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Prioritizing shortcuts: A multilevel method for semi-rural walkability

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Abstract

Rural and semi-rural municipalities often lack effective tools to evaluate and prioritize pedestrian infrastructure. This study aims to develop and test a resource-efficient method for identifying high-impact pedestrian improvements, using the Norwegian municipality of Skaun as a case study.

A two-level framework was applied. At the local level, 25 potential pedestrian shortcuts were assessed across four dimensions: accessibility, safety, comfort, and attractiveness. This assessment utilized GIS-based indicators and a weighted scoring system. To determine the most effective shortcuts, cost estimates were used to calculate benefit–cost ratios. At the network level, an adapted Walk Score® methodology was used to compare three different network scenarios (no shortcuts, prioritized shortcuts, and all shortcuts) to quantify changes in walkability.

The prioritized shortcuts delivered 65% of the total potential benefit, achieving nearly the same reductions in car-dependent areas as full implementation would have. The local assessment effectively identified the most cost-effective projects, while the network analysis demonstrated improvements that lead to more walkable areas with minimal investment.

This first test showed that the method is replicable and suitable for data-limited contexts, enabling municipalities to make evidence-based decisions. Combining detailed local analysis with a network-wide indicator provides a strategic way to maximize impact within constrained budgets.

Introduction

Norway's climate goals include a clear ambition to shift towards more sustainable mobility and reduce car dependency. A key step in this transition is improving pedestrian infrastructure. While larger cities often have resources, data and tools to plan and evaluate such investments, many less populated municipalities face significant challenges (Tennøy et al., 2022). In these contexts, there is often a lack of practical, evidence-based tools to assess pedestrian infrastructure and prioritize improvements. As a result, investment decisions are frequently made without quantitative support.

However, bridging this gap is essential. Well-designed pedestrian improvements can provide significant benefits by reducing walking distances, enhancing safety, and connecting key destinations. This encourages walking and is an effective measure to improve walkability.
This paper aims to address these gaps by focusing on the municipality of Skaun. Located near Trondheim, Skaun has increasingly become an out-commuting municipality in recent years. As a result, it experiences a low percentage of walking as a mode of transport and a high reliance on cars (Statens vegvesen, 2022). Therefore, we seek to answer the following research questions:

1. What methods can be used for identifying the impactful pedestrian improvements in semi-rural areas?
2. What factors make it challenging to apply these methods in practice?
3. How can municipalities use this approach to achieve high impact with limited budgets?

The first research question is addressed in the results section, while the second and third are explored in the discussion. By developing a two-tier framework, we aim to identify the most impactful pedestrian shortcuts and to outline the challenges and opportunities for applying this approach in practice.

State of the art

Worldwide, various methods are used to assess pedestrian infrastructure. Multi-criteria decision analysis (MCDA) frameworks combine land use, roadway and traffic data, street connectivity, and pedestrian attributes to evaluate pedestrian infrastructure (Hossain et al., 2025; Jabbari et al., 2018). GIS-based tools have been developed to prioritise road maintenance by integrating street connectivity, critical buildings, vulnerable populations, and cost factors (Bashiri, 2023). Other approaches, such as Transport for London's Pedestrian Environment Review System (PERS), rely on structured walking audits (Spencer and Davies, 2012). While agencies like the Virginia Department of Transportation incorporate crowdsourced data, allowing users to report damages to pedestrian infrastructure (Zhu et al., 2020). Practical tools such as the ActiveTrans Priority Tool offer municipalities in the US adaptable, spreadsheet-based frameworks for transparent decision-making to improve pedestrian infrastructure along existing roads (NCHRP 803, 2019). Whereas in Norway, the municipalities of Trondheim and Stavanger applied GIS-based methods to evaluate shortcuts based on reduced distances to points of interest, traffic volumes, or observed school travel routes (Berg, 2015; Trondheim Kommune, 2021).

However, most of the existing approaches focus on assessing infrastructure quality without directly linking results to investment prioritization. Cost factors are rarely integrated into different evaluation methods. Often, these tools are developed to assess pedestrian infrastructure in urban areas, leaving a gap for semi-rural municipalities with limited data and planning capacity. Building on these gaps, this study develops and tests a practical, two-level evaluation approach for pedestrian infrastructure in semi-rural areas, combining a detailed local-level shortcut assessment with a simplified, network-wide accessibility analysis adapted from the Walk Score® methodology.

