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Cool Walkability Planning

Shadeways (covered sidewalks) and pedways (enclosed, climate controlled walkways) can provide comfortable walkability in hot climate cities. The Cool Walkshed Index can help plan these facilities.

7 February 2024

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Summary

As the world becomes hotter and more urban pedestrians increasingly experience excessive heat, often exceeding 90° Fahrenheit (32° Celsius) and sometimes 110° F (43° C). This makes walking uncomfortable, unattractive and dangerous, leading to ill health, isolation, traffic problems, and sprawl. To address these, hot-climate cities should plan for pedestrian thermal comfort. This can be accomplished by creating integrated networks of *shadeways* (shaded sidewalks) and *pedway*s (enclosed, climate-controlled walkways) that connect homes, commercial buildings and public transit within *urban villages* (compact neighborhoods where most services and activities are accessible by walking). Although these facilities cost more than basic sidewalks, they can greatly improve walking comfort and are far cheaper than motor vehicle infrastructure. By increasing walking and reducing driving they can provide many economic, social and environmental benefits. Analysis in this report indicates that pedway and shadeway networks can usually repay their costs through road, parking and vehicle savings, and by increasing local property values.

This report examines why and how to improve urban walkability in hot climate cities. It describes the *Cool Walkshed Index* (CWI) which rates shadeway and pedway network quality, suitable for planning applications. Currently, most cities have CWI ratings of D-F, which makes walking unpleasant and dangerous during hot periods; they should strive to achieve A-C in order to ensure pedestrian comfort. Achieving such targets requires that decision makers recognize the unique and important roles that walking plays in an equitable and efficient transportation system, and prioritize walkability improvements in planning and investment decisions.

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Introduction

Nearly all modern automobiles and public transit vehicles have air conditioning for passenger comfort. In hot climate cities, parking lots are often shaded, as illustrated below. This report investigates why and how communities can provide similar comfort to pedestrians.

Figure 1 Shaded Parking in Dubai

In hot climate cities parking lots often provide shade to keep vehicles cool. This report investigates why and how communities can deliver similar comfort to pedestrians.

Walking (including variants such as wheelchairs, hand carts, and lower-speed scooters) is the most basic travel mode; it provides efficient mobility, exercise and enjoyment. Improving walking conditions and increasing walking activity can provide various benefits as summarized below. Uncomfortable walking conditions encourage people to drive, even for short trips, further increasing pollution emissions.

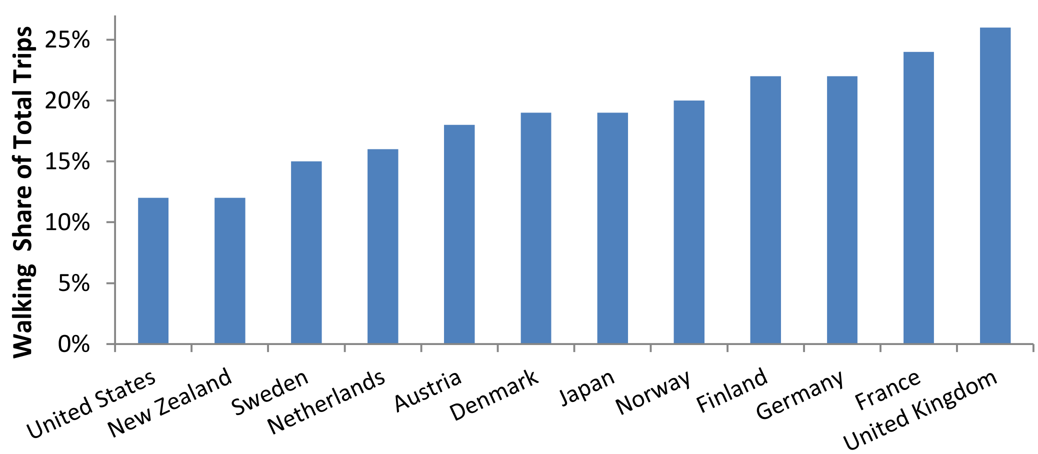
Table 1 **Walkability Benefits** (Litman 2023a)

Economic	Social	Environmental
User savings Road and parking cost savings Increased retail sales and property values	Improved fitness and health Traffic safety (crash reductions) Community cohesion and security	Quiet (reduced noise) Cleaner air (emission reductions) Reduced pavement area

Improved walking conditions and increased walking trips can provide many benefits.

Walking is a common mode of travel, serving 12-25% of total trips, as illustrated below, with higher rates in cities, in areas with good walking conditions, and among lower-income residents.

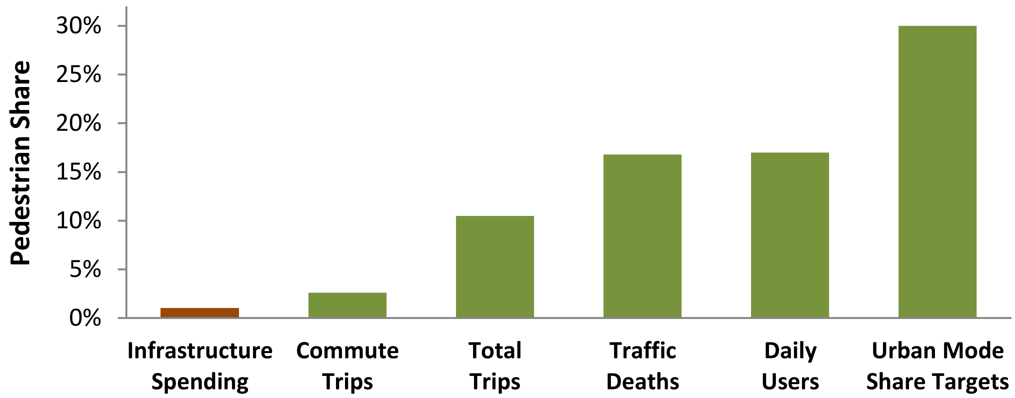
Figure 2 **Pedestrian Mode Shares in Various Countries** (Buehler and Pucher 2023)



In higher-income countries, 12% to 26% of total trips are made by walking. Walking mode shares are even higher in compact urban neighborhoods and lower-income areas.

Despite its importance, walking currently receives relatively little support. Most communities spend less than $50 annually per capita on sidewalks, crosswalks and paths, which is less than 2% of their total transport infrastructure expenditures ([Litman 2023b](#)), and far less than most indicators of walking demand such as its share of trips, traffic deaths, users and targets, as illustrated below.

Figure 3 **Walking Infrastructure Spending Versus Indicators of Demand** ([Litman 2023b](#))

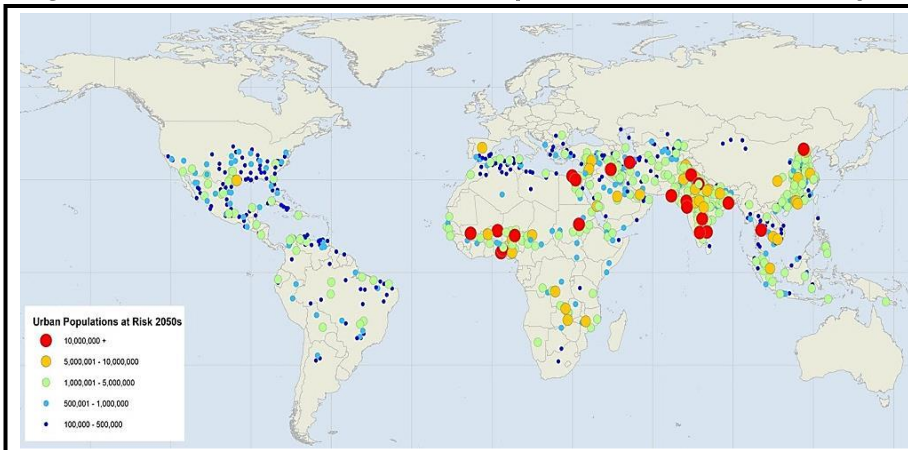


Most communities devote less than 2% of total transportation infrastructure spending to sidewalks and crosswalks, which is less than walking mode shares, traffic deaths, daily users and urban mode share targets.

