Winter Maintenance for Walking and Cycling: Mapping Processes, Identifying Challenges, and Developing Solutions

SPIN UNIT

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BATS

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1. Introduction



1.1 Year-Round Active Mobility

For decades, the planning and maintenance of urban mobility environments in countries with cold winter climates, including Estonia, has been carried out with limited consideration for climate-related conditions: walking and cycling became perceived as fair-weather activities alongside the spread and prioritisation of cars, and infrastructure investment and maintenance policy appeared to treat sustainable modes of transport as optional extras that could hibernate from November to March. A rapidly growing body of research convincingly demonstrates that this paradigm is outdated, economically inefficient, and detrimental to public health and environmental goals.

The car-centric approach to winter mobility has made our mobility systems vulnerable. During heavy snowfall, focusing primarily on carriageway maintenance makes the transport system fragile due to its lack of flexibility. Motor vehicle traffic volumes can drop by 16–47% during snowstorms [1], while accident rates spike sharply.

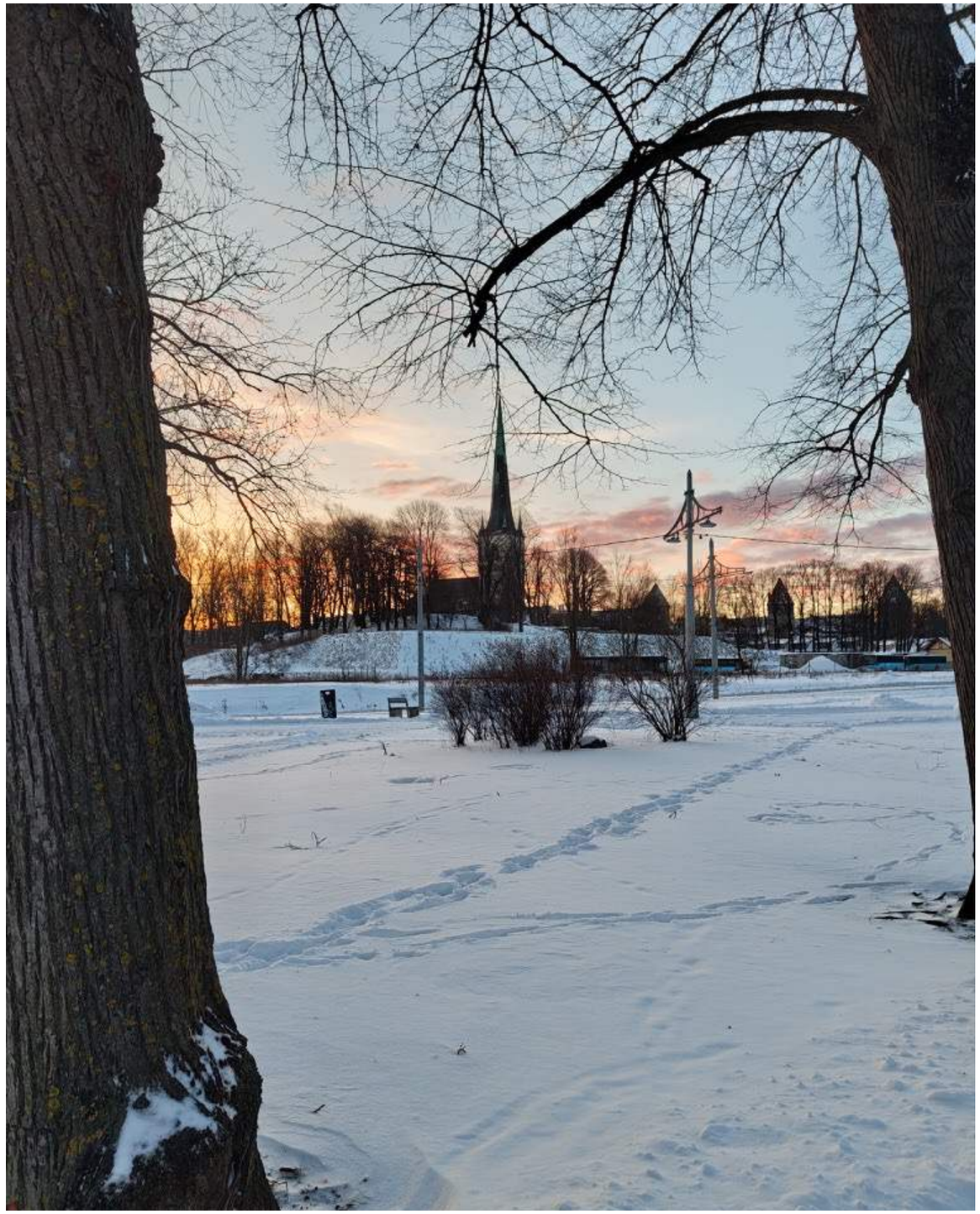
Public transport also suffers, as cold weather and snow cause service delays and trip reductions. The slowdown of the entire system leads to productivity losses, while simultaneously amplifying the seasonal isolation of more vulnerable groups and people with mobility difficulties. However, leading 'winter cities' such as Oulu in Finland - where cycling is a reliable mode of transport even during snow-heavy winters - have proven that this is a political choice, not an inevitability.

Their key to success is not an incomparably different climate; it is a fundamental shift in priorities, underpinned by rapid, consistent, and high-quality winter maintenance of infrastructure that supports active mobility.

The commitment to Year-Round Active Mobility (YRAM) is no longer a niche concept. It has become a central objective in forward-looking regional strategies, including the “Tallinn Sustainable Urban Mobility Plan 2035,” which envisions a network of cycling and pedestrian paths that are “accessible and usable throughout the year” [5].

The participation of the Association of Municipalities of Harju County in the BATS project (a Baltic Sea Region Programme co-funded initiative focused on active mobility solutions) further demonstrates that there is strong interest in promoting walking and cycling even in adverse weather conditions and during periods of low light in Estonia [6].

As this study shows, similar goals have been articulated in several strategy documents. For example, Estonia's Transport and Mobility Development Plan 2021–2035 states that 'the goal of Estonian transport policy is to ensure comfortable, accessible, safe, fast, smart, and sustainable mobility options for residents and businesses in line with objectives set out in EU legislation', and more specifically to increase the share of public transport, cycling, and walking to 55%, and to 60% in urban areas (in 2025 this stands at 38%).



1.1 Year-Round Active Mobility

Environmental sustainability
The environmental arguments for active mobility are now widely recognised. Walking and cycling are zero-emission modes of transport. Every trip made on foot or by bicycle instead of by car directly reduces greenhouse gas emissions, helps mitigate anthropogenic climate change, and improves local air quality by lowering concentrations of pollutants such as nitrogen oxides, particulate matter, and heavy metals in both the atmosphere and the water cycle. Ensuring sustainable and healthy mobility options in winter is also an essential precondition for curbing car dependency and achieving lower levels of emissions and noise pollution.

Economic viability and cost-effectiveness
In addition to the environmental case, there are compelling economic arguments for supporting active mobility, with two key dimensions: the substantial added value generated by action, and the higher societal cost of inaction.
The benefit of action: investments in walking and cycling infrastructure deliver among the highest measurable returns of any public project, generating significant economic benefits. Well-maintained paths that connect people to workplaces and services boost local businesses by increasing footfall and retail turnover [7]. For individuals, active mobility reduces expenditure on fuel, parking, and vehicle maintenance.
The cost of inaction: failing to maintain pavements and cycle paths is not a cost-saving measure — it increases economic costs. The evidence is stark: in neighbouring Finland, slip-and-fall accidents are estimated to cost the state approximately EUR 2.4 billion per year [2]. Crucially, two thirds of these accidents occur when pavements are covered with ice or snow [2]. The average compensation for a single commuting-related fall is approximately EUR 4,000, covering healthcare costs and sick leave [3]. These direct healthcare costs are compounded by indirect costs arising from municipal liability claims [8] and lost productivity — inaccessible paths discourage consumer activity, while delays reduce overall economic output.

Mobility and system resilience
Winter maintenance of routes is not merely a safety issue; it is a central component of mobility strategy. A system dependent solely on the private car is inherently fragile. A severe snowstorm can bring motorised transport to a standstill, paralysing entire regions. A well-maintained active mobility network provides a vital and healthy alternative, offering people a reliable, affordable, and safe means of making essential short- and medium-distance trips — to work, school, or the shops — when cars are gridlocked and buses delayed. Cities such as Edmonton in Canada and Oulu in Finland demonstrate this by prioritising the rapid clearance of the cycle path network, thereby ensuring that a functioning transport option is always available [9, 10].

Human Health and Wellbeing
Among all the impacts of winter maintenance, those affecting public health are among the most significant.

Physical health – Regular, year-round physical activity is one of the cornerstones of preventive health behaviour. It strengthens the immune system, improves cardiovascular health, and substantially reduces the risk of chronic conditions such as type 2 diabetes, stroke, and heart disease. Finnish research compellingly demonstrates that active commuters take an average of 4.5 times fewer sick days per year than their sedentary counterparts [4] — a direct benefit to individuals, employers, and the broader economy. In Estonia, studies indicate that 73.7% of the adult population is physically inactive, with associated care and treatment costs amounting to €24.72 million annually [11].

Mental health – The dark winter months are strongly associated with Seasonal Affective Disorder (SAD) and general winter-related depression. Enabling people to spend time outdoors, remain physically active, and access adequate daylight is one of the most effective countermeasures available. Regular physical activity has been shown to reduce stress, improve mood, and enhance cognitive function — contributing to a happier, healthier, and more productive population [12].

In essence, a snow-covered cycle path or an icy pavement represents a policy failure — one that blocks access to all of the above benefits. It pushes citizens into their cars, undermines public health, costs the economy millions, and erodes the resilience of our entire mobility system.

This study is grounded in the understanding that winter maintenance, alongside investment in physical infrastructure, is one of the key factors in unlocking the full potential of active mobility across Harju County.

References
[1] ResearchGate. (2018). Impact of winter storms on mobility and safety in a highway environment. [Data indicate a 16–47% reduction in traffic volume during winter storms.]
[2] SIRWEC. (2022). Statistical data on slip-and-fall injuries in winter. [Referencing an annual cost of €2.4 billion in Finland and the two-thirds statistic.]
[3] ResearchGate. (2024). Pedestrian winter slip and fall injuries — effectiveness of weather warning services in prevention. [Referencing the Finnish Centre for Occupational Safety (TVK) average cost of €4,000 per injury.]
[4] Finnish Institute for Health and Welfare (THL). (2025). Fewer than one in five working-age adults walk or cycle year-round. [Referencing the Finnish Institute of Occupational Health study finding of 4.5 fewer sick days.]
[5] Central Baltic Project Database. (2020). Sustainable Urban Mobility Strategy for the Tallinn Region 2035 (Tallinn Mobility Plan 2035).
[6] Aalto University. (2024). BATS (Baltic region — Active Travel Solutions — in darkness and all weather conditions).
[7] Zeitgeist Arts. (2023). Making the case — sidewalk snow clearance in Duluth. [Reference to the negative economic impact of uncleared pavements on local businesses.]
[8] LegalMattersCanada. (2024). Clear your sidewalks after snowfall or face liability. [Discussion of municipal and property owner liability in slip-and-fall incidents.]
[9] City of Edmonton. (2025). Winter cycling. [Detailed description of Priority 1 cycle routes cleared within 24 hours.]
[10] Urban Cycling Institute. (2024). Cycling in Oulu — the winter cycling capital. [Detailed description of Oulu's maintenance practices.]
[11] National Institute for Health Development (TAI). (2024). The cost of physical inactivity and excess weight in Estonia.
[12] National Center for Biotechnology Information (NCBI). (2024). Active mobility and mental health: a scoping review towards a healthier world.

