Climate and Sustainability Responses in Transport Sub-Sectors and Modes

SLOCAT Partnership on Sustainable, Low Carbon Transport

TRANSPORT, CLIMATE AND SUSTAINABILITY GLOBAL STATUS REPORT

4TH EDITION

MODULE 4

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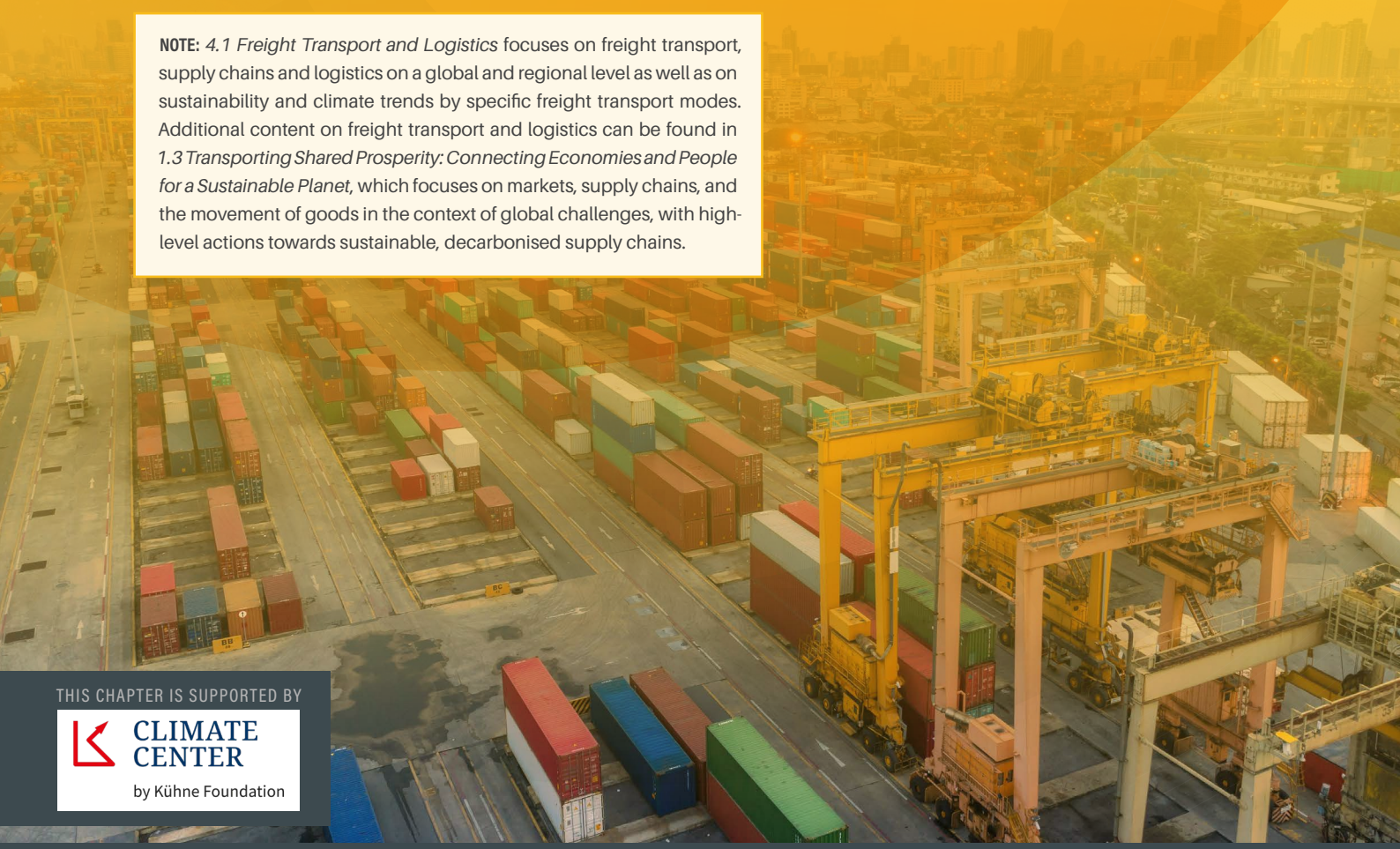
Freight Transport and Logistics

NOTE: *4.1 Freight Transport and Logistics* focuses on freight transport, supply chains and logistics on a global and regional level as well as on sustainability and climate trends by specific freight transport modes. Additional content on freight transport and logistics can be found in *1.3 Transporting Shared Prosperity: Connecting Economies and People for a Sustainable Planet*, which focuses on markets, supply chains, and the movement of goods in the context of global challenges, with high-level actions towards sustainable, decarbonised supply chains.