This is unfair and inefficient. It makes walking uncomfortable and unsafe, particularly for vulnerable groups (children, seniors and people with disabilities). Since most public transit trips include walking links, it discourages transit travel. It causes travellers to drive for trips that, given better infrastructure, would be made by non-auto modes ([AlKheder 2023](#)). Planners are starting to appreciate the unique and important roles that walking plays in an equitable and efficient transport system. Many cities are planning [*urban villages*](#) (also called *15-minute neighborhoods*) where commonly-used services (shops, schools, parks, transit, etc.) are located within convenient walking distances of most homes and jobs.

Of course, the devil is in the details. Walkability planning must reflect a community's unique conditions, including climate. Global warming and urbanization are increasing the portion of people living in cities that experience extreme heat, where temperatures often exceed 90° Fahrenheit (32° Celsius) and sometimes 110° Fahrenheit (43° Celsius). These conditions make walking uncomfortable, unattractive and unhealthy (GHIN 2023; Goodell 2023; Gössling, et al. 2023; Sherriff 2023; WHO 2018).

Figure 4 **Cities Predicted to Experience Extreme Heat by 2050** ([UCCRN 2018](#))

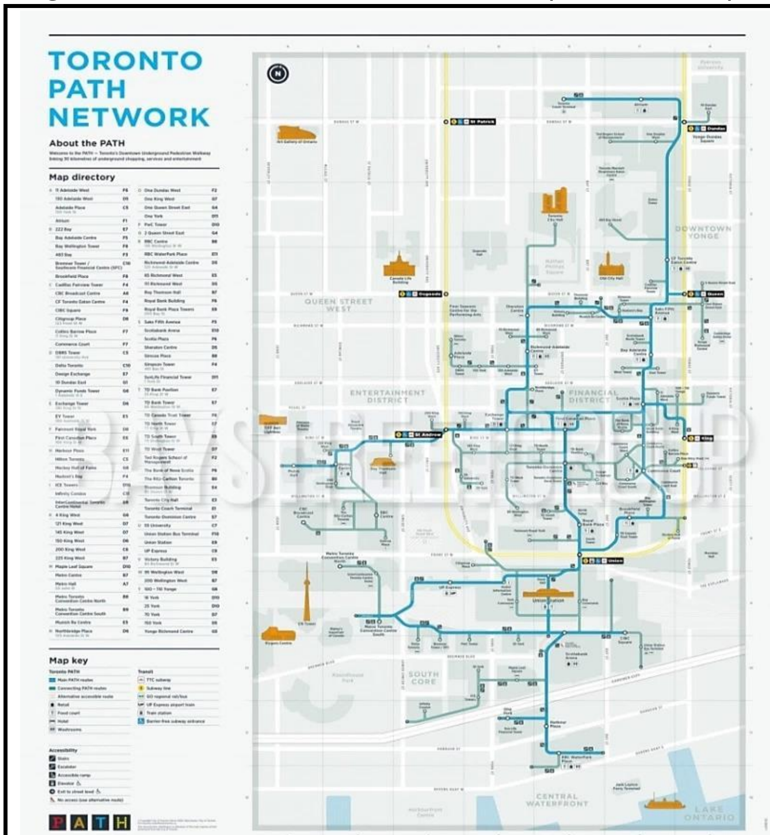


Approximately 200 million people currently live in 350 cities that experience summer temperatures exceeding 35°C (95°F). Even at this level heatwaves are the deadliest of all climate risks. Scientists predict that by 2050 around two billion people living in 970 cities, shown in this map, will experience extreme heat, including temperatures over 43°C (110°F)

Here in Canada we face a similar but opposite problem: extreme cold. Many cold climate cities have extensive *pedway* networks; enclosed walkways that connect buildings to commonly-used services and to public transit stations, making it easy to get around by walking during unpleasant weather. Chicago, Edmonton, Montreal, and some Asian and European cities also have well-developed pedways networks.

A good example is Toronto's PATH Pedway Network. It has 30 kilometers of enclosed walkway that connect the City's downtown, entertainment and financial districts, including more than 75 buildings, six subway stations, the main train station, three major department stores, nine hotels, and many tourist and entertainment attractions such as the Hockey Hall of Fame, Roy Thomson Hall, and City Hall. Each pedway segment is managed and maintained by the owner of the property through which it runs; about 35 corporations are involved. Their operating costs are repaid through higher property values and rents paid by shops incorporated into the network.

Figure 5 **Toronto PATH Network** (Toronto 2021)



Toronto's PATH pedway network includes more than 30 kilometers of enclosed walkways that provide convenient access to many destinations including buildings, shopping centers and subway stations. This makes downtown Toronto a very walkable city even during extreme weather.

Similar pedway networks exist in other cold climate cities such as Chicago, Edmonton and Montreal, and in some hot climate cities such as Bangkok, Hong Kong, Kuala Lumpur and Singapore.

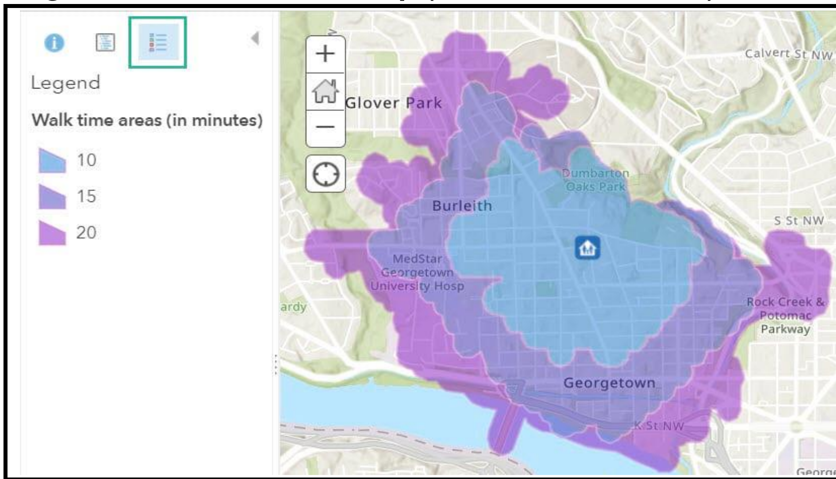
Pedways have the potential to significantly increase walking comfort and safety in hot climate cities, resulting in more walking and less driving, providing substantial savings and benefits.

This report investigates ways to improve and encourage walking in hot climate cities. It describes how planners can evaluate pedestrian comfort using the *Cool Walkshed Index* (CWI) which rates pedway and shadeway network quality, suitable for planning applications. It analyzes the potential savings and benefits from shadeway and pedway networks, and how these can be financed through value capita. Some of the concepts can also be applied to bicycling (Williams 2023). This information should be useful for pedestrian advocates and planners in hot climate cities.

Walkability Planning

Pedestrian access is measured by *walkshed*, that is, the area that can be reached on foot within a reasonable time period; typically 5-15 minutes (0.2 to 1.0 miles, or 0.3 to 1.5 kilometers) for errands and 10-30 minutes (0.4 to 1.5 miles, or 0.6 to 2.0 kilometers) for commutes (Steuteville 2017). Simplistic walkshed indicators measure walking distances as the crow flies, but crows don't walk and pedestrians can't fly! New mapping systems show realistic walksheds, taking into account sidewalk networks and geographic constraints, as illustrated below. This can be descried as an urban village. A successful urban village needs enough people (residents and employees) to support commonly-used services and high quality public transit.

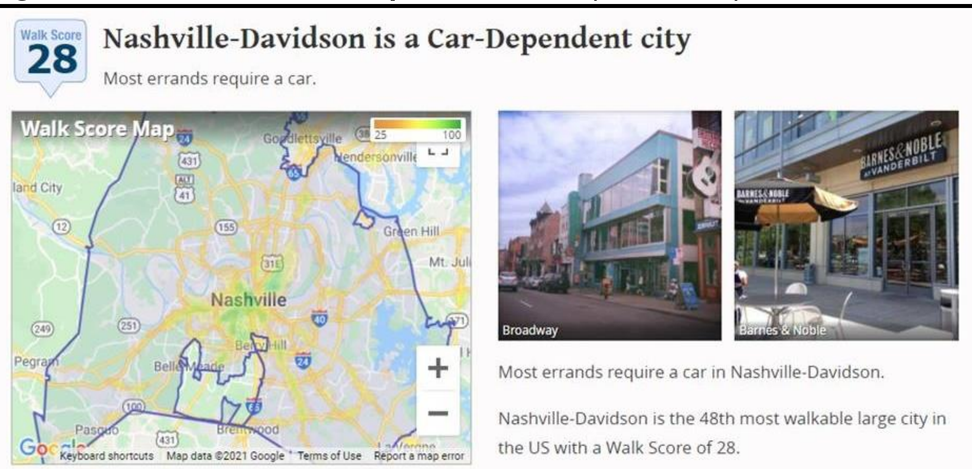
Figure 6 **Walkshed Map** (Esri 2018; Zurn 2021)



New walkshed mapping systems show the area accessible by walking in a given amount of time, taking into account the existence of sidewalks and geographic constraints such as highways and waterways, but seldom indicate sidewalk quality, topography, traffic conditions or thermal comfort.