1.2 Stakeholder Mapping

LOCAL GOVERNMENT	LOCAL GOVERNMENT EMPLOYEES	OTHER PUBLIC BODIES	CITIZENS	COMPANIES & ORGANISATIONS	MAINTENANCE SERVICE PROVIDERS
• City / municipal council • City / municipal government • District government (Tallinn)	• Road maintenance specialists • Transport engineers, planners • Municipal law and procurement specialists • Communications specialists • Other municipal staff dealing with maintenance topics (e.g. parks service)	• Ministries and subordinate agencies • Educational institutions • Public services (rescue, fire, ambulance) • Voluntary rescue organisations • Public transport organisations and companies • Utility service providers (waste collection) • Neighbouring municipalities • Meteorological service • Parking management organisations • Environmental protection organisations	• Local residents and community representatives and groups • Residential property owners • Street users (active mobility) • Road and car infrastructure users • Organisations representing people with reduced mobility • Other interest groups (e.g. urban quality of life, cyclists, car users, etc.)	• Real estate owners (commercial, industrial) • Local businesses, business parks, creative quarters • Companies operating on rented premises, street businesses, etc. • Street-based services (courier services, postal service) • Parking service providers	• Companies providing maintenance services (incl. service vehicle drivers and maintenance workers) • Local residents providing maintenance services

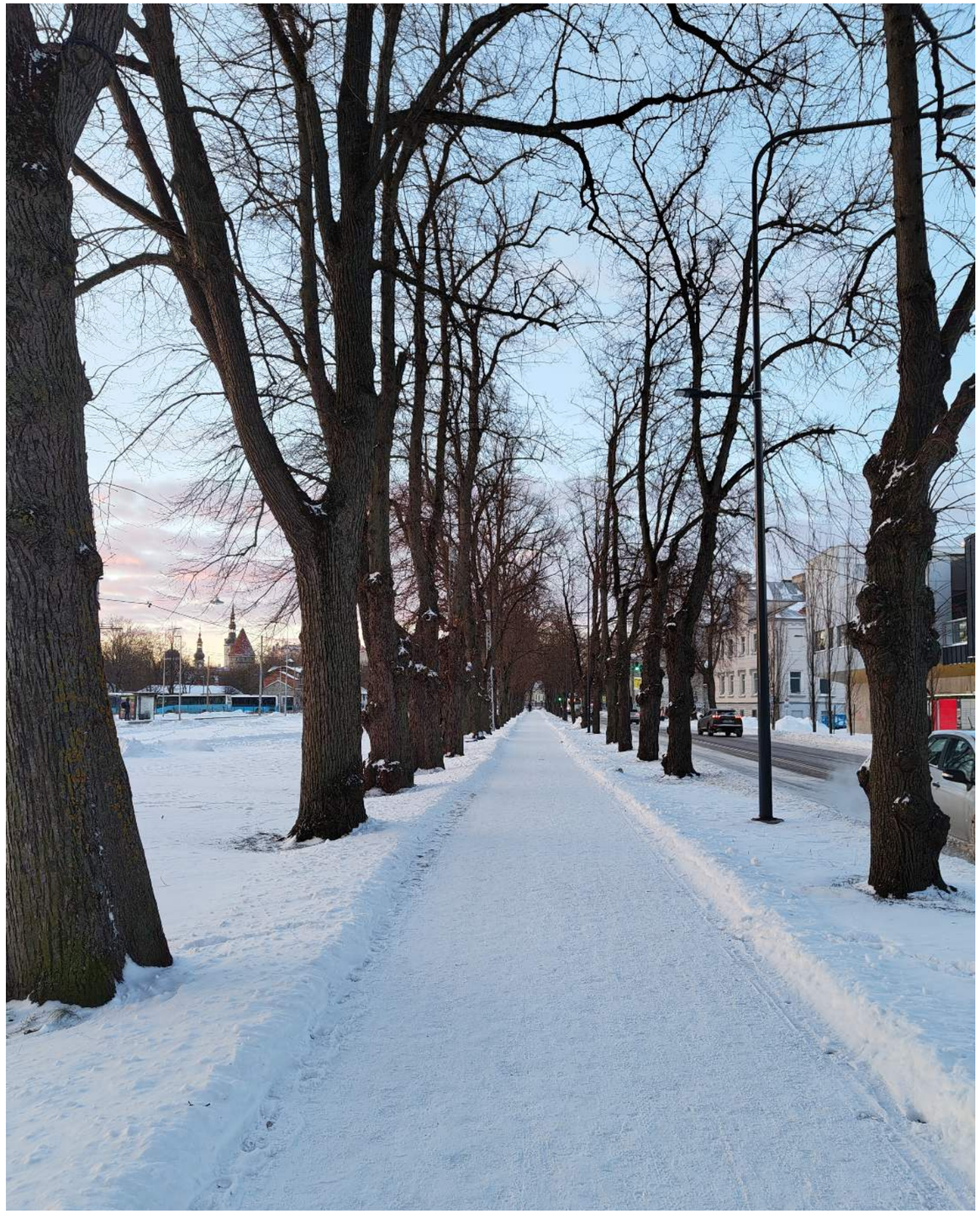
1.3 Legal Framework

The following page presents a schematic overview and key excerpts from the various Estonian laws governing winter maintenance. These are particularly important to read in parallel with the municipal regulations examined in detail in the next sub-chapter, which either tighten national requirements or — as emerges somewhat paradoxically — in some cases relax them.

From the perspective of local governments, the legal foundation is the Local Government Organisation Act, which grants municipalities both the authority and the obligation to address matters of local life — including the maintenance of public space and infrastructure — and to do so in the most favourable manner possible. Winter road maintenance specifically is governed by the Regulation of the Minister of Economic Affairs and Infrastructure on Road Condition Requirements [1], which sets out the minimum condition standards for different road types across seasons (summer and winter), covering both surface quality and overall state. Light traffic routes are classified in the highest condition category, equivalent to Level 4 carriageways.

Those who drafted the legislation and defined the condition levels have had to balance a range of considerations, including the realistic budgetary capacity of Estonian municipalities to meet these standards. Nevertheless, certain requirements raise legitimate questions as to whether they enable the kind of winter maintenance that is consistent with the objectives set out in national mobility strategies. For example, the requirement to leave a 1.2-metre clearance between snow banks is insufficient in urban environments — particularly in densely built areas — if the goal is to increase winter mobility. This clearance must accommodate not only pedestrians with prams or mobility aids, but also cyclists and e-scooter users moving at entirely different speeds. On urban roads shared by cyclists, micro-mobility users, and pedestrians, a minimum clearance of 1.5 metres should be required, so that — for instance — a cargo bike and a pedestrian with a pushchair, or a person using a wheelchair, can pass one another safely.

[1] Regulation of the Minister of Economic Affairs and Infrastructure on Road Condition Requirements (2015).



1.3 Legal Framework

Estonian Road Maintenance Regulatory Framework

Light-traffic road condition requirements — legal basis, standards, and winter maintenance obligations

Local Government Organisation Act (1993)

General principles of local governance (§ 3):

1) Independent decision-making on local matters
2) Guaranteeing rights and freedoms in municipalities
3) Compliance with laws and constitutional obligations
4) Municipal participation in local government
5) Accountability for duties performed
6) Transparency of operations
7) Provision of public services under favourable conditions

Road Condition Requirements Regulation (2015)

Minister of Economic Affairs & Infrastructure — minimum road condition standards by road type, including winter. Annex 10: light-traffic roads.

Paved road (as light-traffic road)

- Cracks max 2.5 cm wide
- Potholes max diameter 5 cm, depth 2.5 cm
- Max permitted unevenness: 5 cm
- Intersection visibility with light-traffic road: 10 m to cut-across
- lane (if terrain/buildings allow)
- Intersection visibility with carriageway: 10 m (if terrain allows)

General winter condition requirements — urban light-traffic roads

- Packed snow or frozen road; surface sufficiently rough, not dangerously slippery
- Clear traffic space (between snow walls) must be full road width;
  if snow is placed on road, minimum width 1.2 m
- Maximum loose snow depth: 6 cm
- Minimum slush or wet-snow depth: 3 cm
- Maintenance cycle for snow/ice removal: 8 h
- Maintenance cycle for general compliance: 12 h

Road owner's winter maintenance obligations

Condition class 1

Class 1 streets and class 4 highways/rural roads — maintained at all times

Condition class 2

Class 3 streets — 6:00–22:00 condition class 2; other times condition class 1 required

Condition class 3

Class 2 streets — 7:00–21:00 condition class 1; other times condition class 1 required

Year-round requirements

Parameter	Paved road	Unpaved road
ROAD SURFACE		
Cracks wider than 2.5 cm	Must not occur	—
Potholes (dia > 5 cm, depth > 2.5 cm)	Must not occur	—
Max permitted unevenness	5 cm	5 cm
VISIBILITY		
Intersection with light-traffic road	Within 10 m, lateral visibility to cut-across lane	
Intersection with carriageway	10 m (paved) / 70 m (unpaved) to cut-across lane	

Winter maintenance requirements

Parameter	Urban roads	Other roads
GENERAL REQUIREMENTS		
Required condition	Packed snow, not slippery	Packed snow, not slippery
Clear traffic space	Full width; min 1.2 m	Full width; min 1.5 m
Surface evenness	Must not endanger traffic	Must not endanger traffic
CRITICAL SNOW / SLUSH THICKNESS		
Max loose snow depth	6 cm	8 cm
Max slush / wet-snow	3 cm	4 cm
MAINTENANCE CYCLE TIMES		
Snow/ice removal	8 h	8 h
General compliance	12 h	12 h

1.3 Legal Framework

Through local regulations and public procurement documents, municipalities establish their own practical winter maintenance requirements, which often diverge from national standards. The following two tables illustrate how various municipalities manage key winter maintenance priorities.

A clear trend emerges from the data: service levels for pedestrian and bicycle paths are consistently lower at the municipal level than the national standard. Consequently, while a state highway passing through a municipality might receive Level 4 (continuous) maintenance, the adjacent active travel paths often suffer from noticeably poorer conditions.

Terminology and Policy Priorities
Terminology also obscures policy priorities across many municipalities. Mobility experts increasingly recommend phasing out the catch-all term “kergliiklustee” (shared-use or light traffic path) [1] in favor of distinct physical and terminological separation between pedestrian sidewalks and dedicated bicycle lanes.

Despite these expert recommendations, local government documents rarely reflect this best practice. Instead, they continue to rely on ambiguous and varied terms such as “kergliiklustee,” “jalgtee” (footpath), and in one instance, “kergtee” (light path).

Furthermore, numerous municipalities fall short of the national clearance requirement. An analysis of municipal documents reveals significant inconsistencies:

- No Minimum Defined: Four municipalities lack any defined minimum width in their available documentation.
- Below National Standard: Seven municipalities require a clearance of only 1.1 meters.
- Meets National Standard: Only two municipalities meet the national standard of 1.2 meters.
- Exceeds National Standard: Only Saku Parish mandates a wider clearance of 1.3 meters.

As demonstrated earlier in this report, heavily trafficked urban corridors should ideally maintain a cleared width of at least 1.5 meters, if not more. However, interviews with municipal officials indicate that stricter standards are enforced in high-priority zones—such as near bus stops, schools, and railway stations—where maintenance crews are explicitly directed to clear wider walkways.

Data Sources
The data presented in this section is compiled from regulations published in the State Gazette (Riigi Teataja), official municipal websites, and public procurement documents.

[1] "Teedeinsener Marek Rannala: kergliiklusteed võiks linnadesse ehitamata jätta" [Transport Engineer Marek Rannala: Shared-Use Paths Should Not Be Built in Cities], Eesti Päevaleht (2021).