Method

Analytical Framework

The two-tiered analytical framework integrates a local-level (micro-level) and a network-level (macro-level) assessment of pedestrian infrastructure. This approach allows us to identify shortcuts that perform well locally while also contributing to improve walkability across the settlement.
In order to assess the local-level walking needs, we adapted the Norwegian planning principles for walking infrastructure (Nistov and Farner, 1973) with the theory of hierarchy of walking needs (Alfonzo, 2005). Therefore, we focused on four dimensions (accessibility, safety, attractiveness, comfort) to assess the local-level walking needs. These four dimensions form the basis for evaluating the performance of individual shortcuts.

The network-level analysis complements this by examining the broader accessibility effects of the most relevant shortcuts using an adapted Walk Score measure (Walk Score, 2025).

Local-level assessment

The local-level assessment uses multi-criteria decision analysis to calculate a score for each dimension and each shortcut (Garau et al., 2024). The score for each dimension was calculated by the following steps: first, identifying key attributes for each dimension, second, calculating these attributes for each shortcut and its corresponding alternative (shortest path without the shortcut), and third, calculating four different dimension scores. In the end, an overall score that consists of the four single dimensions was calculated. To identify the most effective shortcuts, a benefit–cost ratio (BCR) and the benefit share for each shortcut were calculated. The process is explained in more detail below.

1. Identifying and calculating attributes

Walkability factors can differ between urban and semi-rural contexts. Based on the literature (Basu et al., 2022; Scanlin et al., 2014), we identified the following key attributes for each dimension:

Dimension	Attribute	Description/Calculation
Accessibilty	Route directness	Ratio of route length with shortcut to alternative route without shortcut (m)
	Travel distance to nearest point of interest	Time to nearest POI (leisure, nature, shopping, education) reflecting semi-rural context
Comfort	Average slope	Average slope of route, capped at 10%
	Surface type	Surface type classified as paved/unpaved; weighted average by route length
Safety	Number of crossings with motorized traffic	Count of crossings with motorized traffic
	Weighted average traffic speed segments	Weighted average speed along route
	Weighted average route length with sidewalk or without sidewalk	Proportion of route length with /without sidewalk
Attractivity	Built-up to non-built-up area ratio	Ratio of built-up to non-built-up area within a 50 m buffer

Table 1: Description of attributes

These attributes were operationalized by using OSM and geodata sets provided by the municipality. The attributes were calculated for each shortcut and for the existing route without the shortcut.

2. Calculating scores and overall score

Each single score is calculated by the sum of each attribute. These attributes are normalized to a 0–1 scale and aggregated into the four-dimensional scores: accessibility, comfort, safety, and attractiveness. Within comfort and safety score, the sub-attributes were weighted equally. For the accessibility score, we assigned a weight of 75% to route directness and 25% to the change in proximity to the nearest destination. This reflects that greater distances and lower network connectivity make direct routes particularly valuable.

Finally, the overall score for each shortcut was calculated as a weighted sum of the four-dimensional scores:

$$Overall\ Score = w_{acc} * AC + w_{comf} * C + w_{safe} * S + w_{attr} * AT$$

where **A** = accessibility score, **C** = comfort score, **S** = safety score and **T** = attractiveness score

Base-case weights were set to $w_{acc} = 0.35$, $w_{comf} = 0.25$, $w_{safe} = 0.25$, and $w_{attr} = 0.15$. Accessibility received the highest weight due to its critical role in route choice, while safety and comfort were balanced equally, and attractiveness was given lower importance as it tends to play a secondary role in utilitarian walking (López-Lambas et al., 2021).

To test robustness, two alternative weighting schemes were applied: an equal weights across all dimensions, and an access-focused scheme (wacc = 0.45, wcomf = 0.15, wsafe = 0.30, wattr = 0.10). Both produced minimal changes in shortcut rankings, indicating stable results.

3. Calculating cost–benefit ratio and benefit share

For prioritisation, we calculated the benefit–cost ratio (overall score / estimated construction cost) and benefit share (shortcut's contribution to the sum of all benefits). The construction cost for each shortcut was estimated by using project-internal reference values (NOK/m).

Network-level assessment

For the network-level assessment, we examined how the top-performing shortcuts (above the median in both total benefit and benefit–cost ratio) influence settlement-wide walkability. We calculated an adapted Walk Score for three scenarios: (1) no shortcuts (baseline network), (2) prioritized shortcuts (only selected high-performing ones), and (3) all shortcuts (full implementation).