Walk Score is another useful indicator of pedestrian accessibility; it measures the density of services within walking distance but provides little information on walking conditions such as sidewalk and path quality, road traffic and topography. Various pedestrian level-of-service, walkability indices and Universal Design Standards rate walking conditions. Climate, including cold, wind, rain and heat, also affect walkability. The following section describes ways evaluate pedestrian thermal comfort, particularly in hot climate cities.

Figure 7 **Walk Score Map of Nashville** (Walkscore)



Walk Score maps indicate the density of services and activities within walking distances, but provide little information on the quality of walking conditions.

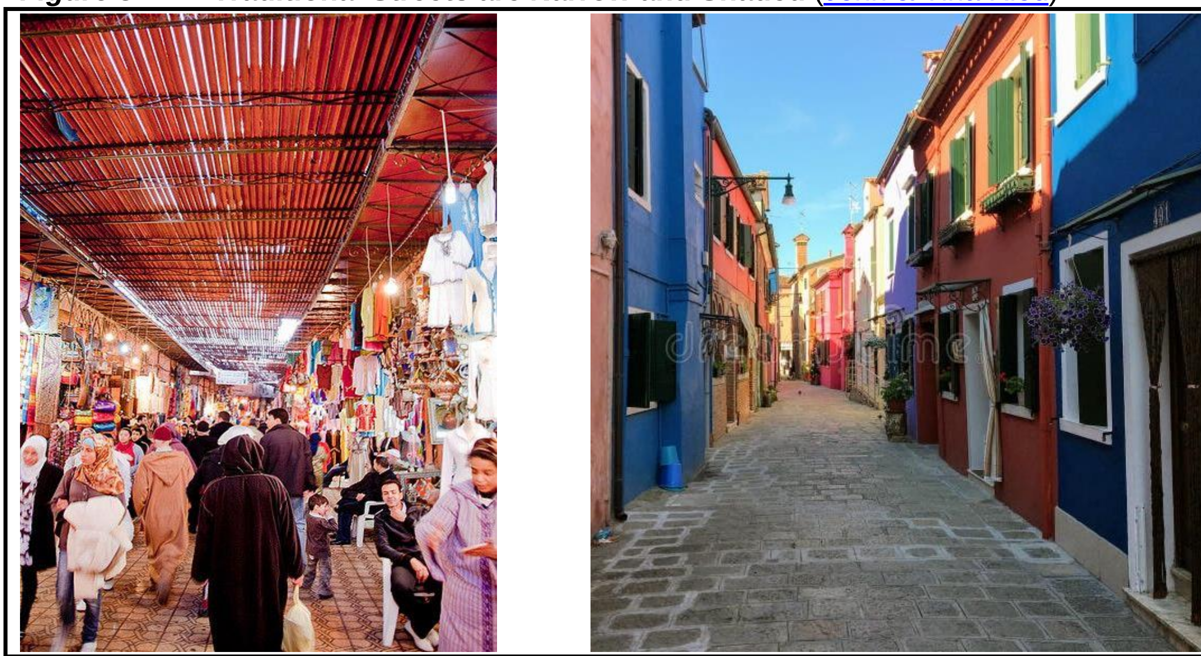
Hot-Climate Walking Comfort

Outdoor physical activity, including walking, is uncomfortable and unhealthy when dry-bulb (minimal humidity) temperatures exceed about 100°F (38°C), wet-bulb (maximum humidity) temperatures exceed 32 °C (90°F), or the heat index exceeds 55 °C (131°F) (National Weather Service). Wet-bulb temperatures over 35°C (95°F) are considered deadly. Many communities already experience excessive heat, and this is likely to increase with global warming and urbanization (UCCRN 2018). A recent study, "Quantifying the Human Cost of Global Warming," predicts that the number of people suffering from extreme heat will increase from about 600 million now to two billion by 2030 (Lenton, et al. 2023).

Walking on hot unshaded paths tends to cause discomfort and risk because pedestrians are physically active and absorb radiant heat as sunlight reflected from light-colored surfaces and heat radiated from dark surfaces. These problems are particularly severe in cities due to the *heat island effect* which increases ambient temperatures 1-7°F due to more dark surfaces (pavement and roofing), less greenspace (such as tree cover), and heat-generating activities such as motor vehicle operation (USEPA 2023). This discomfort discourages walking, which reduces physical activity and increases driving, creating a self-reinforcing cycle of more emissions and pavement, more urban heat, and more pedestrian discomfort (AlKheder 2023; Basu, et al. 2024; Silva and Akleh 2018).

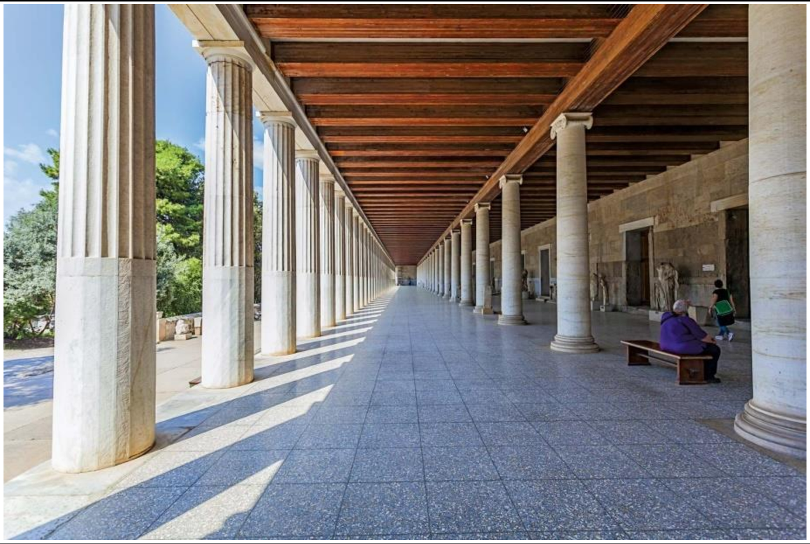
There are many ways to reduce urban heat exposure including designing buildings with natural and mechanical cooling, providing shade, and increasing greenspace and tree cover (Atef 2013; Chaudhry 2011; Ladd and Meerow 2022; Litman 2022; Rahman 2019). Pedestrians and bicyclists can be protected with *shadeways* (shaded sidewalks and bikeways) and *pedways* (enclosed, climate-controlled walkways). The *Abu Dhabi Urban Street Design Manual* (ADUPC 2009) and *Abu Dhabi Public Realm Design Manual* (ADUPC 2010) include detailed design guidelines. To be effective these must be planned as integrated networks to provide convenient and comfortable pedestrian connections between homes, services and public transit within a compact community.

Figure 8 **Traditional Streets are Narrow and Shaded** (John & Tina Ried)



Traditional hot climate urban design includes narrow, shaded streets that provide natural cooling.

Figure 9 **Traditional Building with Colonnade** (Britannica)



Some traditional urban buildings have colonnades that provide cool walking corridors.

Figure 10 **Trees Can Provide Beautiful Shadeways** (Deep Root)

A line of large trees can provide excellent shade for sidewalks and paths, but they require adequate space plus reliable water, and take many years to grow.

Trees can provide beautiful shade, as illustrated above, but they require adequate space plus reliable water and maintenance, and take many years to grow. Providing all-day shade may require trees on both sides of a walkway, which is often infeasible. Trees alone seldom provide sufficient shade (more than 80% of sidewalk coverage); structures and awnings are often needed. There are many possible designs, including metal, wood, bamboo and fabric, as illustrated below. They also provide protection from rain and snow. In extreme dry heat, walkways can incorporate misting systems to cool outdoors, but these add costs, consume water, and are not generally suitable for large areas (The Plumber 2016).