Local Regulations – Winter Road Maintenance by Municipality

	Maardu	Paldiski	Raasiku	Rae	Saku	Saue	Tallinn	Viimsi
Use of ash or chlorides for snow and ice control on footpaths, cycle paths or light traffic paths	–	Prohibited (pursuant to Lääne-Harju regulation)	Prohibited: use of ash or chlorides for snow and ice control on footpaths or park paths	Prohibited	Prohibited: use of ash or chlorides for snow and ice control on light traffic paths	Prohibited: use of ash or chlorides for snow and ice control in public spaces	Prohibited	Prohibited
Mandatory clearance width to be left on footpath when piling snow (m)	1.1	1.1 (from Lääne-Harju regulation)	–	–	1.3	1.2	1.2	1.1
Free snow removal on private roads	For apartment owners on private roads on their property (incl. co- owners or persons using the property as actual residence)	Organised jointly with Lääne-Harju municipality. Selectively on certain shared-use roads.	First application based on registration; second application requires at least 1-year registration	Based on at least 1-year registration	Private roads covered by public-use agreements, built to standard, serving ≥5 dwellings with ≥75% registered municipality residents. Also for persons requiring social care.	Private roads of public interest and dispersed settlement roads leading to households used year-round by residents registered in the population register	City does not organise winter maintenance on private roads	Municipality does not organise winter maintenance on private roads
Conditions for private road snow removal	Not specified	Priority: roads used by public transport incl. school buses. Priority areas: settlements, school bus routes, high-use roads. Last: single-household roads.	Work begins within 12 h of blizzard or snowfall ending if fresh snow depth exceeds 15 cm.	Work begins within 24 h of blizzard or snowfall ending. Snow removal does not include ice control.	Priority: highest-traffic roads, then school and childcare parking and access roads, then remaining roads.	Free snow removal begins within 12 h of blizzard or snowfall ending if snow depth exceeds 20 cm on road.	–	–
Road condition levels and other conditions	No relevant info found on municipal website, public order statute, public procurement register or other documents	Work begins when fluffy snow depth exceeds 10 cm, or earlier for wet snow. Public transport roads cleaned first, then other roads. Light traffic road maintenance not separately specified.	13 road sections (light traffic paths, 'soft paths' and squares); most must be cleared by 07:30 or 08:00; priority: school vicinity.	Light traffic paths and footpaths mostly ST 3, with isolated exceptions lower.	Footpath & cycle path condition level: ST 3 on 6 sections, ST 2 elsewhere. Maintenance machinery max 6,000 kg; blade width min 3 m.	4 districts total. Cycle & footpaths: ST 2 – 56.49 km ST 3 – 92.12 km Bike parking: 1,401 m² Manually maintained bus stops: 98	City follows national condition level standards.	Public and public-use footpaths and cycle paths: condition level 3 regardless of surface type in winter.

Local Regulations – Winter Road Maintenance by Municipality

	Anija	Jõelähtme	Keila	Kiili	Kose	Kuusalu	Loksa	Lääne-Harju
Use of ash or chlorides for snow and ice control on footpaths, cycle paths or light traffic paths	Prohibited	Prohibited	Prohibited	Prohibited	Only ash is prohibited on footpaths	Ice control may use sand, fine gravel or treated crushed stone. Only ash is prohibited on footpaths.	Prohibited: use of ash or chlorides for snow and ice control on footpaths or park paths	Prohibited
Mandatory clearance width to be left on footpath when piling snow (m)	1.1	1.1	1.1	–	1.1	–	1.1	1.1
Free snow removal on private roads	Owner or permanent resident of a commercial or production building in the municipality	Max 10x per winter. Requires registration in Jõelähtme and a valid waste collection contract.	–	Based on at least 1-year registration	Year-round for registered residents living in Kose	Permanent residents with population register entry	City offers residents the option to order 'tractor snow removal' at €45/hour	Applicant may be the property owner, co-owner or person using the property as permanent residence
Conditions for private road snow removal	Work begins if snow depth exceeds 10 cm (fluffy snow) or 5 cm (slush/wet snow/salt mix) on roads; in dense settlements: 8 cm fluffy or 4 cm slush. Depth measured between wheel tracks.	Property owner must themselves assess when ploughing is needed and notify the dispatcher.	–	Begins within 12 h of blizzard or snowfall ending if snow depth exceeds 10 cm. Does not include ice control.	Not specified	Not specified	–	Begins together with public road snow removal or within 24 h of completing public road snow removal in the area. Does not include ice control.
Road condition levels and other conditions	ST 3 – total 12 km of roads, car parks, crossings, bus stops, footpaths and light traffic paths. 32 maintained bus stops, ~25 km of light traffic paths, 102 crossings. ST 2 – 37 km roads. ST 1 – internal quarter roads.	ST 3: on streets, light traffic paths, bus stops, car parks and crossings, snow clearance must be completed within 5 h of snowfall onset; ice control within 4 h of icing. Max snow depth: fluffy – 4 cm; wet – 2 cm.	Roads used by school buses, streets, car parks and footpaths/ cycle paths: ST 2. All other roads: ST 1. Difference is in maintenance cycle time. Light traffic paths must be cleared within 4 h.	Work begins when fluffy snow exceeds 10 cm, earlier for wet snow. Public transport roads first, then remaining roads. Streets maintained to ST 2; local roads to ST 1. Snow/slush depth measured from compacted snow surface.	Light traffic path condition level in municipality: 2. Before start of workday, access to public buildings (offices, schools, social facilities) must be ensured for pedestrians and light vehicles by 07:00.	Snow removal on streets follows ST 2 requirements; local roads ST 1. Snow/slush depth measured from compacted surface. All roads must be fully cleared at least 6 h after snowfall/blizzard ends.	No relevant info found on city website, public order statute or procurement register	Work begins when fluffy snow exceeds 10 cm, earlier for wet snow. Public transport roads first, then remaining roads and streets.

1.4 International Benchmarks

The international benchmarking framework—developed for this study and included in the supplementary materials—highlights best practices from cities across Northern Europe and North America for building weather-resilient infrastructure.

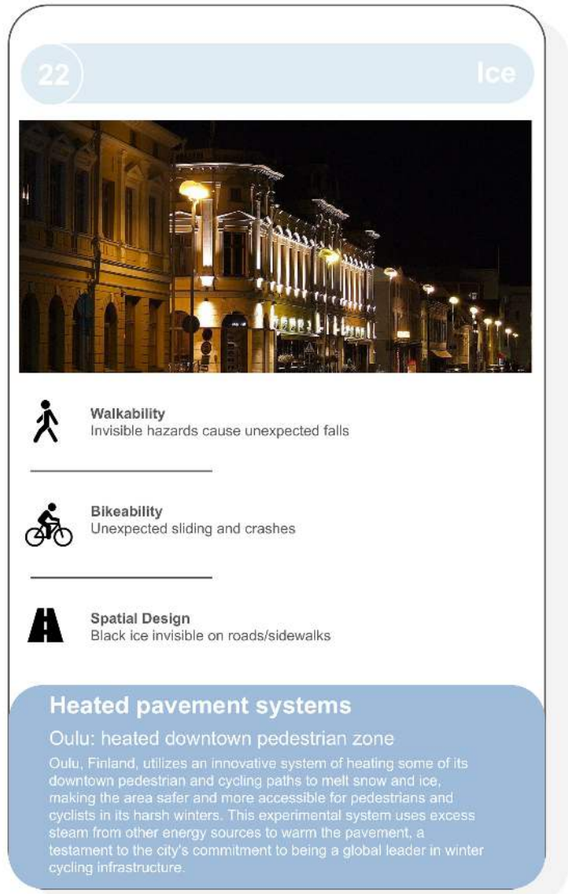
Drawing on over 60 case studies, these cities have demonstrated that the disruptions caused by extreme winter conditions—including severe cold, darkness, ice, sleet, snow, high winds, and freezing rain—can be effectively mitigated. Success relies on a holistic approach that integrates thoughtful urban design, strategic material selection, optimized maintenance protocols, and the deployment of new technologies.

Crucially, this research emphasizes that climate adaptation strategies are transferable. As global weather patterns become increasingly volatile and unpredictable, cities outside of traditional winter zones can proactively adopt and benefit from the established resilience practices of Nordic "winter cities."

To make these findings actionable, the case studies are presented as thematic summary "cards." Each card references specific cities, links to relevant supporting literature, and outlines core mitigation strategies.

The examples are categorized into the following thematic blocks based on the specific climate challenge:

- Wind Chill / Perceived Cold (Külmatunne)
- Extreme Cold Temperatures (Äärmuslikud külmakraadid)
- Black Ice / Glaze (Jäide)
- Freeze-Thaw Cycles (Jäätumise-sula tsüklid)
- Rain and Freezing Rain (Vihm / Jäine vihm)
- Slush and Melting Snow (Lobjakas / sulalumi)





1.4 International Benchmarks

Key Lessons from the Benchmarking Study

• Interconnected Risks: Weather conditions pose a complex, interconnected set of risks to pedestrians and cyclists in public spaces that cannot be addressed in isolation.

• Multi-Layered Integration: Cities that successfully plan for winter or extreme weather do so by integrating solutions across multiple levels: infrastructure, material selection, operational practices, and technology.

• Proactive Over Reactive: The most effective interventions anticipate weather events rather than just responding to them. Examples include heated pavements, smart lighting, strategic drainage design, wind mitigation through landscaping, and strategies designed to ensure thermal comfort.

• Systematic Approaches: Northern cities lead by example through systemic planning. They rely on comprehensive design guidelines, standardized practices, and long-term investments rather than isolated, ad-hoc pilot projects.

Core Conclusions for Policy Makers

• Climate as a Primary Driver: Climate-resilient cities design for year-round comfort and safety, treating local weather conditions as a foundational element of urban planning rather than an afterthought.

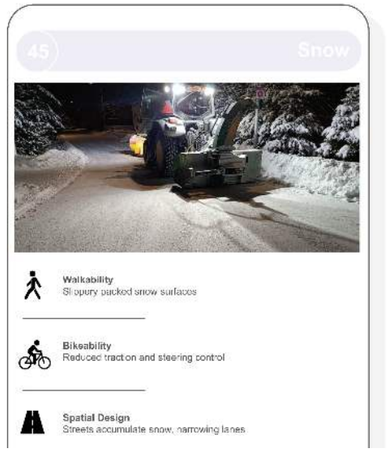
• Micro-Details Matter: Granular design choices significantly impact usability and safety. This includes the strategic placement and design of curbs, expansion joints, tactile paving, handrails, drainage points, and systematic maintenance schedules.

• Technological Integration: Smart technology is becoming a standard baseline. This ranges from IoT-connected road surface sensors to GPS-tracked maintenance fleets and adaptive lighting systems.

• Operations Equal Design: Maintenance is just as critical as the initial design. The best-performing cities combine superior physical infrastructure with operational excellence.

• Context is Crucial: There is no one-size-fits-all solution. Successful climate adaptation strategies must be tailored to the specific local climate, municipal governance capacity, and cultural expectations of the community.

BENCHMARKING CASE STUDIES



Prioritizing Snow Clearance on Active Travel Paths

Strategic reprioritization of winter maintenance yields measurable results. As highlighted in the Estonian Cycling Strategy (Eesti Rattastrateegia 2040), Copenhagen’s policy of prioritizing snow clearance on bicycle paths successfully maintains winter cycling volumes at 75% of their summer peak. Similarly, when Stockholm restructured its maintenance priorities to clear pedestrian and cycling infrastructure first, the city saw a 30–40% increase in winter cycling trips.



Designing for Thermal Comfort in Public Spaces

Copenhagen’s approach to thermal comfort and Stockholm’s microclimate management serve as highly relevant models for Estonia. Given Estonia’s cold winters—with average temperatures ranging from -3 °C to -10 °C—and Tallinn’s ongoing investments in public space and maintenance quality, adopting these strategies could be highly beneficial. Copenhagen integrates green infrastructure and urban morphology to actively reduce the perceived cold (wind chill) in public spaces. Key design components include using landscaping and architectural elements to shield pedestrians and cyclists from wind, snow, and rain.



Heated Pavement and Transit Infrastructure

While Estonia lacks the extensive geothermal resources of a city like Reykjavík, it possesses its own robust energy infrastructure that can be leveraged for similar results. Between 2024 and 2025, Tallinn is rolling out 1,200 new bus waiting pavilions. Concurrently, Estonia relies heavily on district heating, which accounts for over 60% of the country's heat production across approximately 200 localized networks. This extensive district heating infrastructure could potentially be tapped to power heated bus stops and keep high-traffic pedestrian zones free of ice and snow, successfully adapting Reykjavík's geothermal model to the Estonian context.

2. Interviews and analysis



2.1 Interview Methodology

The Implementation Gap: Policy vs. Practical Reality

The preceding analysis of current legislation established a baseline understanding of street maintenance policies and procedures. It outlined the institutional and organizational framework—essentially, how political will is theoretically translated into physical reality through laws and regulations.

While this overview suggests that Estonia has a robust, multi-layered street maintenance system on paper—complete with national and local winter maintenance protocols and comprehensive contractor requirements—the practical reality tells a different story. Consistently ensuring safe, accessible, and attractive pedestrian and bicycle paths during the winter season remains a persistent challenge for most municipalities.