The Walk Score is a widely used method for assessing walking accessibility (Carr et al., 2010; Duncan et al., 2011) and was adapted for a semi-rural context. Adaptations included adding access points to nature and neighborhood meeting points, as well as including healthcare facilities (general practitioners, pharmacies), which are particularly relevant in rural areas(Maddock E. et al., 2025). Destinations were mapped from OpenStreetMap, FKB, and municipal datasets and geocoded for use in a pedestrian network analysis.

Networkwide accessibility scores were calculated from a 100×100 m population grid, measuring shortest-path distances to each facility type and converting them into weighted scores using a cumulative Gaussian distance decay function (full score within 300 m, decreasing to 25% at 1.5 km, and excluded beyond 2.5 km)(van der Vlugt et al., 2024). Facility weights were adapted from the original Walk Score categories and extended with the additional rural-relevant destinations. Scores were scaled to a 0–100 range.

Category	**Facilities Included**	**Weight(s) applied**
Food & Drink	Restaurants (up to 10 nearest)	0.75, 0.45, 0.25, 0.25, 0.225, 0.225, 0.225, 0.225, 0.20, 0.20
	Cafés (up to 2 nearest)	1.25, 0.75
Shopping	Shops (up to 5 nearest)	0.50, 0.45, 0.40, 0.35, 0.30
	Grocery store	3.00
Services	Bank	1.00
	Library	1.00
Recreation	Leisure facility	1.00
	Sports facility	1.00
Education	School	1.00
Healthcare	Pharmacy	1.00
	General practitioner (up to 2 nearest)	1.25, 0.75
Other	Nature access points	1.00
	Public transport stop	0.50
	Neighbourhood meeting point	0.50

Table 2: Facilities included in Walkscore

Intersecting the results with population data allowed us to estimate how many residents fell into each walkability category (Very Car-Dependent to Walker's Paradise) in each scenario. Comparing scenarios shows whether a limited set of high-priority shortcuts can deliver similar benefits to full implementation, providing evidence for cost-effective investment decisions.

Results

Descriptive characteristics of shortcuts

In total, 25 potential shortcuts were analysed, ranging from 22.8 m to 635.6 m in length (mean: 182.7 m). Most are situated within residential areas, where they improve local accessibility and connectivity within neighbourhoods. Five longer shortcuts link residential zones to key facilities across undeveloped land, potentially serving a wider catchment and contributing to network-level accessibility improvements. These basic characteristics provide important context for evaluating shortcut performance.

In the following local-level assessment, we analyse how each shortcut performs across four key dimensions: accessibility, safety, comfort, and attractiveness, compared to its corresponding shortest-path alternative without a shortcut.

Local-level assessment

Figure 1 summarizes the changes in each local-level dimension, and Figure 2 shows the breakdown by sub-dimensions. The local-level assessment revealed that, compared to their corresponding shortest-path alternatives, the accessibility dimension increased the most, with an average change of +0.52. This dimension combines route directness and accessibility to the nearest point of interest. Within it, route directness showed the strongest improvement (+0,66), while the average change in distance to the nearest facility was more modest (+0,11). This is not surprising, as a single shortcut rarely produces large changes in proximity to destinations.

Safety improved on average by +0.32, driven primarily by reduced traffic speed exposure (+0,48), followed by fewer motorized-traffic crossings (+0,22) and increased separation from motorized traffic (+0,22). Given that many shortcuts are physically separated from vehicle routes, such a gain is plausible and consistent with expectations for semi-rural areas.

In contrast, comfort decreased on average by −0.10. Comfort reflects average slope and surface type; since nearly all shortcuts were paved (surface type change +0,08), slope exerted the dominant influence (−0,31). In the hilly terrain of the study area, many shortcuts traverse steeper gradients, which reduces perceived walking comfort despite potential travel time savings.

Finally, attractiveness, measured as the ratio of built-up to non-built-up areas along the route, changed only slightly (+0.01). This is likely because several shortcuts pass through open fields or forested areas, which do not significantly alter the built-environment ratio.

Overall, these results show that the main benefits of shortcuts lie in improving accessibility and safety, while comfort may decline in hilly contexts. Attractiveness remains largely unaffected, suggesting it is less sensitive to shortcut interventions in semi-rural areas. These insights informed the selection of candidates for the subsequent network-level assessment.