Figure 11 **Structured Shadeway in Dubai**

Figure 12 **Commercial Shadeway Structure** (Darshan Industries)

Figure 13 **Commercial Shadeway Structure** (Upside Innovations)

Shade canopies can incorporate solar panels, such as the 196 meter walkway connecting the Singapore Discovery Centre with a nearby bus-stop, illustrated below. These can power pedway cooling systems.

Figure 14 **Shadeway with Solar Panels** (Singapore Records 2018)

Sidewalk canopies, such as this 196 meter walkway in Singapore, can incorporate solar panels to provide both shade and electricity.

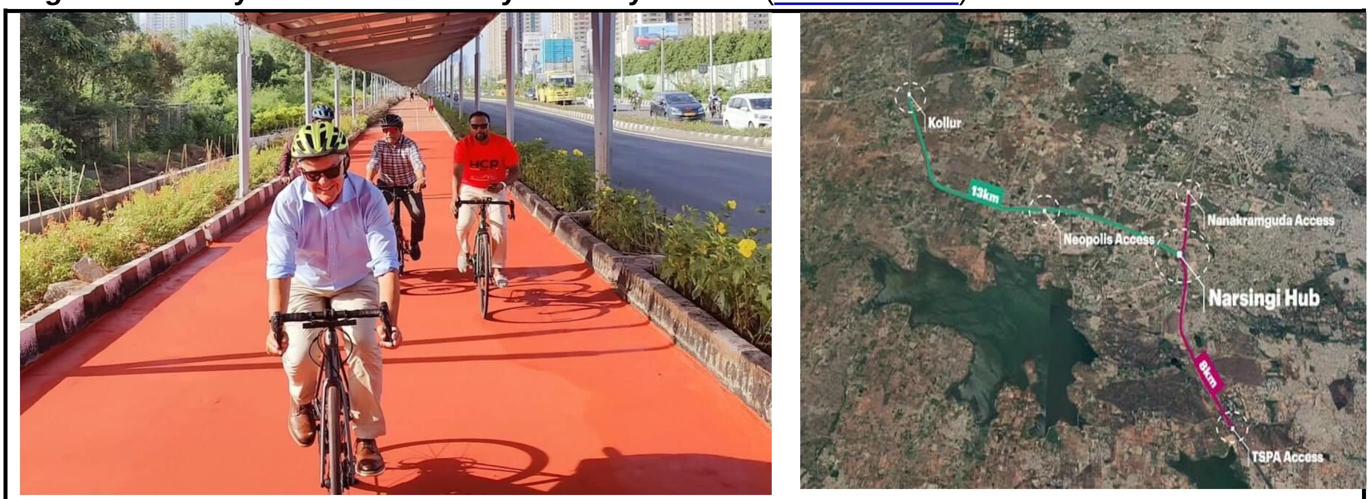
Bike paths can also have shadeways. The 20-mile path between Daejeon and Sejong, South Korea contains 5.5 miles of awnings with 7,502 solar panels that help power municipal services.

Figure 15 **Hyderabad Healthway Solar Cycle Path** (Johnson 2023)

The Daejeon to Sejong highway contains a 20-mile bike path with 5.5 miles of solar panel awnings. It uses 7,502 solar panels to power municipal services.

Hyderabad, India's Healthway is a 23-kilometer three-lane track covered by solar panel awnings that connects many urban destinations. It includes amenities such as bike docking and rental stations, food courts, water fountains, restrooms, bicycle repair shops, security cameras and parking.

Figure 16 **Hyderabad Healthway Solar Cycle Path** (Johnson 2023)



Hyderabad Healthway 23-kilometer solar panel covered walking and bicycling track connects many destinations. This image shows former Norwegian minister and renowned environmentalist Erik Solheim riding it with Arvind Kumar, Secretary of Hyderabad's Municipal Administration and Urban Development Department.

Currently, most shadeway and pedway planning is ad hoc, built where they are convenient to build, not necessarily where they are most needed. A more systematic approach is needed to plan integrated hot-climate pedestrian networks.

The Cool Walkshed Index

The *Cool Walkshed Index* (CWI) summarized below can be used to evaluate the pedestrian thermal comfort of walkways, buildings and neighborhoods in hot climate cities. CWI maps can be used to identify where shadeways and pedways are justified; rate hot weather pedestrian accessibility between homes, services, jobs and public transit stations; and set targets for improvements.

Cool Walkshed Index (CWI) Ratings

A: Connected to a continuous, enclosed, climate controlled pedway that provides access to commonly-used services (shops, restaurants, social and cultural activities), and high quality public transit stations.

B: Located within 1,000 feet (300 meters) of a pedway entrance where ambient temperatures frequently exceed 100° Fahrenheit (38°Celsius); and within 300 feet (100 meters) of a pedway entrance where temperatures frequently exceed 110° Fahrenheit (43° Celsius).

C: Connected to a continuous shadeway (walkway with at least 80% shade coverage during mid-day) that provides access to commonly-used services and high quality public transit, with shaded transit waiting areas.

D: Connected to a continuous but unshaded walkway that provides access to commonly-used services and high quality public transit.

E: Connected to an incomplete walkway that provides inadequate access to local services and public transit.

F: Has major barriers to walking to local services and public transit.

The Cool Walkshed Index (CWI) indicates comfortable walkability for a building or area in a hot climate city. These values should be adjusted to reflect specific conditions and needs. The recommended maximum distances to a pedway entrance (100 to 300 meters) reflect the lower range of acceptable outdoor walking distances between buildings and parked vehicles or transit stations (Pueboobpaphan, Pueboobpaphan and Sukhotra 2022; Smith and Butcher 2006).

Currently, most buildings and neighborhoods have CWI ratings of **E** (incomplete and largely unshaded sidewalks and paths) or **D** (complete but largely unshaded sidewalks and paths) to nearby services and activities. Few neighborhoods have well-developed shadeways that provide **C** ratings, and only a few cities have pedway networks that provide **B** or **A** ratings.

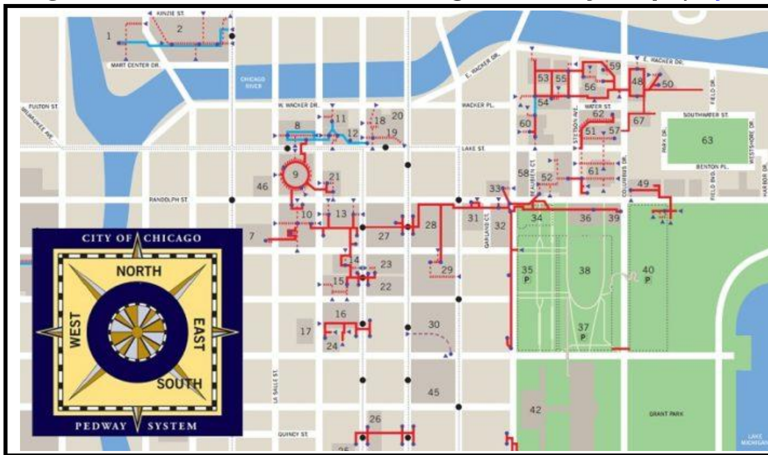
CWI ratings can help individuals make better location decisions, and communities make better planning decisions. For example, families may choose homes with higher CWI rating, and can rationally pay more if improved walking comfort increases their exercise and enjoyment, and reduces their vehicle expenses. Developers and property owners can justify helping finance neighborhood shadeways or paying for a pedway connection in order to raise their CWI ratings.

Of course, shadeways and pedways must be properly designed and managed. They should reflect universal design principles to accommodate all types of users including people with disabilities, families with children, travellers with hand carts and wheeled luggage (NTA 2021). Shadeways should be designed with shadow analysis to ensure that sidewalk and path surfaces have at least 80% shade during summer mid-days (10:00 am to 4:00 pm) (Rodriguez 2020). They should be designed with sufficient capacity to avoid crowding, and well maintained for comfort, safety and attractiveness.