Beyond a certain regulatory apathy evident in the legislation, there is a critical systemic gap: established policies and allocated resources frequently fail to deliver the expected on-the-ground results, as pedestrians and cyclists experience firsthand every snowy winter.

Identifying the Bottlenecks

The root cause does not appear to be the absence of a system. Rather, the issues stem from the complexities of coordination, execution, and accountability across multiple stakeholders, compounded significantly by the underlying quality of the physical infrastructure itself.

To look beyond the regulatory perspective and identify the root causes of these operational bottlenecks, it was necessary to map the situation through qualitative interviews. Our primary objective was to understand why maintenance issues stubbornly persist despite the existence of a comprehensive system designed to prevent them.

Interview Methodology and Rationale

To capture the true operational reality of winter maintenance, we conducted a series of structured interviews with key stakeholders:

Municipal Officials: Staff members responsible for overseeing the daily operation of the maintenance system and actively solving on-the-ground problems.

Subject Matter Experts: Professionals working to improve the system through technological innovation, as well as those driving strategic shifts in societal and governmental attitudes through education and advocacy.

The interviews were structured around key thematic areas. To ensure thorough and well-considered responses, participants were provided with the questions in advance.

Interview Participants

We engaged a diverse group of urban planning and maintenance experts, as well as municipal specialists representing various administrative levels and functional sectors (including transport, infrastructure, and environmental services).

Representatives from the following organizations participated in the qualitative interviews:

Estonian Transport Administration (Transpordiamet)
AS Teede Tehnokeskus (Infrastructure Engineering Center)
City of Tallinn: Representatives from the City Center District Administration and the Environment and Public Works Department
City of Keila
Kiili Municipality
Viimsi Municipality
Anija Municipality
Jõelähtme Municipality
Lääne-Harju Municipality
Saku Municipality

Key Findings from the Interviews

The discussions revealed a clear split between universal, systemic issues experienced by all, and highly localized challenges dictated by geography and density.

Several recurring pain points emerged across nearly all interviewed municipalities, regardless of size or location. These include:
Concerns regarding the adequacy and capacity of contractors' equipment.

Difficulties in accurately calculating and forecasting maintenance workloads.

High administrative burdens associated with contract management.

The interviews also highlighted the stark contrast in problems and opportunities across Harju County. Sparsely populated municipalities like Anija and Jõelähtme face fundamentally different logistical realities compared to the City of Tallinn, where the primary friction stems from the sheer complexity of a dense, multi-layered urban system.

Despite their differences, a unifying challenge for all municipalities is managing the "seams" of the network. Disputes and gaps in service frequently occur at the borders between different administrative units, or where municipal property meets private land.

Monitoring contractor performance to ensure high-quality maintenance and the responsible use of public funds is a universal priority. On a positive note, all interviewed municipalities now mandate GPS monitoring of contractor activities and guarantee a 24/7 dispatcher service to maintain operational oversight.

Ultimately, the quality of the underlying infrastructure is a universal prerequisite for successful winter maintenance and a pleasant user experience. The interviews confirmed that while municipal needs and financial capacities vary drastically, the existing national requirements and design standards are not fully up-to-date or sufficient to support modern, high-quality urban spaces.

2.2 Harju County Municipal Practices

Issues and Solutions – General System

Domain	Problem	Mitigation Method #1	Mitigation Method #2	Mitigation Method #3
GENERAL SYSTEM	Complex system with too many responsible parties and actors — for example, Tallinn has 4 parties that separately hire snow removal (KeKo, Kadrioru parks, district governments, apartment associations), further divided by mobility type (road, cycle path, footpath), each of which may have different condition standards.	Several municipalities, e.g. Jõelähtme and Viimsi, have simplified the system by keeping the number of service-providing parties as low as possible. In some cases, the company handling snow removal also performs landscaping work.	Tallinn has started addressing the complexity problem by trying to reduce the number of different parties in work areas when organising new procurements.	
	National maintenance standards for cycle paths and footpaths are too universal and, in many views, not sufficiently detailed for more sensitive and high-use areas.			
	Road maintenance is costly, especially in dispersed settlement areas for private households and apartment associations.	Road owners have in certain cases transferred road ownership to municipalities along with the maintenance obligation.	Many municipalities clear snow from roads on private land under certain conditions.	Tallinn brought costs under control after a critical review and has gradually begun removing snow from footpaths on private land as well, which has started to improve conditions for cyclists and pedestrians.
	Several Harju municipalities have seen positive population growth in the past decade, enabling more investment in infrastructure and its upkeep.			
	Tightening of national requirements in any area has generally not been accompanied by a corresponding increase in support funding.			
	There is a lack of longer-term vision and political ambition to create a unified system and adopt a common methodology and information-exchange technology.			
	At the boundaries between work areas of municipalities and various service providers, snow ridges form or snow is pushed onto neighbouring work areas.	Generally, municipalities have resolved this through communication and cooperation, but this requires greater coordination and does not prevent disrupted user experience for several hours.	Many municipalities have established stricter rules in sensitive locations such as around schools and transport hubs.	
	Those who violate maintenance requirements are subject to penalty fines.			
	Saku has established a mandatory minimum clearance width wider than the national standard (1.2 m) that must be left on footpaths during snow removal.			

2.2 Harju County Municipal Practices

Issues and Solutions – Data / Analysis / Communication & Legal Framework / Budget

Domain	Problem	Mitigation Method #1	Mitigation Method #2	Mitigation Method #3
DATA / ANALYSIS / COMMUNI- CATION	Citizen feedback places a heavy burden on local government staff, leading to burnout and deteriorating services.	Most municipalities have started hiring 24/7 telephone answering services, or this is procured together with the maintenance service tender.		
	Lack of foresight: the service provider delays or fails to respond in time, and snow accumulation creates a chain reaction that later requires more expensive machinery.	Municipalities verify the machinery capacity of tender participants, and the contractor must demonstrate the ability to carry out the required volume of work.	Several municipalities (e.g. Viimsi, Tallinn) are increasingly piloting sustainable stormwater solutions to enable local snow storage.	Tallinn is designing a spatial experiment for a snow-melt landscape solution in the city centre as part of the EU Urbreath project.
	Situational awareness is limited, relying only on visual assessment or user feedback (e.g. angry phone calls).	Many municipalities invest in local storage. Tallinn has given political approval to use parking spaces in some locations for snow storage, to keep footpaths and cycle paths clear.	Viimsi: investment in web-based situational awareness development that provides residents with information on maintenance vehicle locations, recently completed work trajectories, and accurate road condition data.	Transport Board: live-feed cameras on main roads; Anija municipality measures snow depth in Kehra using a ruler placed in camera view.
	Information on roads — especially footpaths and cycle paths — is outdated or of low/uneven quality.	Roads Technology Centre: some municipalities have made regular data updates a priority and update GIS data annually.	Roads Technology Centre: pilot projects in Finland aimed at creating good situational awareness for pedestrians and cyclists.	
LEGAL FRAMEWORK / BUDGET	Financial difficulties for service providers during low-snow winters.	Anija: symbolic maintenance fee for low-snow periods.	Viimsi, Jõelähtme and others: 4–5-year contract agreements are made with the expectation that winters with varying conditions will occur during the period, ultimately creating a cost-benefit balance from both the buyer's and provider's perspective.	
	Complex land and road ownership relations create a bureaucratically costly system.	Jõelähtme, Kiili, Saku: the municipality maintains most private roads where at least one person is registered as a resident.		
	The legal framework for organising tenders is rigid and leaves little flexibility for greater citizen involvement in carrying out maintenance work.	Jõelähtme: cross-use of equipment — in some areas, citizens who own ATVs or SUVs provide the service.	Anija: cross-use of equipment — two farmers cooperate with the tender-winning company, using their own machinery.	Saku: service providers can participate with the same equipment in both local and Transport Board tenders. This may create a new problem during heavy snowfall periods, as national roads take priority in that case.
	Snow removal and transport is difficult to measure (and costly).			

2.2 Harju County Municipal Practices

Issues and Solutions – Equipment / Monitoring & Spatial Design

Domain	Problem	Mitigation Method #1	Mitigation Method #2	Mitigation Method #3
EQUIPMENT / MONITORING	Equipment is expensive, especially for municipalities with low population density and a smaller tax revenue base, making it difficult to achieve a balance between investment and income.	Anija: cross-use of agricultural equipment during the off-season for primary work.	Jõelähtme: citizens use their own equipment (ATVs, SUVs) to clear snow on certain sections.	Saku: service providers can participate with the same equipment in both local and Transport Board tenders. This may create a new problem during heavy snowfall, as national roads take priority in that case.
	Service providers report more kilometres as work volume than they actually cover.	All interviewed municipalities: GPS tracking is now mandatory for maintenance vehicles.		
	The same equipment is registered and used in different regions, causing shortages during heavy snowfall.	Tallinn: different districts simultaneously organise equipment roll-call days to verify service providers.		
	Companies in municipalities with smaller budgets struggle to maintain roads to higher standards.	Leaving a thin layer of snow on less-used roads (which is later roughened to prevent icing).		
	Service providers do not fulfil their obligations on time or submit inaccurate data.	Salt use is permitted in certain areas (generally not in pedestrian zones).	Most municipalities apply penalties for violations.	
SPATIAL DESIGN	Poor spatial planning of streets and residential areas that does not allow for snow storage.	Many municipalities (e.g. Viimsi, Tallinn) are increasingly piloting sustainable stormwater solutions that are also suitable for snow storage.	Tallinn is designing a spatial experiment for a snow-melt landscape solution in the city centre as part of the EU Urbreath project.	
	Projects are not properly audited — it has happened that builders follow old practices by placing lighting and traffic sign posts on footpaths and cycle paths, which hinders both movement and snow clearing.	Both Tallinn and the Transport Board have, following public (or internal institutional) criticism, required builders to correct errors on several projects.	Most municipalities/local governments supervise projects and require proper design solutions, including a green strip between the road and footpath (where possible).	
	Snow removal and transport is costly and there is insufficient space in the city to store large volumes.	Jõelähtme: in some locations where redesign is not possible or too costly, and existing equipment allows clearing pedestrian paths, the municipality has an agreement with locals to use private equipment (ATVs).		

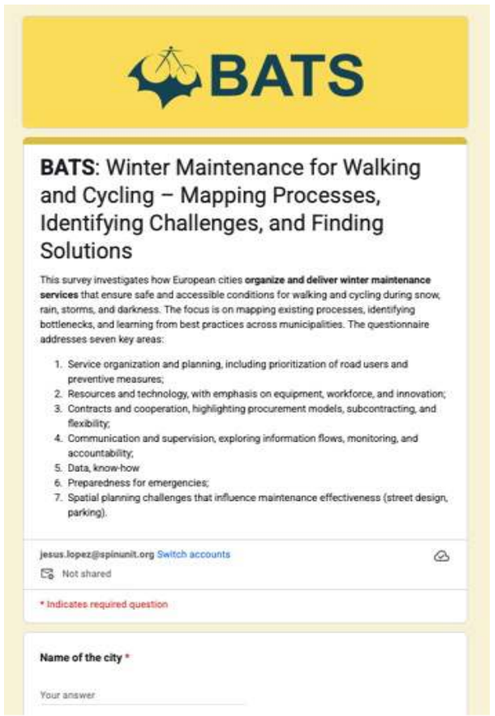
2.3 Comparative Best Practices

International Survey Insights
To establish a baseline for comparing international practices, a comprehensive 41-question survey was distributed to partner organizations within the BATS project. We received detailed responses from four key stakeholders representing three different countries.

The responses highlighted several critical pain points, which can be grouped into two primary categories: systemic knowledge gaps and operational service bottlenecks.

Knowledge and Communication Bottlenecks
- There are significant deficiencies in cross-municipal communication, standardized reporting, and the strategic documentation of past operational experiences.
- In practice, winter maintenance priorities directly contradict the established hierarchy of sustainable urban mobility. Resources are disproportionately allocated to car traffic first, followed by public transport and cycling paths, leaving pedestrians as the lowest priority.

Service and Operational Bottlenecks
- A reliance on old or inadequate technology limits the efficiency and quality of maintenance work.
- The financial penalties for breaching service agreements are currently too low. Consequently, it remains financially "affordable" for contractors to underperform rather than invest in meeting the required standards.
- Rigid winter maintenance contracts restrict agility, severely hindering the ability to deliver adequate services during unexpected extreme weather events or peak demand periods.


