up 2021	Survey 2021	Follow-up 2018	Survey 2018	Previous studies [9]
Number of trips in different seasons	Cyclists: numbers fall considerably in the winter.	(Pedestrians: numbers fall in the winter) Cyclists: numbers fall in the winter.	A significant decrease in the number of cyclists during winter, compared to data from May 2015	Pedestrians: slight fall in the number of journeys in winter Cyclists: significant decrease in the number of journeys in winter	Pedestrians: considerable increase in winter Cyclists: significant decrease during winter
Temperature	Low temperatures result in less bicycle traffic.	-	Low temperatures result in fewer pedestrians and cyclists on the paths	Pedestrians: slight impact Cyclists: slight impact	Pedestrians: increases in temperature result in fewer pedestrians Cyclists: a rise in temperature increases the number of cyclists on the route (not the only factor in winter, however)

Precipitation/Rainfall	Cyclists: moderate volume-decreasing effect when it is raining or sleeting. Possibly a moderate, indirect volume-decreasing effect when it is snowing.	-	High volume-decreasing effect for both pedestrians and cyclists	Pedestrians: moderate obstacle Cyclists: moderate obstacle	Moderate decreases in pedestrian and cycling rates Depending also on the time of the study / study sample
Snow/ice on the path	Cyclists: discernible obstacle. Significant obstacle when combined with rain or melted ice on the surface.	(Pedestrians: possible a slight obstacle) Cyclists: moderate obstacle.	Significant obstacle when combined with rainfall	Highly significant obstacle for both groups	Highly significant obstacle
Slipperiness	Cyclists: clear volume-decreasing effect on bicycle traffic.	(Pedestrians: possible obstacle)	High volume-decreasing effect for both pedestrians and cyclists Significant correlation only when the surface friction changes	Pedestrians: highly significant obstacle Cyclists: significant obstacle	Significant obstacle
Traffic environment	Improvements to the traffic environment have had the effect of increasing bicycle traffic volumes significantly.	The improvements have had the effect of increasing the number of journeys on foot and by bicycle to some extent.	-	The safety of the traffic environment and a viable traffic network are important enablers. Separation of travel modes is desired.	The safety of the traffic environment and a viable traffic network are important enablers.

7. HOW CAN THE ROUTE'S TRAFFIC ENVIRONMENT AND WINTER MAINTENANCE BE IMPROVED FURTHER?

Some proposals for measures were drawn up in phase 1 of the study, some of which have not been implemented. They are as follows:

- Simplification of management, adaptability and flexibility of quality requirements, and improved contract models and agreements as suggestions for measures are aimed at developing approaches and operating models nationwide. The maintenance contract model for the research site has been revised. What maintenance work should actually consist of and its standard have been agreed locally.
- Modular snow removal equipment has not been introduced. Antislip/antiskid treatment does not extend to gritting the path with salt, as the maintenance requirements do not stipulate that salt should be used,
- The maintenance control systems have not been changed, because the current system has been found to be viable and adequate for current needs. The current maintenance control system has been made more efficient, so the proposal may be seen as partially implemented.
- The introduction of path and road condition data systems and connecting them to road user services is a broad proposal which it is intended to develop as a nationwide service. Its very scope means that no significant progress has been made in developing the system since phase 1 of the study.

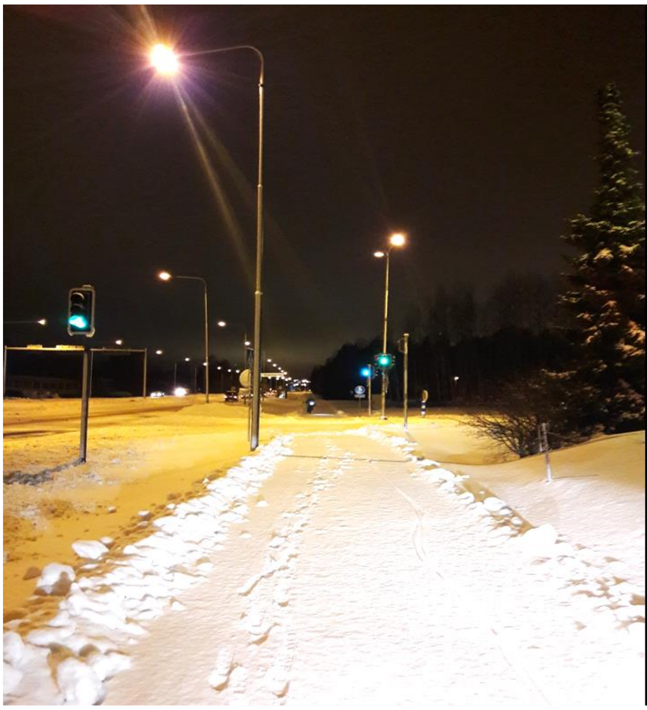
The survey responses mentioned the following areas where the traffic environment could be improved:

- better lighting on the path
- more litter bins, handrails and benches to rest on
- separation of the pedestrian and cycling paths by means of painted lines

The maintenance follow-up data suggest that maintenance has been carried out well. Furthermore, the road users who responded to the survey thought that the winter maintenance in the area under study was quite good.

On the basis of the study survey and responses, the following development measures are proposed:

- standards of winter maintenance should be raised on pedestrian and cycling paths connecting to the research site
- maintenance should be of consistent quality at points where the party responsible changes
- the timing of snowploughing operations should be improved on nearby routes in situations where snow on the carriageway is ploughed and dumped on the pedestrian/cycling path, e.g. at bridges
- a more even ploughed track should be achieved through the use of other types of ploughing equipment
- alternative antislip/antiskid methods should be introduced, such as the use of sand rather than crushed stone (which causes punctures) - salting is not desirable
- An interactive information system should be introduced that would offer road users support in planning a route and scheduling a journey (when was the path snow-ploughed? - what condition is the path in?). An interactive system could also be used to report problems on the path, so that the most problematic areas could undergo enhanced maintenance.



Principles of winter maintenance

1. Keep your promises (contracts).
2. Do not try to do everything at once. Select a prioritised route of a suitable length for high-quality maintenance throughout the year.
3. Monitor the level of maintenance throughout the winter and maintain ongoing dialogue with the contractors.
4. It is easier to develop maintenance when you know the situation on the streets.
5. Take maintenance requirements into account when planning the routes. Significant savings can be achieved by planning the places for snow storage, for example.
6. Select the most appropriate maintenance methods for the weather conditions in the city.

Figure 13 - Principles of winter maintenance [8]. Realtime maintenance information is more important to road users than information on path conditions.

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