Pedway Network Examples

Many cities have pedway networks (basement versions are called underground cities and elevated versions are called skyways), although most are limited in scale, serving only a portion of destinations and walking trips (Cui 2021). Toronto's PATH network, described earlier, is one of the most complete, with more than 30 kilometers of enclosed walkway that connect directly to or close to most downtown buildings, public transit stations, and attractions (Toronto 2021). Chicago, Edmonton, Montreal are other cold-climate cities with extensive pedways.

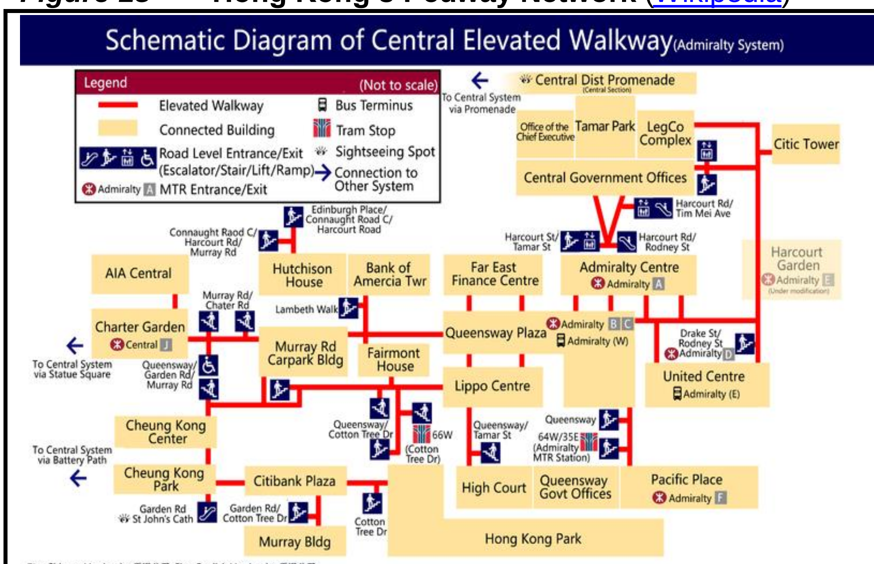
Figure 17 **Downtown Chicago Pedway Map** (Style Chicago 2017)



Downtown Chicago has approximately five miles of underground and overhead pedways that tens of thousands of pedestrians use each day to access public and private buildings, rail stations and popular attractions such as parks, museums and recreational facilities.

There are also pedway networks in hot climate cities. Hong Kong has two multi-level walking networks, the Central and Admiralty systems, which connect many buildings, transit stations and attractions. It was built over the last half-century by the Hong Kong Government and major downtown developers. The network includes shaded elevated pathways separated from traffic, plus air conditioned corridors in many commercial buildings (Tan and Xue 2014).

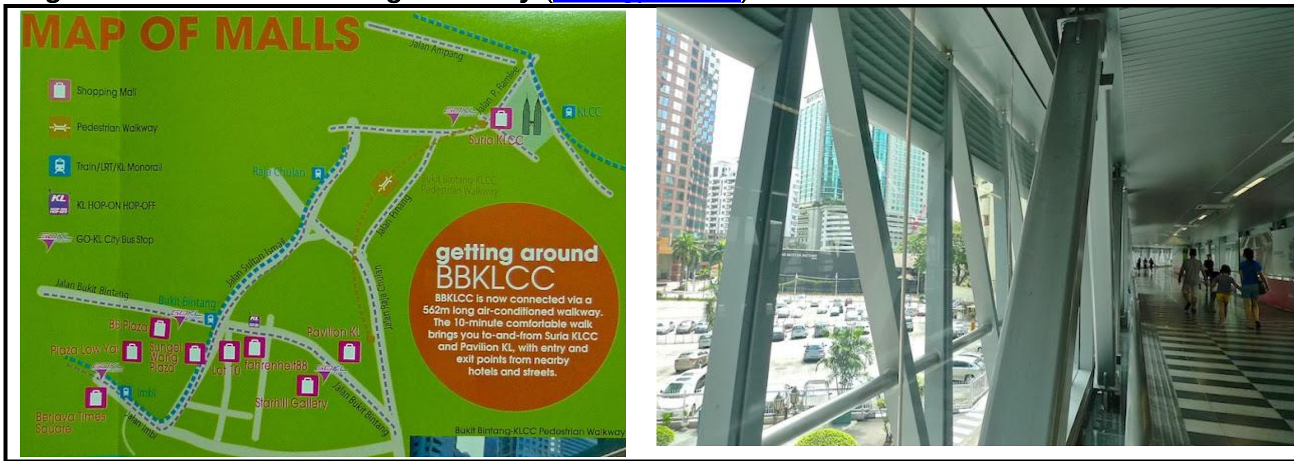
Figure 18 **Hong Kong's Pedway Network** (Wikipedia)



Hong Kong's pedway network includes shaded walkways separated from traffic and air conditioned corridors in many commercial buildings.

Bangkok's Skyway system is suspended between the elevated Skytrain tracks. It is promoted as a convenient and comfortable alternative to walking on city streets with crowded sidewalks and busy traffic, but as of 2020 only 15% of the proposed system is completed and progress is slow (BigChili 2020). It is financed by private businesses, with minimal government support. Kuala Lumpur's Bukit Bintang Walkway, completed in 2012, is a 1.2 kilometer enclosed and air conditioned pedway that connects the Convention Centre, shopping malls, hotels and other major destinations.

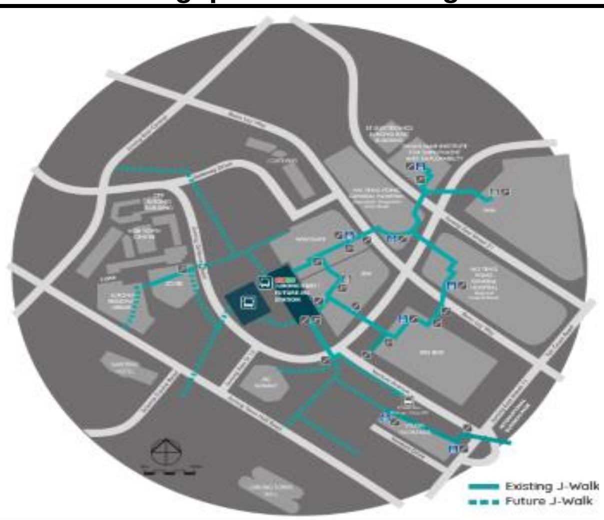
Figure 19 **Bukit Bintang Walkway** (Foongpc 2013)



Kuala Lumpur's KLCC - Bukit Bintang Walkway connects a convention center with shopping malls, hotels and public transit stations in a downtown that is otherwise not very pedestrian friendly.

Singapore's J-Walk is a network of approximately 25 kilometers (15 miles) of elevated and underground pedestrian walkways that connect commercial, health-care and institutional developments to public transport stations. It is developed by Singapore's Urban Redevelopment Authority, which has plans to create pedways around major transit stations, as illustrated below (Leow 2008).

Figure 20 **Singapore Western Region Pedway Plan** (URA 2019)



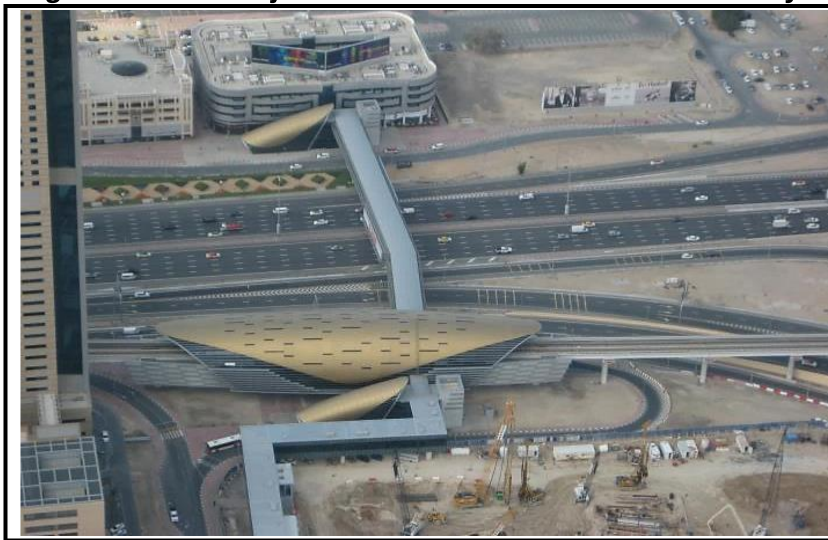
Singapore's Urban Redevelopment Authority has plans to develop J-Walk pedestrian facilities around most rail stations, creating walkable, transit-oriented neighborhoods. It envisions widening existing footpaths and bike lanes, and lining them with shade trees for a pleasant walking and bicycling experience.