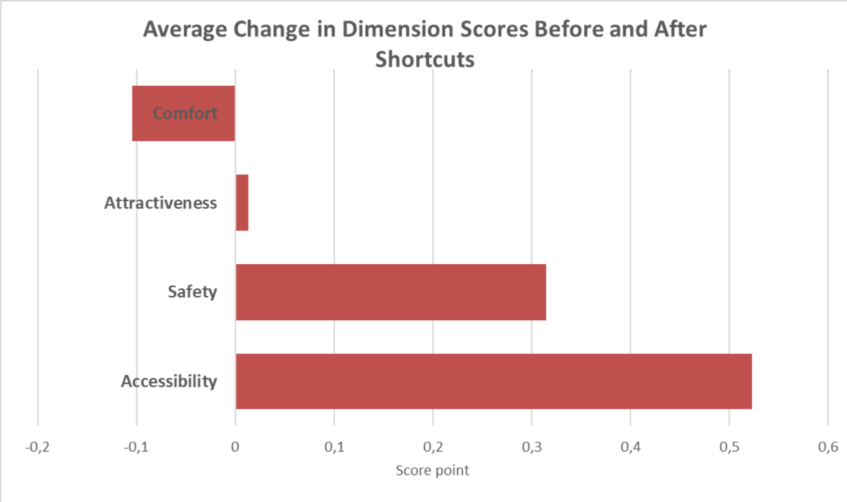

Figure 1: Average change in dimension scores before and after shortcuts implementation

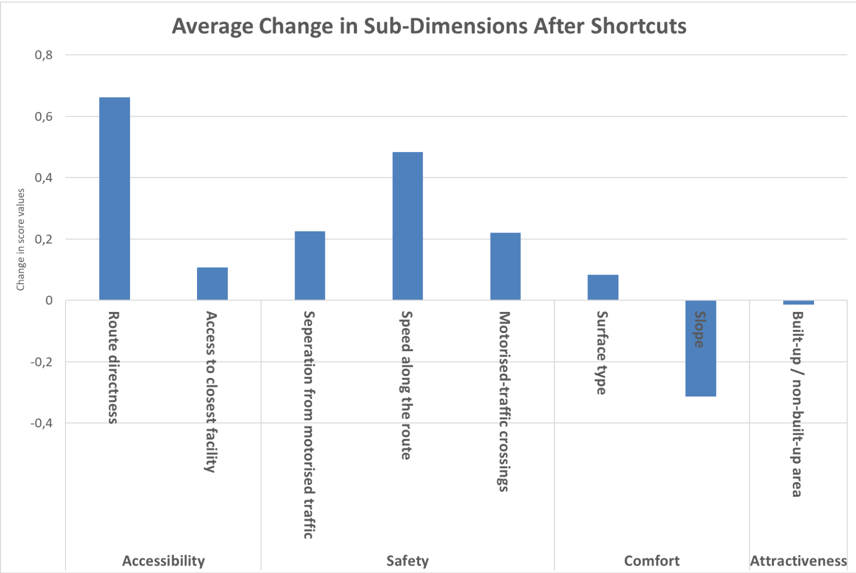

Figure 2: Average change in sub-dimension scores before and after shortcuts implementation

For prioritization, we calculated the total score, the benefit–cost ratio, and the cumulative distribution. Figure 3 illustrates several key observations. First, the benefit values for each shortcut are relatively similar, as indicated by the comparable slope of the cumulative benefit curve. Second, when incorporating costs, the prioritization changes, and differences between shortcuts become more pronounced. This suggests that the shortcuts have similar qualitative characteristics, which is not surprising given that no design features such as benches or landscaping were included in the assessment. For example, shortcut SC_11 delivers a moderate total benefit but a particularly high benefit–cost ratio.

A notable pattern is that a small group of high-ranking shortcuts (e.g., SC_25, SC_16, SC_11) account for a disproportionate share of benefit–cost performance, representing clear "early wins." Looking at the cumulative benefit curve, the largest gains occur in the first 10–12 shortcuts, with each adding approximately 3–6 percentage points to the total benefit. After about the 15th shortcut (≈70–75% of cumulative benefit), the curve flattens noticeably, and additional shortcuts contribute less than 2–3 percentage points each. This indicates a plateau effect, where adding more shortcuts yields only minor incremental improvements. In a resource-constrained context, this pattern suggests that focusing on the top-performing shortcuts could deliver most of the total benefit at a much lower overall cost. Finally, shorter shortcuts tend to be prioritized, whereas longer ones remain inefficient in the analysis, as their length increases costs without generating proportionally higher utility scores.