BATS

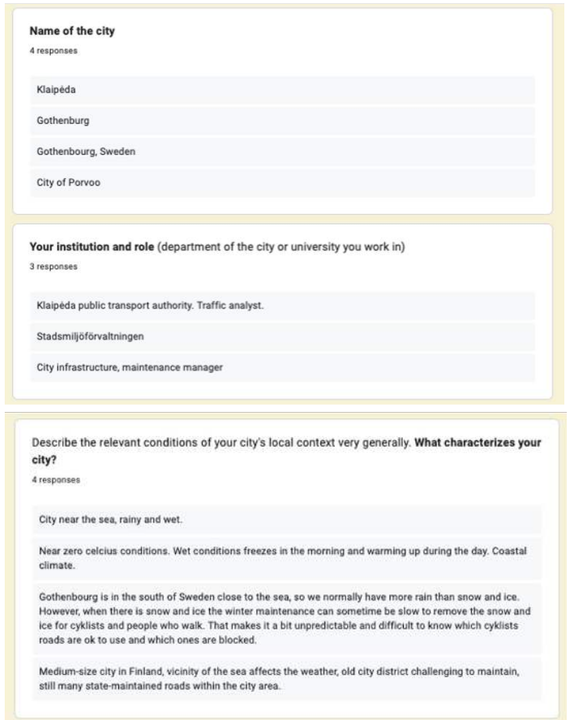
BATS: Winter Maintenance for Walking and Cycling – Mapping Processes, Identifying Challenges, and Finding Solutions

This survey investigates how European cities **organize and deliver winter maintenance services** that ensure safe and accessible conditions for walking and cycling during snow, rain, storms, and darkness. The focus is on mapping existing processes, identifying bottlenecks, and learning from best practices across municipalities. The questionnaire addresses seven key areas:

1. Service organization and planning, including prioritization of road users and preventive measures;
2. Resources and technology, with emphasis on equipment, workforce, and innovation;
3. Contracts and cooperation, highlighting procurement models, subcontracting, and flexibility;
4. Communication and supervision, exploring information flows, monitoring, and accountability;
5. Data, know-how
6. Preparedness for emergencies;
7. Spatial planning challenges that influence maintenance effectiveness (street design, parking).

jesus.lopez@spiniunit.org Switch accounts
Not shared
* Indicates required question

Name of the city *
Your answer

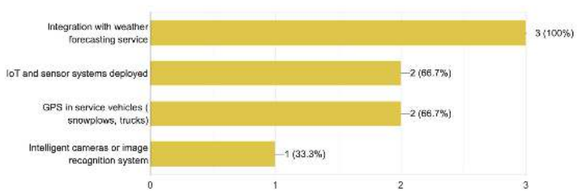

Name of the city
4 responses
Klaipėda
Gothenburg
Gothenbourg, Sweden
City of Porvoo

Your institution and role (department of the city or university you work in)
3 responses
Klaipėda public transport authority. Traffic analyst.
Stadsmiljöförvaltningen
City infrastructure, maintenance manager

Describe the relevant conditions of your city's local context very generally. **What characterizes your city?**
4 responses
City near the sea, rainy and wet.
Near zero celcius conditions. Wet conditions freezes in the morning and warming up during the day. Coastal climate.
Gothenbourg is in the south of Sweden close to the sea, so we normally have more rain than snow and ice. However, when there is snow and ice the winter maintenance can sometime be slow to remove the snow and ice for cyklists and people who walk. That makes it a bit unpredictable and difficult to know which cyklists roads are ok to use and which ones are blocked.
Medium-size city in Finland, vicinity of the sea affects the weather, old city district challenging to maintain, still many state-maintained roads within the city area.

What opportunities to exchange experiences or **learn from other municipalities** facing similar challenges is your city benefiting from?
2 responses
Meetings and sometimes visits to discuss common problems.
National conferences and seminars, personal networks

How is **knowledge from past winters** (successes and failures) documented and used to improve planning?
2 responses
Meetings with contractors.
Failures are reflected in order to improve the action, no regular survey or other measure of satisfaction

Do you use smart city applications or real-time data (e.g. sensors, GPS on vehicles, weather data integration) to guide and monitor services (e.g. snow removal or street clearance)?
3 responses


Best Practices Identified

Smart City Integration: Municipalities are successfully deploying smart city solutions and advanced monitoring technologies to assess road and path conditions in real time.

Actionable Citizen Feedback: Residents are empowered to report issues through multiple accessible channels. Crucially, this crowdsourced data is not just collected, but actively used to adjust and optimize daily service delivery.

Diversified Procurement Models: To combat the rigidity of traditional maintenance agreements, at least one municipality has adopted a mix of different service contracts and procurement types simultaneously. This diversified approach significantly increases the overall agility of the system, allowing for a better response to unpredictable weather events.

2.3 Comparative Best Practices



INTERACTIVE SYSTEM MAPPING: THE "STAKEHOLDER-ELEMENT" WORKSHOP

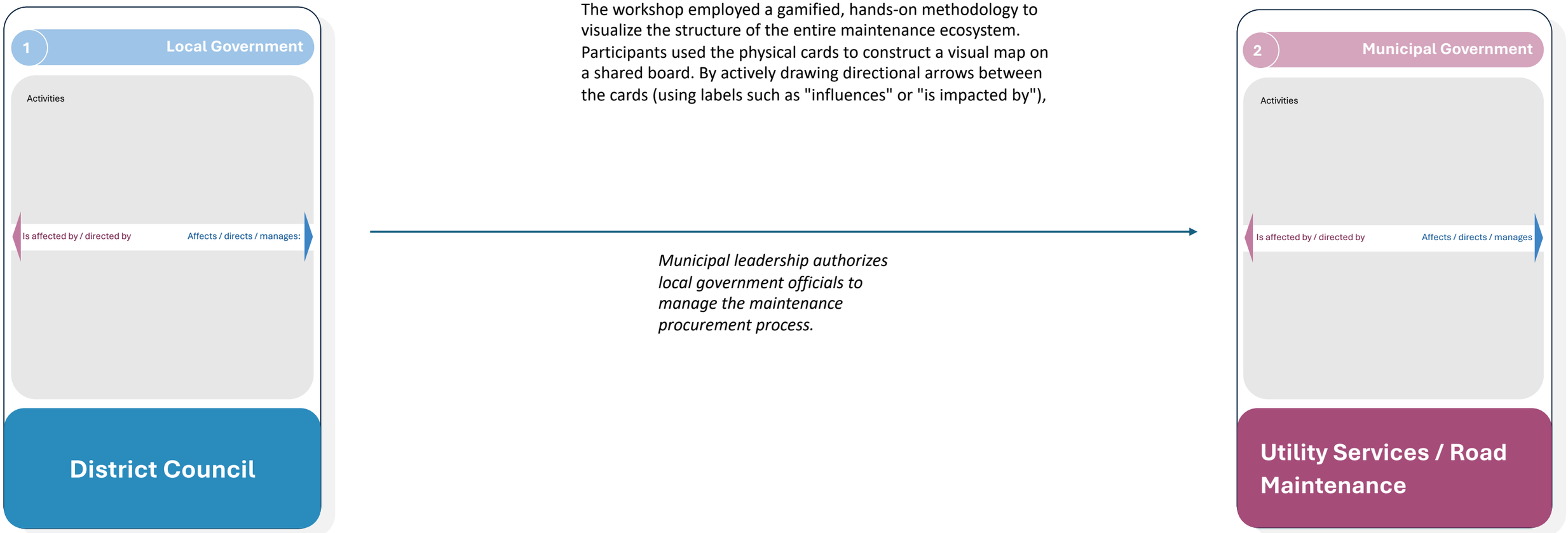
To facilitate the project's interactive workshop, we developed a set of "Stakeholder-Element" cards. These tools were directly informed by our qualitative stakeholder interviews, capturing the maintenance processes and critical bottlenecks exactly as they are experienced by the people operating within the system.

Defining Systemic Relationships
We translated these qualitative insights into a framework designed to map all the actors involved and their complex interconnections. To ensure analytical precision, every relationship was defined bidirectionally (for example, mapping both "A hires B" and "B is contracted by A"). This two-way categorization clearly highlights the directionality of power, responsibility, and operational flow within the network.

A Gamified, Collaborative Approach
The workshop employed a gamified, hands-on methodology to visualize the structure of the entire maintenance ecosystem. Participants used the physical cards to construct a visual map on a shared board. By actively drawing directional arrows between the cards (using labels such as "influences" or "is impacted by"), they defined the exact nature of each systemic link.

Crucially, this mapping exercise was not an individual task. It served as a catalyst for collective debate and negotiation among stakeholders from diverse professional backgrounds. Through this collaborative, critical, and analytical process, participants co-created a shared, mutual understanding of how the system actually operates in practice.

The Outcome: An Unbiased System Map
The ultimate result of this methodology is a comprehensive, tangible diagram that maps all identified stakeholders and their functional ties. This provides a unified, objective, and highly transparent overview of the stakeholder network and the underlying operational logic that drives—or hinders—effective street maintenance.



2.4 System Complexity

Winter maintenance operates within a complex systemic framework that varies across municipalities. The accompanying diagram illustrates the overarching operational logic of this system, mapping the various influencing factors, the stakeholders involved, and their interrelationships. Potential operational bottlenecks are highlighted in red.

The Fragmented Landscape of Tallinn

The most complex and fragmented situation is found in Tallinn, where the responsibility for commissioning maintenance work is divided among four distinct entities:

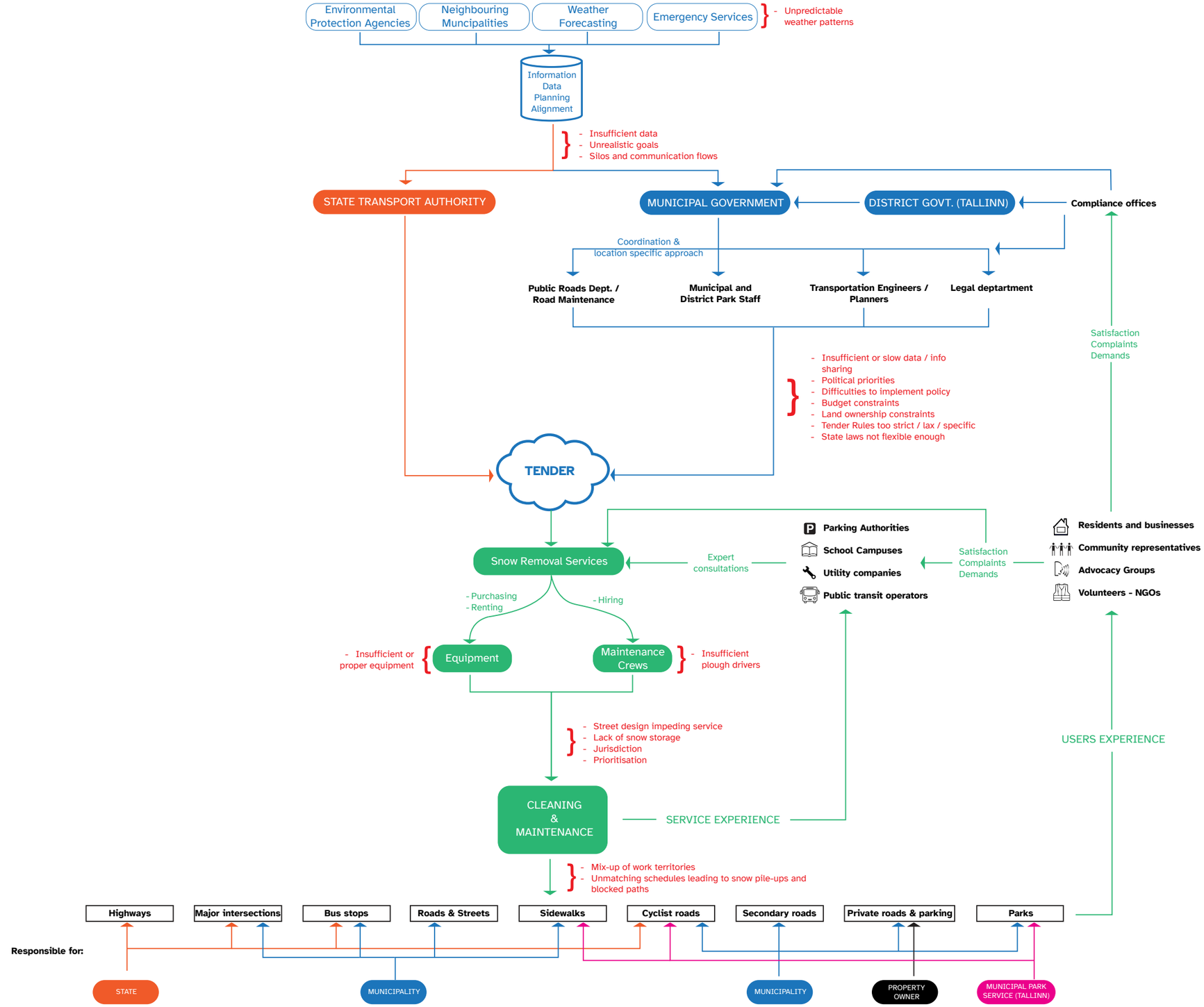
The Environment and Public Works Department

District Administrations

Kadriorg Park

Local Housing Associations (korteriühistud)

Each of these parties may independently contract different service providers. Furthermore, the required maintenance standards vary across their respective jurisdictions, resulting in a highly intricate and patchwork system (see pages 23–24).