Seoul, South Korea has a well-developed underground network that connects metro stations to popular attractions such as shopping centers and museums. Taipei, Taiwan has underground pedways connecting many metro stations, the main train station and a large underground shopping mall and other attractions.

Many Chinese cities have underground pedway networks. The largest is in Zhujiang New Town which connects metro stations to the basements of over 35 office towers, numerous shopping malls, medical centers, and other downtown attractions. Harbin has several large, multi-level underground shopping areas such as the roundabout intersection of Xida Zhi and Hongjun streets, where three levels of markets meet under a giant atrium. Hangzhou's Wulin Square connects an underground mall to a subway station and nearby office buildings. Guangzhou has more than 16 pedways around rail stations. Nanjing has an underground mall around Xinjiekou metro station. Qingdao has two small underground shopping areas.

Dubai's Metro system has beautiful stations, some with enclosed walkways over busy highways, such as the half-mile pedway between the Burj Khalifa Station and the Dubai Mall, illustrated below. Dubai has proposed but not built enclosed air conditioned bikeways (Leigh-Hewitson 2023).

Figure 21 **Burj Khalifa Station to Dubai Mall Pedway**



Dubai's metro stations are beautiful, efficient and comfortable. Some have enclosed, air conditioned walkways over busy highways, such as this connection to the Dubai Mall, viewed from the Burj Khalifa (the world's tallest building). However, this is an exception. Most station areas have poor sidewalks, busy roads, little shade and dispersed development, making walking between transit stations and destinations uncomfortable, particularly during hot summer days. These obstacles reduce transit ridership and increase driving.

In 2009 the Dubai Road and Transport Authority (RTA) announced plans to build air-conditioned pedways to link major buildings, shopping centres, Metro stations and bus stations (Ahmed 2009). The RTA presented a pedway planning methodology at the 2011 International Association of Public Transportation meeting. The engineering firm Arup developed various pedway designs that include air conditioned and naturally-ventilated walkways, and shaded sidewalks (Dunn 2009). They explain,

> Arup's microclimate experts modelled thermal comfort and sensations over time starting from walking in the winter sun to define a comfortable transient sensation level. They analysed transient comfort, considering walking speed, metabolic rate and walking distances. This led to the proposal that the pedway would need air conditioning at regular intervals to bring thermal sensation back down between naturally ventilated sections.

Benefits and Costs

This section described shadeway and pedway benefits and cost. For additional information see "Evaluating Active Transport Benefits and Costs," (Litman 2023a).

Benefits

*Improved user comfort and fitness***.** Increasing pedestrian comfort increases walking activity which improves public fitness and health. Because disadvantaged groups rely on walking and are vulnerable to heat they can benefit significantly from shadeways and pedways.

User savings. Residents of walkable urban villages typically own fewer vehicles, drive less, and spend much less on transportation residents as in automobile-dependent areas (*Housing + Transportation Affordability Index*). This can save thousands of dollars annually per capita.

Increased property values. Residential and commercial property values tend to increase with improved walkability and access to high quality public transit services (Boyar 2016). One study found that a 10-point increase in Walk Score is associated with a 5% to 8% increase in commercial values (Alfonzo 2015) with even larger gains from proximity to high-quality transit stations (Smith and Gihring 2022).

Increased local business activity and tax revenue. Businesses located in walkable commercial districts tend to have more customers and sales (ALR 2013). One major study found that improving walkability can increase local sales up to 80% (Alfonzo 2015). This can increase sales and property tax revenues.

Reduced traffic problems. Improving walkability can reduce automobile traffic and associated costs. Urban village residents typically make about half as many vehicle trips as in automobile-oriented areas, which reduces traffic congestion, infrastructure costs, crash risk and pollution emissions. By reducing vehicle traffic, pedways networks can make cities more attractive and successful.

Travel Impacts

Many shadeway and pedway benefits depend on the amount that they increase walking and reduce automobile travel. Shadeways and pedways can significantly increase walking and reduce driving, particularly in affluent cities where many travellers can afford to drive (CPSTF 2017). Neighborhoods with excellent walkability often have 20% to 50% walking mode shares and much lower vehicle ownership and use than in auto-oriented areas (Buehler and Pucher 2023; C40 2019; Schneider, Handy and Shafizadeh 2014).

Ambient temperatures significantly affect walking, particularly by women, children and seniors (Shaaban, Muley and Elnashar 2017). Shaaban and Muley (2016) found that in Doha, Qatar, walking trips declined 57% during summer days when temperatures ranged from 35-42°C (95-108°F) compared with 20-28°C (68-82°F) in winter. Public transit ridership also declines in hot conditions (Shaaban and Siam 2021). A survey of Dhahran, Saudi Arabia residents found that 43% would like to walk daily but many are hesitant due to summer heat and inadequate sidewalks (Rahman and Nahiduzzaman 2019).

To maximize benefits shadeways and pedways should be developed in compact, mixed urban villages where many homes and worksites are located within walking distances of commonly-used services; with excellent taxi/ridehailing, carsharing and public transit services so households can reduce private automobile ownership; unbundled parking so residents are not required to pay for parking facilities they don't need; and with transportation demand management (TDM) incentives that reward travellers for reducing their vehicle ownership and use. Together, these factors can maximize travel impacts, benefits, and economic returns.

Costs

Shadeways and pedways are more costly than basic sidewalks and paths. A typical sidewalk costs $50 to $150 per linear foot, depending on materials and conditions (Litman 2023a). Adding a sturdy canopy can double those costs, and enclosed pedways are even more expensive, particularly if they require tunneling or overhead structures, escalators and elevators.[1] They can also increase operating, administration and liability costs. However, they are inexpensive compared with urban roadway, parking facility and motor vehicle costs.

2 Table **Typical Shadeway and Pedway Costs**

Type	Costs
Fabric awnings.	Very low
Structured awnings.	Low
Above-ground pedways.	Moderate
Integrated underground pedways.	High
Retrofitted underground pedways.	Very high

Urbanists sometimes criticize pedways for being sterile, privatized spaces that remove pedestrians from the public realm, reduce street activity, and exclude lower-income people (Ponting and Lim 2015; P-World News 2024). They are also criticized for increasing air conditioning energy consumption. Such criticisms may be legitimate where travellers choose between walking in pedways or on vibrant public sidewalks, but not if they would otherwise drive.

Pedways can be planned to provide a quality walking experience, maximize community livability, and welcome diverse users. They should be interesting and attractive places that provide opportunities for spontaneous social interactions. Pedways can include places to sit, viewpoints and artwork to enjoy, and non-commercial attractions such as schools, museums, libraries, indoor recreation facilities and community centers. For example, Toronto's PATH pedway network includes many family activities, and Chicago's pedway network has underground attractions that attract many visitors.

Air conditioning has economic and environmental costs, so buildings and pedways should rely on passive cooling where possible and maximize cooling system efficiency (Litman 2022). However, passive cooling is inadequate in extreme heat so mechanical cooling is often necessary. With modern high performance solar panels and air conditioning, shadeway solar arrays can power a major portion of cooling loads. Pedway energy costs are much smaller than consumed if travellers drive rather than walk.

The table below summarizes shadeway and pedway benefits and costs. Because they are expensive, pedways are most justified in dense urban centers where they experience heavy use. It would be very costly to connect *all* buildings to pedways (CWI **A**); a more realistic goal is to locate most buildings within a short walk of pedway entrances, with distances depending on heat exposure (CWI **B**).

Table 3 **Shadeway and Pedway Benefits and Costs Summary**

Benefits	Costs
• Increased pedestrian comfort and enjoyment. • Increased walking improves public fitness and health. • Vehicle and parking cost savings. • Increased property values for connected and nearby properties. • More local business activity and tax revenues. • Reduced traffic problems (congestion, crashes, pollution, etc.)	• Additional construction costs. • Pedway air conditioning costs. • Sterile and isolated walking conditions.