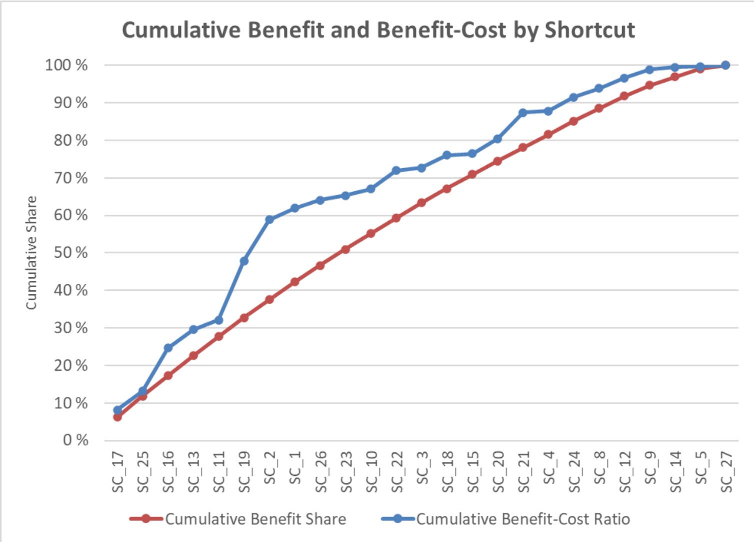

Figure 3: Cumulative distribution of benefits by shortcut

Based on these findings, for the macro-level assessment we selected the most important shortcuts — those with above-median values for both total benefit and benefit–cost ratio (SC_13, SC_17, SC_19, SC_20, SC_21, SC_22, SC_25, SC_1, SC_11, SC_2). These top 11 shortcuts account for 65% of the average total benefit and were carried forward for further analysis of influences at the network level.

Network-level assessment

To assess the impact of shortcuts on network accessibility, we calculated Walk Score results for three scenarios: (1) no shortcuts in the network, (2) only the prioritized shortcuts identified in the local-level assessment, and (3) all potential shortcuts without prioritization. By intersecting the Walk Score results with population data, we calculated how many residents fall into each walkability category (see Figure 4). In the base scenario without shortcuts, about 1,000 residents live in *very car-dependent* areas (Walk Score <25) and approximately 1,400 in *car-dependent* areas (25–50). Around 600 residents live in *somewhat walkable* areas (50–75), with only small numbers in the *very walkable* (75–90) and *walker's paradise* (>90) categories.

Introducing only the prioritized shortcuts reduces the *very car-dependent* population by roughly 70 residents and the *car-dependent* population by more than 350, while increasing the *somewhat walkable* population by over 330 and the *very walkable* population by about 370. Interestingly, the *walker's paradise* population nearly doubles compared to the base case, matching the gain achieved by the full set of shortcuts.

Implementing all shortcuts yields a slightly larger reduction in *car-dependent* areas compared to the prioritized set and increases the *very walkable* population by about 270 more residents. However, the differences between the prioritized and full implementation are relatively small in the lowest and highest walkability categories. The main difference lies in the shift between *somewhat walkable* and *very walkable* areas, where the full set offers greater gains.

In summary, the prioritized set of just 11 shortcuts achieves nearly the same reductions in *car-dependent* and *very car-dependent* areas, and the same increase in *walker's paradise* areas, as the full implementation. The key difference is in the middle walkability categories, where full implementation shifts more residents into the *very walkable* category. This suggests that substantial accessibility improvements can be achieved with a limited, well-chosen set of interventions.