2.5 Case Studies

The diagrams on the following pages illustrate the operational reality in Tallinn across two highly problematic locations. As noted previously, winter maintenance responsibilities in the capital are divided among four distinct entities:

- The Environment and Public Works Department (KeKo)
- District Administrations
- Local Housing Associations: These entities typically hire private contractors to clear their respective roads and parking lots, or often manage the snow clearance themselves.
- Kadriorg Park: Manages snow clearance across various city green spaces using its own equipment.

The primary challenge in this highly compartmentalized system is the inability to guarantee continuous, unobstructed routes for all mobility groups.

Because adjacent sections of the transport network are maintained at varying times by different entities, contractors frequently violate regulations by pushing snowbanks directly across pedestrian and active travel paths. This issue persists even when adjacent sidewalks and roadways are managed by the same contractor. While a single contractor should theoretically ensure smoother communication and coordinated workflows, snowbanks still form because the company deploys its roadway and sidewalk machines on completely different schedules.

Interviews with municipal specialists indicate that these operational failures are most severe during the first snowfalls of the season and when onboarding new contractors. While performance generally improves as the season progresses due to warnings and financial penalties, the damage is often already done. For vulnerable user groups, encountering just a few severe disruptions early in the winter is enough to force them to stay home or abandon active mobility altogether for the rest of the season.

Key Observations and Policy Implications

Complexity vs. Efficiency: While denser urban environments naturally require more complex management systems, Tallinn's current model raises a critical question: should the city seek solutions that drastically reduce the number of independent parties responsible for adjacent maintenance zones?

Regulatory Failure: Although the law strictly prohibits contractors from pushing snow into another jurisdiction's maintenance area, this remains a widespread and systemic practice in reality.

The Case for Streamlining: Transitioning to a simpler, more consolidated maintenance system would yield significant, cross-sector benefits:

For the City: A massive reduction in administrative and contract-management burdens.

For the Public: A safer, more reliable winter environment with far fewer snowbanks and mobility disruptions.

For Contractors: A more predictable operational environment resulting in fewer financial penalties and fines.



2.5 Case Studies

The Complexity of Winter Maintenance Jurisdictions in Tallinn:

Fragmented Contracting
Multiple distinct entities are involved, each independently hiring different contractors for their specific areas of responsibility.

Varying Private Capabilities
Private landowners and housing associations possess highly inconsistent operational and financial capacities to handle effective snow clearance.

Vulnerable Border Zones
The physical "seams" where different maintenance jurisdictions meet pose the highest risk for the formation of obstructive snowbanks and piles, severely disrupting mobility.



Footpath maintenance: Tänavapuhastuse AS
(Condition level 3)

Road maintenance: Tänavapuhastuse AS
(Condition level 4)

Footpath maintenance: Kadrioru park

Footpath & yard maintenance:
Apartment associations, private landowners

Road maintenance: Kesklinna valitsus

Risk of snow ridges from overlapping
work territory boundaries

2.5 Case Studies

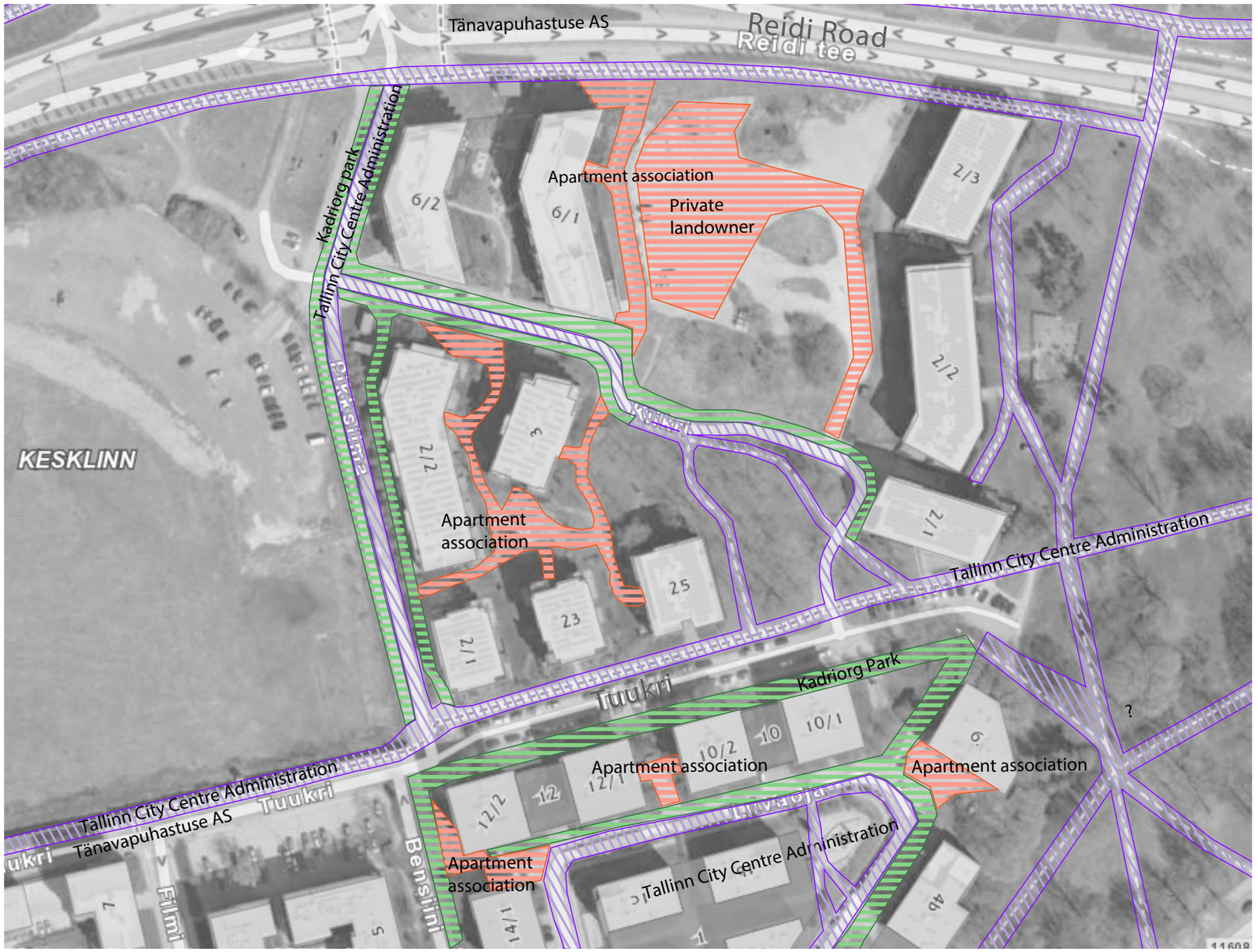
The Complexity of Winter Maintenance Jurisdictions in Tallinn:

Fragmented Contracting: In this scenario, four distinct entities are involved, each independently hiring their own contractors for their specific areas of responsibility.

Varying Private Capabilities: Private landowners and housing associations possess highly inconsistent operational and financial capacities to handle effective snow clearance.

Vulnerable Border Zones: The physical "seams" where different maintenance jurisdictions meet present the highest risk for the accumulation of obstructive snowbanks and piles.

Uncoordinated Schedules: The deployment schedules of maintenance crews clearing adjacent but distinct transport corridors (e.g., roads vs. sidewalks) are not synchronized. Consequently, snow plowed from the roadways can completely block pedestrian and bicycle paths for several hours before being addressed by the appropriate crew.



Footpath maintenance: Tänavapuhastuse AS
(Condition level 3)

Road maintenance: Tänavapuhastuse AS
(Condition level 4)

Footpath maintenance: Kadrioru park

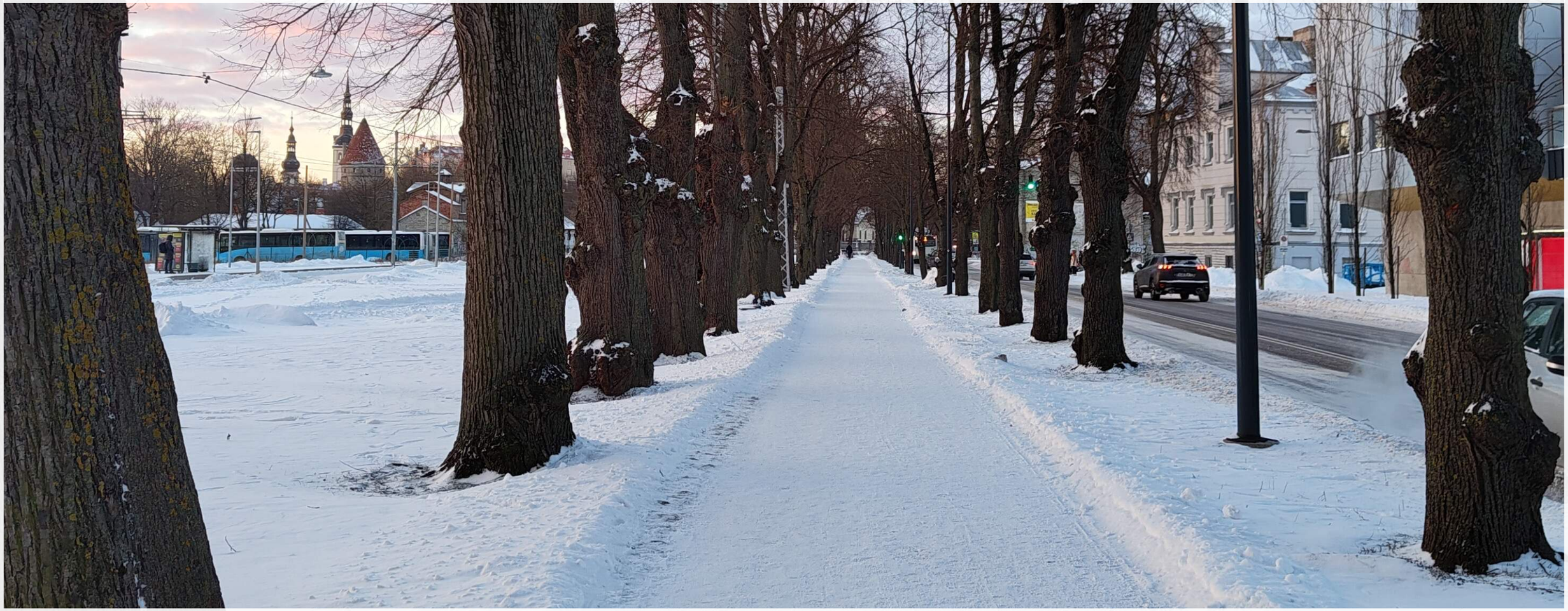
Footpath & yard maintenance:
Apartment associations, private landowners

Road maintenance: Kesklinna valitsus

Risk of snow ridges from overlapping
work territory boundaries



3. Conclusions



3.1 Recommendations for the Future

The Path Forward: Bridging the Gap Between Policy and Reality
As outlined in the preceding sections, current winter maintenance practices and policies fall short of both national strategic objectives and the expectations of the public.