Shadeways and pedways can have various benefits and costs. Comprehensive evaluation considers them all.

[1] Based on estimates from commercial suppliers such as Upside Innovations (https://upsideinnovations.com), Darshan (www.darshanpeb.com) and Duo-Gard Industries (www.duo-gard.com).

Business Case Example

This example evaluates the benefits and costs of a typical pedway network.

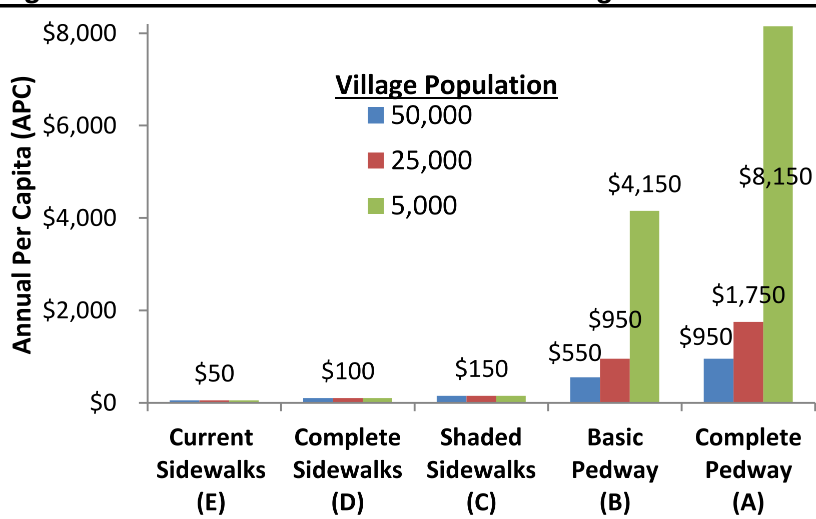
As previously described, most jurisdictions currently spend less than $50 annually per capita to build and maintain public sidewalks and paths. The report, *Completing Sidewalk Networks: Benefits and Costs* (Litman 2024) indicates that funding increases are justified to achieve various economic, social and environmental goals, and are often very cost effective when all benefits are considered. A few jurisdictions, such as Albuquerque, Denver, Los Angeles, and Washington State spend about twice the normal levels to complete their sidewalk networks and meet universal design standards. Building shadeways on main sidewalks and paths (those on arterials, around shopping districts, and near schools), representing 10-20% of total length is estimated to cost an additional $50 annually per capita.

Pedway costs are estimated to average $10 million per mile to build, which is comparable to the cost of adding an urban arterial lane in U.S. cities (FHWA 2020). Of course, this will vary depending on conditions, with lower costs for pedways developed in conjunction with building and roadway projects, and higher costs when they are retrofitted or where conditions are particularly challenging.

Assume that in a typical urban village, a basic pedway network that provides CWI **B** (most homes and businesses are located within a 300 to 1,000 feet walk of a climate-controlled pedway) requires two pedway miles, and a more complete pedway network that provides CWI rating **A** to most homes and worksites (most buildings have pedway connections) requires four pedway miles.

The figure below compares the costs of achieving various CWI ratings. CWI **E** (the incomplete sidewalk networks that currently exist in most communities) is estimated to cost about $50 annually per capita (APC). CWI **D** (a complete sidewalk network) is estimated to cost about $100 APC. CWI **C** (shaded sidewalks on main routes) is estimated to cost about $150 APC. CWI **B** (pedway access within 300-1,000 feet of most homes and worksites) is estimated to cost between $550 APC if it serves 50,000 people, or up to $4,150 APC if it serves just 5,000 residents and workers. CWI **A** (a complete pedway network connecting most residences and commercial buildings) is estimated to cost between $950 and $8,150 annual per capita, depending on walkshed population.

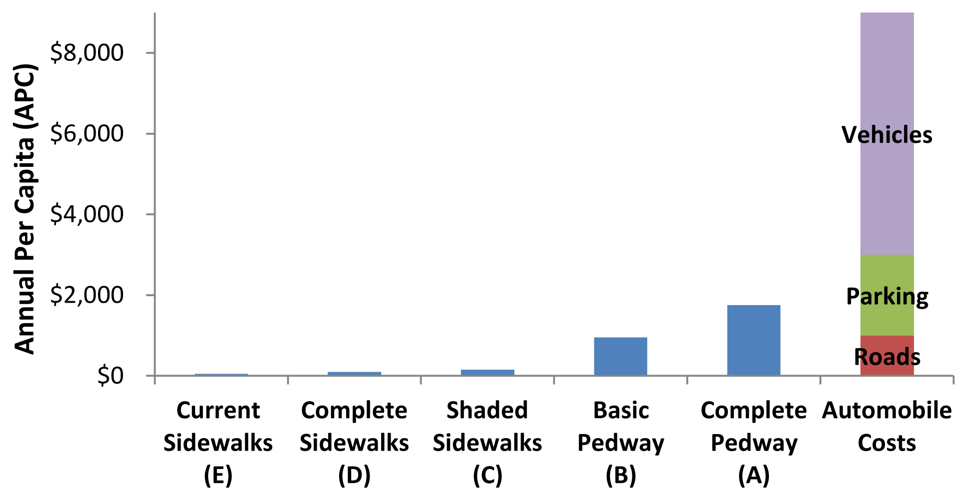
Figure 22 **Estimated Costs of Achieving Cool Walkshed Ratings**



*CWI **E** (incomplete sidewalk networks) cost about $50 annually per capita (APC). CWI **D** (a complete sidewalk network) costs about $100 APC. CWI **C** (shaded sidewalks on busy routes) costs about $150 APC. CWI **B** (pedway access within 300-1,000 feet of most buildings) costs $550 if costs are distributed among 50,000 users, or up to $4,150 for just 5,000. CWI **A** (complete pedway network connecting most buildings) would cost between $950 and $8,150 APC, depending on walkshed population.*

Are these facilities expensive? A comprehensive shadeway and pedway network would require large increases in pedestrian spending, which makes them seem costly. However, they are inexpensive compared with what governments currently spend on roads and traffic services (about $1,000 annually per capita), what businesses spend on parking facilities (more than $2,000 annually per capita), and what motorists currently spend on vehicles in automobile-dependent areas (more than $6,000 annually). If shadeway and pedway investments allow road, parking and vehicle costs to decline 5% to 20% they can more than repay costs and provide other economic, social and environmental benefits. They become more cost effective if developed during building and roadway construction (which minimizes their costs); if implemented in large compact urban villages (which maximizes their usefulness); and if implemented with TDM incentives (which increases their use).

Figure 23 **Estimated Walkshed and Automobile Costs for 25,000 Population Village**



*In an urban village with 25,000 residents and workers, a complete pedway network (CWI **A**) is estimated to cost about $1,750 annual per capita (APC). This is more than is currently spent on sidewalks (about $50 APC), but small compared with the total annual costs of urban automobile travel including roads ($1,000), parking ($2,000) and vehicles ($6,000).*

The table below summarizes the value chain from shadeway and pedway investments. By improving walking conditions they can increase walking, which increases enjoyment and health. By reducing driving they reduce vehicle and parking costs, and local traffic problems. These changes tend to increase local property values and business activity, leading to higher tax revenues. These additional public revenues can often repay shadeway and pedway investments.