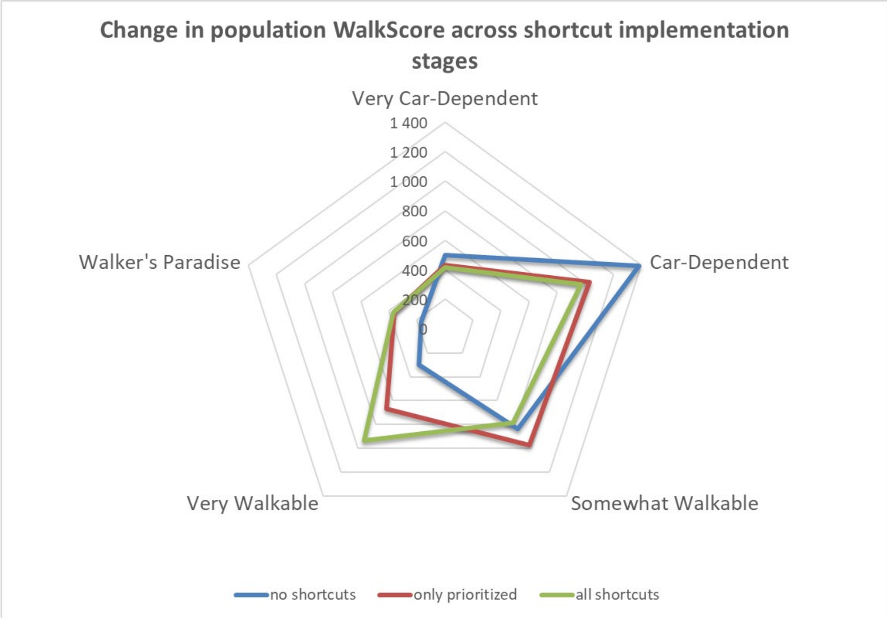

Figure 4: Change in population WalkScore across shortcut implementation stages

Discussion

This study demonstrates how pedestrian infrastructure in semi-rural areas can be evaluated by combining local- and network-level assessments, even when only limited data is available. The approach uses a structured local framework to assess individual shortcuts and a simplified network-level indicator to estimate wider accessibility impacts.

Multi-level assessment to prioritise pedestrian network improvements

Our results show that combining a detailed local-level assessment with a simplified network-level measure provides a clear, repeatable way to identify high-impact shortcuts in semi-rural pedestrian networks. The local-level framework evaluates each shortcut across four dimensions, accessibility, safety, comfort, and attractiveness, using only GIS-based indicators and straightforward calculations. This makes it transparent, easy to replicate, and suitable for municipalities without advanced modelling capabilities. Integrating cost–benefit analysis ensures that prioritization is based not just on qualitative performance, but also on financial efficiency.

Barriers to apply the method

Applying this method in practice faces several challenges. First, some important network effects, such as potentially trip reduction by car, seasonal accessibility, health effects or climate resilience, were not fully integrated, limiting the breadth of the network-level assessment. In addition, accessibility in semi-rural contexts is often affected by seasonal conditions such as snow, which can make some shortcuts unusable in winter. Finally, while Walk Score offers a quick way to estimate accessibility gains, it does not directly measure pedestrian usage directly. Without GPS-based walking data, the actual behavioural impact remains partly uncertain (Zhu et al., 2020).

Maximizing impact with limited resources

The analysis shows that focusing on the top-performing shortcuts delivers most of the accessibility benefits at a fraction of the cost. In our case, the 11 highest-priority shortcuts captured around 65% of total benefits, while avoiding many longer, less cost-effective routes. This demonstrates that municipalities can achieve significant improvements in walkability without implementing every potential project. The approach can be directly applied to other municipalities, providing a ready-to-use decision-support tool that balances cost, impact, and feasibility.

While the framework is transparent and replicable, it has three key limitations: (1) it focuses on accessibility and does not yet integrate broader impacts such as modal shift or climate resilience, (2) seasonal and maintenance factors that affect shortcut usability were not included, and (3) Walk Score measures potential rather than actual pedestrian behaviour.
Future research should link this approach with GPS-based walking data, extend the network-level assessment to cover environmental and health effects, and test the framework across different municipalities to refine weighting and prioritisation thresholds.

Conclusion

This study shows that pedestrian networks in semi-rural areas can be effectively assessed using a combined local- and network-level approach. By evaluating shortcuts across four dimensions, accessibility, safety, comfort, and attractiveness, and integrating cost–benefit analysis, the method provides a transparent and replicable way to identify high-impact, cost-efficient improvements. Network-level Walk Score analysis further illustrates the wider accessibility gains for residents, even when only prioritised shortcuts are implemented. The framework offers municipalities a practical decision-support tool that works with limited data and can be adapted to different contexts.

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Statement on the use of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used ChatGPT to improve the readability and language of the article. After using the tool, the authors reviewed and edited the content as necessary and take full responsibility for the content of the published article.