However, this report demonstrates that significant progress can be achieved by optimizing the current system. Many of these solutions require little to no additional financial outlay. These low-cost, high-impact interventions include:

- Reducing systemic and administrative complexity.
- Enhancing cross-border and inter-agency collaboration.
- Strategically revising public procurement terms and contractor requirements.

While systemic optimization is crucial, the broader targets set forth in national strategy documents and urban development plans cannot be fully realized through efficiency alone. Strategic financial investment is required to upgrade physical infrastructure and guarantee its safety and usability year-round.

Furthermore, a fundamental prerequisite for long-term success is a cultural shift in mobility attitudes. This shift must occur at both the individual citizen level and the municipal leadership level. For this to happen, it is critical that both national legislation and local government priorities explicitly align with—and actively enforce—these sustainable mobility goals.



Photo: Pekka Tahkola

3.1 Recommendations for the Future

Modernizing Policy Frameworks

- Strategic Alignment: Synchronize local winter maintenance priorities with the overarching objectives established in national frameworks, specifically the Transport and Mobility Master Plan 2021–2035 and the Estonian Cycling Strategy 2040.
- Public Accountability: Ensure that operational priorities are realigned to reflect the actual mobility expectations and needs of the citizenry.
- Driving a Paradigm Shift: Foster a fundamental cultural shift that champions sustainable, healthy, and year-round active mobility. Cities like Oulu (Finland) and Copenhagen (Denmark) serve as prime international benchmarks for seamlessly integrating winter cycling with high-quality maintenance practices.

CYCLE STRATEGY 2040

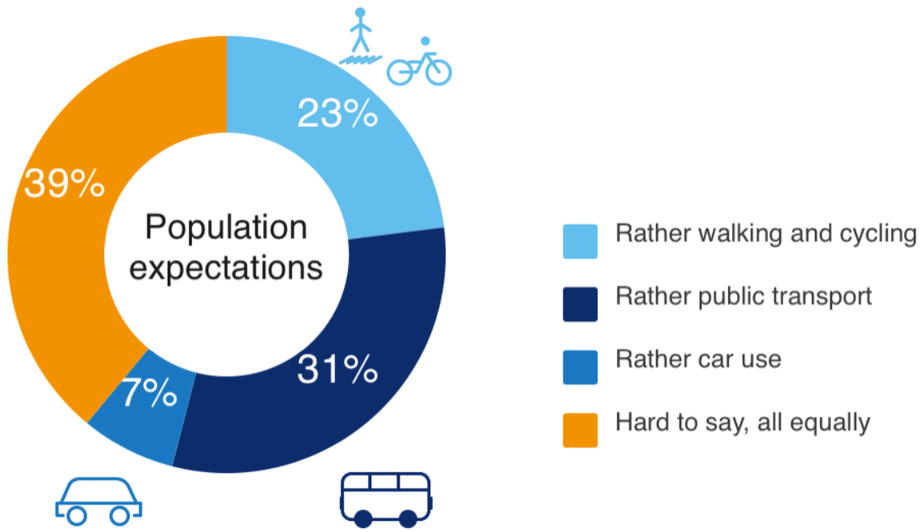
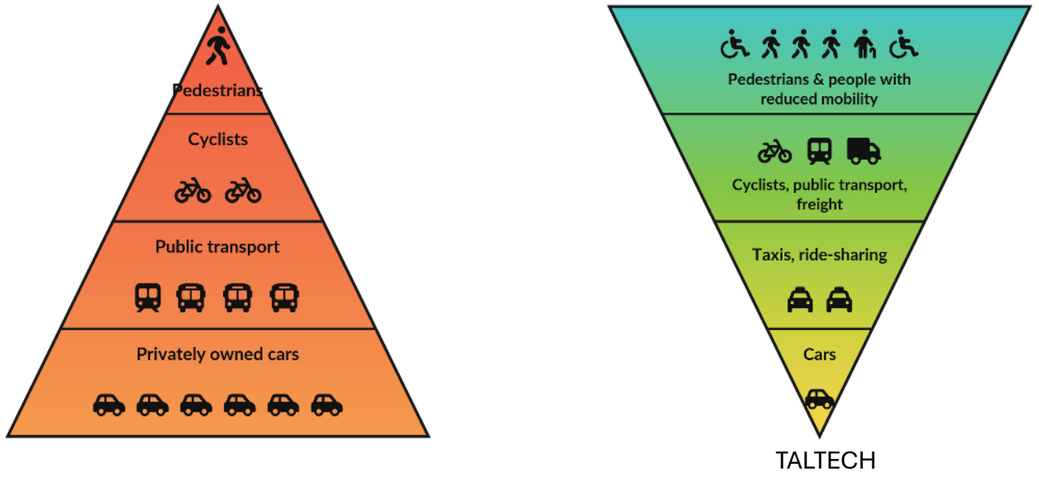


Figure 10. Population expectations for the state and local governments to promote different transport modes.
Source: EELU 2021

Implementing the Mobility Pyramid

Modern Prioritization: Future maintenance planning must embrace the modern urban planning concept of the "Mobility Pyramid." This framework dictates a strict hierarchy of service: pedestrians hold the highest priority, followed by cyclists, public transit, and finally, the essential services necessary for societal functioning (such as freight and logistics).

Universal Design and Empathy: Policy must be rooted in the principles of universality and empathy. Every member of society is a pedestrian at some point in their daily journey. Crucially, pedestrians and cyclists are inherently the most vulnerable user groups and are the most profoundly impacted by the quality of winter maintenance.



3.1 Recommendations for the Future

Collaboration

- Foster closer collaboration between local governments to actively share operational experiences and best practices.
- Initiate joint pilot projects and coordinate the procurement of new maintenance technologies across municipalities to increase purchasing power and reduce individual risk.
- Recognize that active support, mediation, and funding from the national government are essential to successfully scale these initiatives across multiple domains.



Photo: The stakeholder information day held at the Estonian Museum of Architecture as part of this study.

Planning

- Urban design and planning guidelines must be systematically updated to explicitly account for the realities of winter mobility. Infrastructure must be designed from the ground up to ensure it can be maintained transparently and to a high standard year-round.
- The planning and expansion of bicycle networks must be strictly based on actual user needs and data, utilizing tools such as the Estonian Transport Administration’s "Potential walking and cycling movements" spatial map application.



Methodological Upgrades

Modernize daily maintenance methodologies by adopting proven international best practices:

- Targeted Hazard Removal: Deploy dedicated ice and icicle removal crews to proactively eliminate overhead hazards for pedestrians and cyclists. Concurrently, update building codes and construction practices for street-adjacent properties to prevent icicle formation in the first place.
- Hard-Packed Snow Maintenance: In sparsely populated or rural areas, transition to maintaining hard-packed snow surfaces rather than attempting to clear roads entirely down to the pavement—a highly successful and resource-efficient practice widely used in Finland.
- Inclusive and Sustainable Lighting: Design infrastructure lighting around the safety needs of all users while adhering to sustainability principles (referencing the Stockholm and Helsinki case studies in Section 1.4). This includes implementing adaptive lighting solutions, optimizing beam angles, and calibrating brightness levels specifically for the comfort and safety of pedestrians and cyclists.
- Advanced Data Collection: Innovate the methods used for collecting and analyzing road condition data to enable more proactive maintenance responses.



3.1 Recommendations for the Future

CITIZEN ENGAGEMENT

- Communicate more with citizens regarding their needs and preferences.
- Where possible, involve local residents in maintenance work (e.g., in Anija and Jõelähtme municipalities, locals clear specific road sections).



CROSS-USE OF EQUIPMENT

- Neighboring municipalities should consider coordinating procurements or joint tenders to enable better cross-use of machinery.
- Some municipalities already allow contractors to provide services across two parishes using the same equipment.



COORDINATION AND SIMPLIFICATION

Many maintenance quality issues stem from a fragmented, overly complex system. Ideas to consider:

- Fewer service providers: Reduce the number of parties involved, especially in Tallinn.
- Real-time data sharing: Live information between maintenance crews would improve coordination and prevent snowbanks. A good example is Viimsi's VAAL environment (pictured), whose functionality could be expanded from cars to include other mobility groups.
- Rethink clearance priorities: Adjust workflows so clearance starts with the most vulnerable street sections (pedestrian and bicycle paths) and smaller streets, gradually pushing snow onto larger roads where high-capacity machines operate (e.g., City of Montreal).



3.1 Recommendations for the Future

Tech innovation

- Fleet Upgrades: Update the vehicle fleet to operate efficiently on narrow pedestrian and bicycle paths.
- Automation: Deploy automated machines for simpler tasks to help alleviate labor shortages.
- Tailored Equipment: Procure infrastructure-appropriate equipment, such as narrower plows designed specifically for active travel paths.



Yarbo robo snow blower. Sima.org

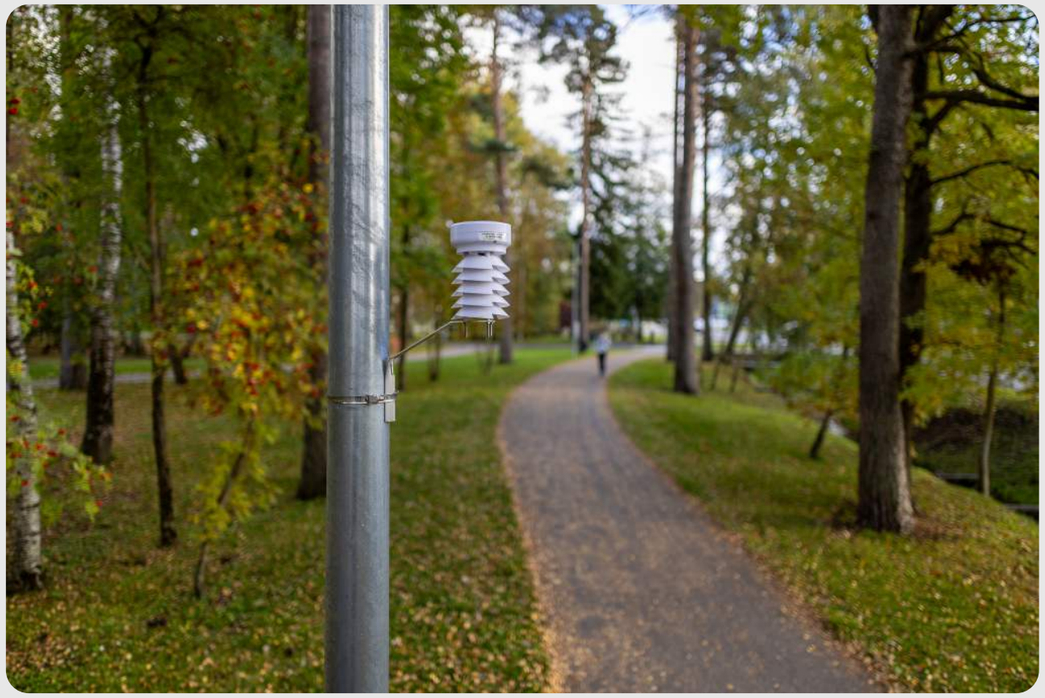
Lighting

- Projected Signage: Project traffic signs directly onto the path in sensitive or high-risk locations.
- Smart Lighting: Implement user-responsive (adaptive) lighting solutions to increase both safety and energy efficiency.
- Quality Enhancements: Use high-quality lighting to make navigating the public space a more pleasant experience.


Yle.fi

WEATHER MONITORING AND DATA SHARING

- Real-Time Monitoring: Develop the capacity to monitor road weather conditions and provide real-time updates to citizens.
- Active Mobility Focus: Shift the development focus toward priority mobility groups, specifically pedestrians and cyclists.
- Expanding Existing Systems: Build upon successful models (such as Viimsi's VAAL system, the Teede Tehnokeskus pilots in Tartu/Espoo, or Stockholm's weather alert system) by expanding them to serve all mobility groups, rather than just drivers.