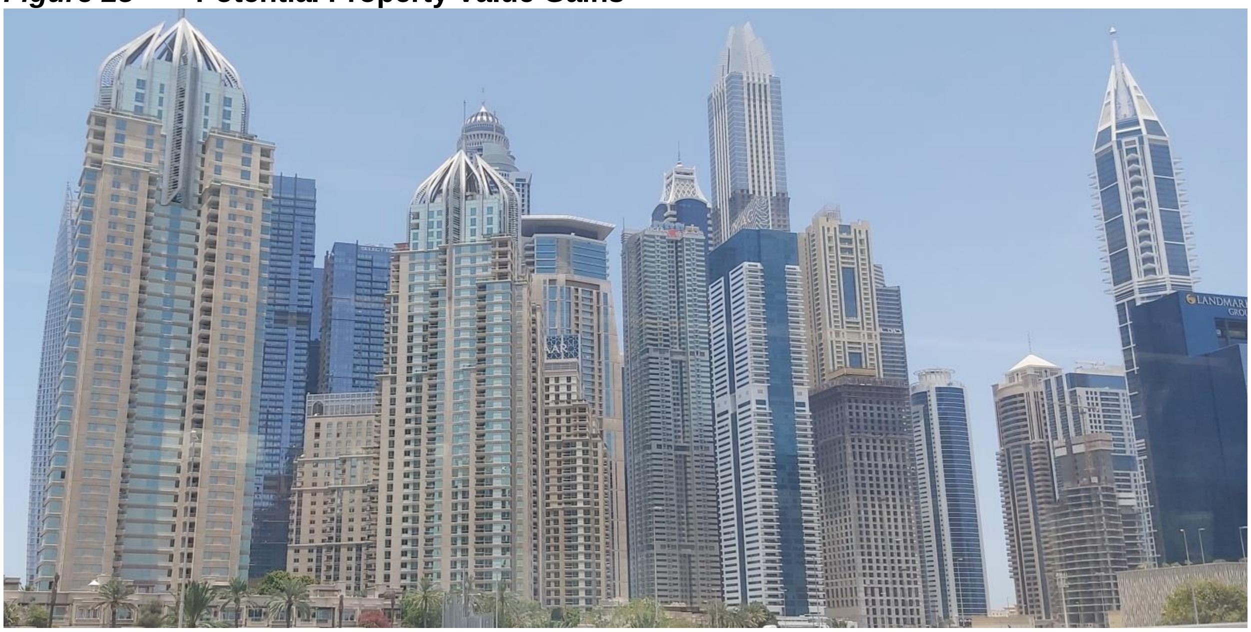
Figure 24 **Shadeway and Pedway Value Chain**

Shadeway and Pedway Investments
↓
Better Walking Conditions
↓
More Walking | **Less Driving**
↓ | ↓
Increased Enjoyment and Health | **Vehicle and Parking Cost Savings** | **Reduced Local Traffic Problems**
↓ | ↓ | ↓
More Valuable Housing and More Local Business Activity
↓
Higher Tax Revenue (which can be reinvested in pedestrian facilities)

Shadeway and pedway investments can improve walking conditions, which increases walking, and therefore enjoyment and health. It also reduces driving which reduces vehicle and parking costs, and local traffic problems. These changes increase local property values and business activity, increasing tax revenues, which can repay their costs.

Previously mentioned studies indicate that improved walkability often increases property values 5-15%, and access to high quality public transit can doubles that value. This occurs because improved non-auto access provides vehicle and parking facility savings that can be reinvested in rents and mortgages. A pedway network that connects dozens of residential and commercial buildings can generate millions of dollars in total annual savings and economic benefits. Some of this value can be captured through connection fees or special taxes.

Figure 25 **Potential Property Value Gains**



Large commercial centers often contain dozens of high rise buildings each worth more than a hundred million dollars. If pedway connections increase their value by 5-15%, by improving pedestrian access and reducing vehicle and parking costs, the property value gain can total billions of dollars.

To maximize impacts and benefits, urban development policies should support the creation of compact urban villages and encourage property owners to connect to pedways. Parking minimums should be reduced or eliminated for buildings with higher CWI ratings so owners can save on parking infrastructure costs. Fees and taxes should be implemented gradually to avoid discouraging development in catchment areas. For example, if a pedway connection is estimated to increase a building's future value 10%, a connection fee or value capture tax could be 0% the first year and increase one percentage point each year for five years, so cost burdens are initially low but increase as building revenues grow.

Factors to Consider

Shadeway and pedway planning should consider the following factors.

Local Climate and Topography

Shadeway and pedway benefits are greatest in areas with extreme heat, cold, rain, snow, pollution, smoke or dust. The more severe and frequent these conditions, the greater their benefits. Shadeways tend to be helpful in temperatures over 85° Fahrenheit (30° Celsius), and pedways over 90° F (32° C), particularly with high humidity or steep terrain that makes walking unpleasant.

Development Density and Mix (Urban Villages)

The more people, jobs and services located within a walkable area, the more people will walk and benefit from pedways and shadeways. Comprehensive pedways require an urban village with at least 10,000 residents or workers within the walkshed. Since shadeways are less expensive they can serve lower density areas, but still require compact and mixed development.

Facility Quality

To maximize benefits, shadeways and pedways should be well designed and managed; they should meet universal design standards, be clean, comfortable, safe and seldom crowded, including clear wayfinding (signs and maps to help users navigate the system), and have points of interest to make them attractive destinations. They should be managed similar to other enclosed semi-public spaces such as public transit facilities and shopping malls

Integration

Because they experience economies of scale, shadeways and pedways should connect to the maximum number of homes, services and destinations. They should be integrated with overall pedestrian networks, with numerous entrance-ways, and with public transportation networks, with connections to air conditioned or shaded stations and stops. They should have standardized wayfinding. Their benefits tend to increase with TDM incentives such efficient parking pricing (motorists pay directly for using parking facilities), public transit service improvements, commute trip reduction programs, and traffic prioritization, so travellers are encouraged to shift from driving to walking and public transit.

Social Equity Goals

Shadeways and pedways ensure that physically and economically disadvantaged travellers, who often rely on non-auto modes and are vulnerable to extreme weather, have comfortable walking conditions and receive a fair share of transportation infrastructure investments. Where possible, shadeways and pedways should be connected to affordable housing, and public services used by disadvantaged groups.

Smart Business Models

As much as possible, pedways should be financially self-sustaining; their costs should be repaid through connection fees and rents. Pedways can be linear shopping centers, lined with commercial spaces. Local governments can either require or encourage building owners to connect and maintain their portion of the network. Public transit agencies can support pedways as extensions of their stations. Local governments and business associations can promote the networks to businesses, home buyers, customers and visitors.

Conclusions

Improving walkability can provide significant benefits to people, businesses and communities, particularly in dense urban areas where vehicle traffic imposes high costs. Since extreme heat and cold can make walking uncomfortable and unhealthy, it is important to plan for pedestrian thermal comfort.

Well-designed *shadeway* and *pedway* networks in compact urban villages can provide convenient, comfortable and efficient non-auto access during extreme weather. They can create multimodal communities where residents, workers and visitors walk and use public transit, and minimize vehicle travel. This reduces user costs, infrastructure costs and traffic problems. Many cities have some shaded sidewalks and air conditioned walkways but few have comprehensive, integrated shadeway and pedway networks that serve a major portion of destinations.

The Cool Walkshed Index (CWI) is a practical way to evaluate walking facility thermal comfort. It can be used to rate hot weather pedestrian access to a building or in area, to identify problems, and to set improvement targets. Currently, most urban buildings and neighborhoods have CWI **E** (incomplete sidewalk networks) or **D** (complete but unshaded sidewalk networks). Moderate-heat cities should aspire to CWI **C** (shaded sidewalks on busy routes); high-heat cities should aspire to CWI **B** (enclosed, climate-controlled pedways within 300 to 1,000 feet or 100 to 300 meters); and extreme-heat cities should aspire to CWI **A** (enclosed, climate-controlled pedways connected to most residences and commercial buildings).

To be successful these networks require effective planning and support. They experience economics of scale; these networks become more cost-effective and beneficial as they expand and connect more people, businesses, and services. As a result, property owners should be encouraged or required to connect and support to them. Shadeways are slightly more costly and pedways significantly more costly than basic sidewalks, so developing these networks requires significant investments. However, their costs are far less than the total costs of urban automobile travel, including roads, parking facilities and vehicle expenses. Although pedway air conditioning consumes energy, this is much less than what is required for automobile travel, and can be offset if shadeways have solar panels. These networks are most cost-effective if integrated into compact urban villages with at least 10,000 residents and workers located in their walksheds, and implemented with TDM incentives that encourage their use. Their costs can be recovered through value capture, with connection fees or special taxes.

The main obstacles to comprehensive pedway development are well-entrenched biases that favor motorized travel and undervalue non-motorized modes in transportation planning and investment. Transportation agencies have tools to plan and justify road and parking projects and dedicated funds to build them, but lack comparable tools and funding for walkability improvements even if they are more cost effective and beneficial overall. More rational planning would support urban village development and increase pedestrian facility investments, including shadeways and pedways in hot climate cities.

Shadeway and pedway development can substantially improve the walkability in hundreds of cities, and improve the lives of billions of people.

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