3.1 Recommendations for the Future

INFRASTRUCTURE

- Maintenance-Friendly Design: Design streets that accommodate snowplow machinery, explicitly avoiding the placement of poles or other obstacles on pedestrian and bicycle paths.
- Stricter Oversight: Improve supervision during the execution of construction projects to ensure design standards are actually met on the ground.



THERMAL ENERGY

- Surface Heating: Consider leveraging district heating or excess thermal energy from buildings to melt snow at bus stops and on high-priority sidewalks.
- Architectural Solutions: Implement heated roof eaves and other building design methods to prevent icicles and falling snow from repeatedly blocking pedestrian walkways.



GREEN AND BLUE INFRASTRUCTURE

- Strategic Landscaping: Design green spaces and planting to shield path users from the wind, which improves thermal comfort and naturally prevents snowdrifts from forming on the paths.
- Integrated Drainage and Snow Storage: Prioritize maintenance and water runoff in infrastructure planning. Systematically implement Sustainable Urban Drainage Systems (SUDS) and integrate designated snow storage zones directly into these solutions.
- Attractiveness: Utilize high-quality green and blue infrastructure to make walking and cycling routes visually appealing and inviting year-round.

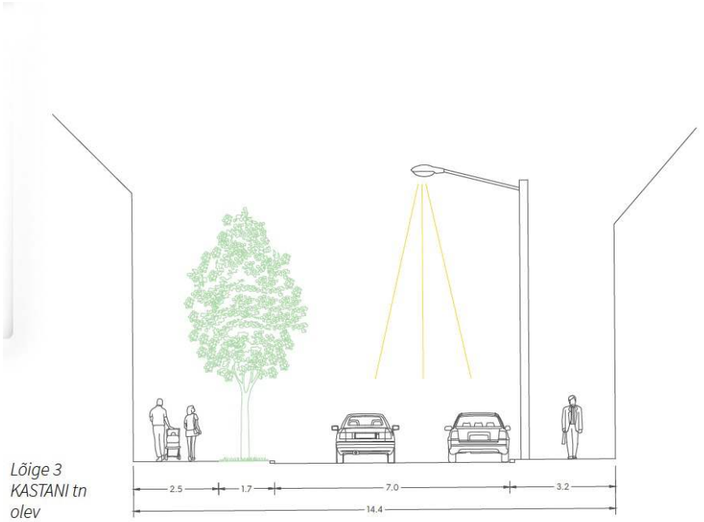


3.1 Recommendations for the Future

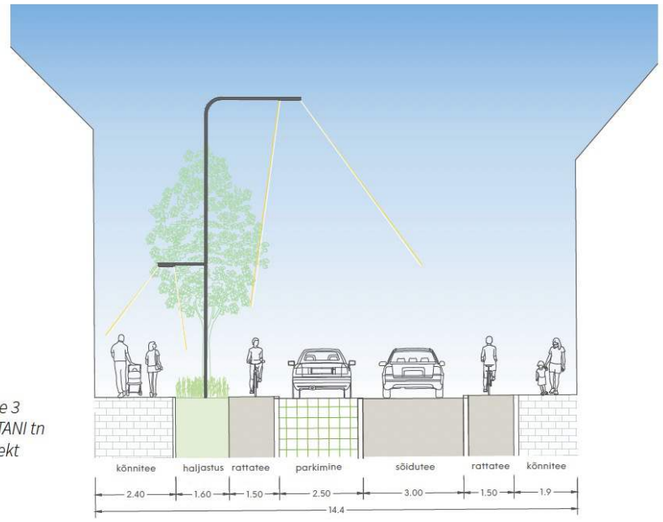
STREET AND ROAD DESIGN

Infrastructure design is central to effective winter maintenance. The City of Tartu's "Healthy Street" (Tervislik tänav Tartus, 2021) study offers thoroughly developed street design models that promote active mobility while solving core maintenance challenges:

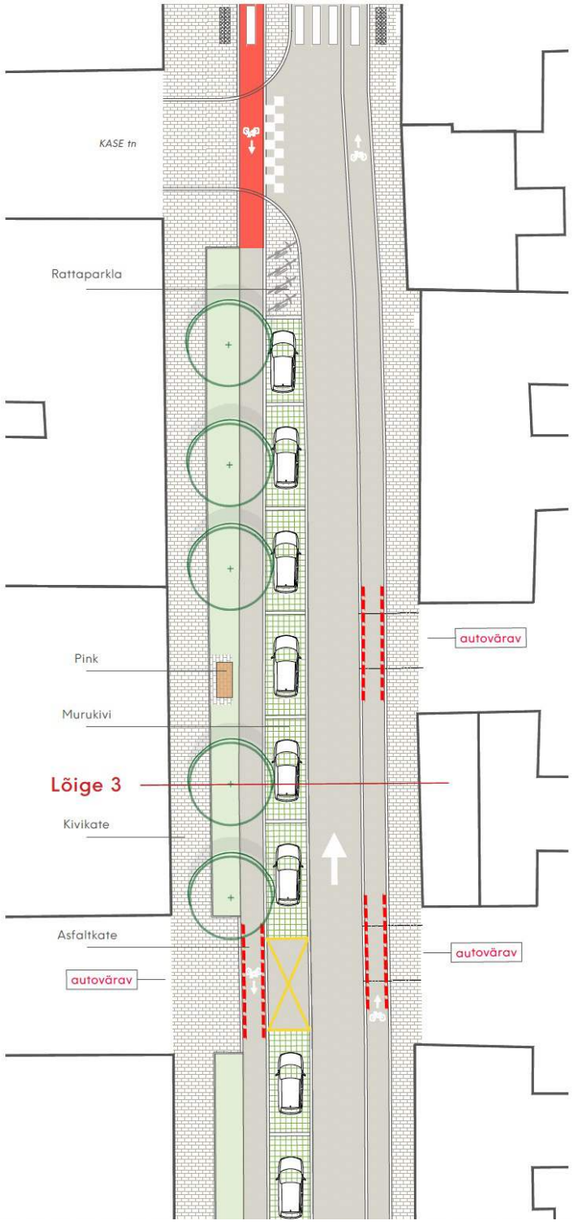
- Uninterrupted Paths: Pedestrian and bicycle routes are strictly separated with no physical or visual interruptions, ensuring smooth and rapid operation for snow-clearing machinery.
- Strategic Pole Placement: Lighting and traffic signs are placed in green buffer zones to guarantee that all mobility paths retain their full, required clearance widths.
- Integrated Snow Storage: Green strips are intentionally designed to accommodate temporary snow storage during peak winter events.
- Salt Protection: Primary green spaces are physically separated from roadways to protect vegetation from harmful de-icing salts.
- Vulnerable User Protection: Pedestrians—the most vulnerable mobility group—are explicitly prioritized by routing them as far away from vehicular traffic as possible.



Lõige 3 KASTANI tn olev



Lõige 3 KASTANI tn projekt



From the guide "Healthy Street" (Tervislik tänav Tartus, 2021)

3.2 Summary

This study provides a comprehensive overview of winter maintenance challenges, the relevant legal frameworks and national strategies, and how Harju County municipalities set and implement their operational priorities. It also highlights numerous international examples of cities solving similar issues. While there is no universal, one-size-fits-all system—due to the unique spatial, social, and climatic context of each municipality—many successful foreign practices are highly applicable to Estonia.

The primary focus of this research was on the operational workflows and experiences of Harju County municipalities, with less emphasis on end-user experiences or contractor perspectives. Insights from interviews and the stakeholder information day revealed a highly fragmented picture of how different municipalities tackle identical problems, underscoring a clear need for closer knowledge exchange. Many such solutions are detailed in the chapters "International Benchmarks" and "Recommendations for the Future."

Fortunately, Harju County already hosts several initiatives that stand out internationally and could be scaled elsewhere to shift the focus from cars to active mobility. One prime example is Viimsi's "VAAL" platform for real-time citizen communication, which could be expanded to better serve pedestrians and cyclists. The same applies to AS Teede Tehnokeskus's pilot projects in Espoo and Tartu, whose implementation potential in Harju County should be seriously evaluated.

maintenance is a complex process crucial for sustaining both socioeconomic functions and public health. Society has skewed toward car-centricity—over 50% of Estonians use a car for daily commuting—which is heavily reflected in infrastructure investments and winter maintenance priorities. Conversely, studies show that residents strongly desire better conditions for walking, cycling, and public transit.

Consequently, the current maintenance system neither supports national strategic goals nor meets public expectations. Municipal feedback attributes this to budget constraints and, frequently, a lack of political will. Therefore, a significant portion of this study's recommendations focuses on actionable, low-cost interventions and strengthening inter-municipal collaboration.

However, it must be emphasized that achieving a true systemic leap forward requires stronger state-level coordination, strategic infrastructure planning, modernized construction standards, and stricter operational requirements—all of which necessitate increased financial investment. Yet, these are smart, high-ROI expenditures: a more active, healthier population reduces the long-term burden on the national healthcare system, and active mobility infrastructure is fundamentally cheaper to build and maintain than car-centric networks.

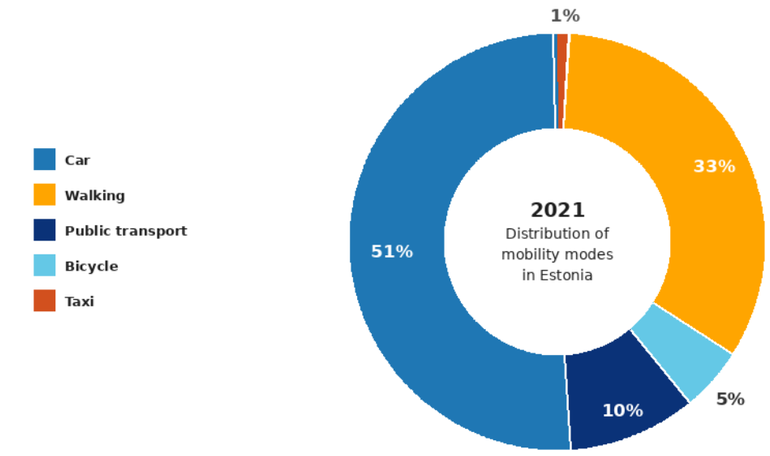
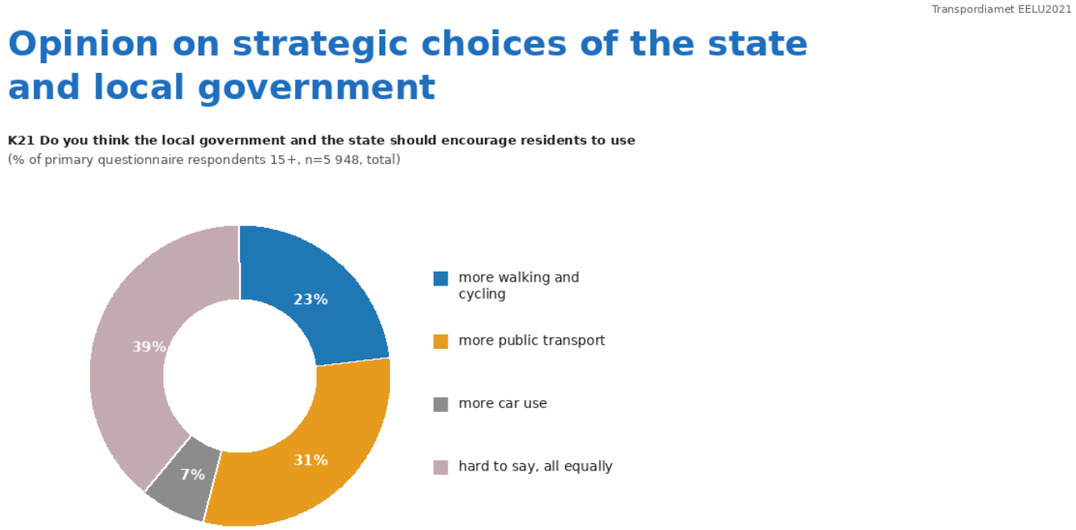


Figure 1. Distribution of mobility modes among Estonian residents, % of trips, 2021.
Source: EELU 2021



THE NEED FOR SYSTEMIC CHANGE
As demonstrated throughout this report, winter



SPINUNIT OÜ, Tallinn-Helsinki, April 2026

Hannes Aava, Jesús López Baeza, Damiano Cerrone