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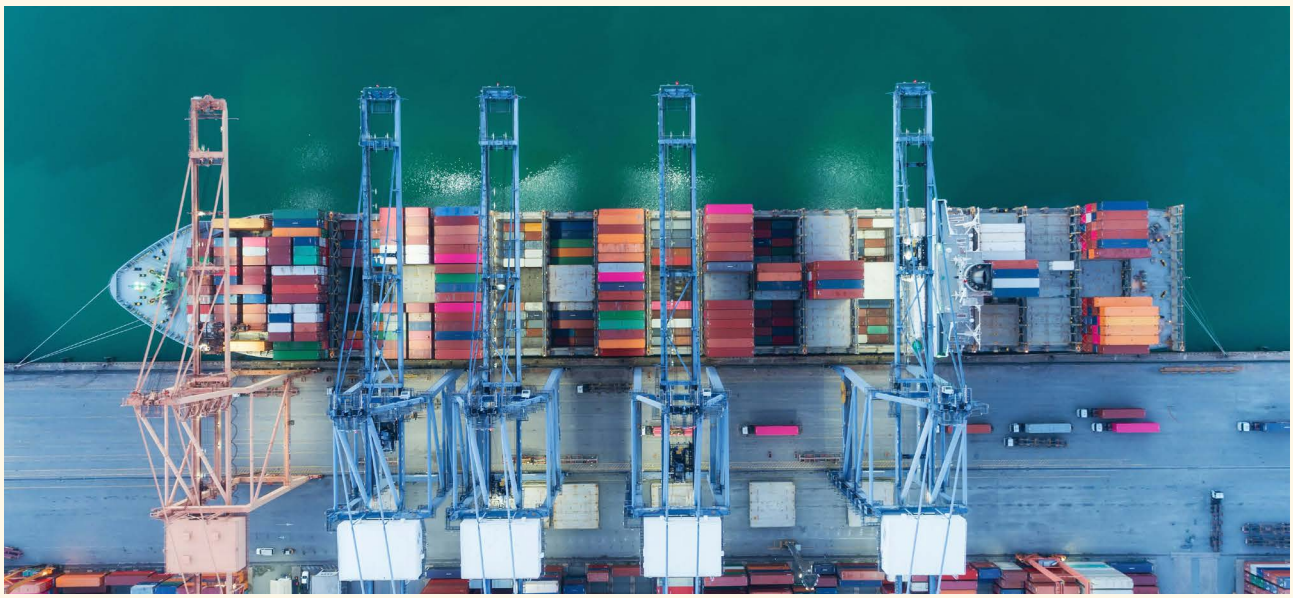
KEY FINDINGS

Demand, use and access

- Freight transport is intertwined with the economy. Logistics services – including warehousing, administration and management – generated revenues of around USD 10 trillion in 2024, or 5-10% of the global gross domestic product (GDP), with annual growth of 6-10% depending on the region. Freight transport has grown continuously in recent decades, slowing only briefly during periods of global economic crisis.
- Global freight activity grew an estimated 8% between 2020 and 2025 to surpass 171 trillion tonne-kilometres. Most of the world's freight is carried by water – in 2025, international maritime shipping accounted for 74% of all freight tonne-kilometres, and domestic maritime shipping for 5% – followed by rail (11%), road transport (10%) and aviation (0.1%).
- Shares of inland freight transport have remained relatively stable for decades, although rail's share has declined in countries that have growing market economies, such as China and India, putting into question the ambition of a modal shift from road to rail.
- Because rail transport is much less energy intensive than road transport, sustainability advocates have long supported shifting the movement of goods from road to rail. Yet so far, public policies and investments have had limited success, as the share of rail globally has dropped sharply.
- As the share of the world's people living in cities surges from 55% in 2018 to a projected 68% by 2050, urban freight transport will continue to grow. Most of this urban growth is anticipated in Africa and Asia. In 2019, urban freight activities accounted for an estimated 5% of global freight activity.
- The focus of sustainable urban freight has mainly been on technical and economic solutions, but there is a need to address pressing social issues such as health effects and social inequity.
- The weight of goods moved by maritime transport tripled over a 30-year period, rising from 4 billion tonnes in 1993 to 12 billion tonnes in 2023; by comparison, e-commerce flows achieved similar growth in less than 10 years – rising from 1.3 billion to 6.5 billion tonnes between 2014 and 2023.
- Under business as usual, freight tonne-kilometres are expected to increase 55% by 2050; Africa is likely to double its share in global freight, whereas growth in the Global North will be around 33%. International shipping and rail are expected to grow by half their 2025 volumes, while trucking activity will double and domestic shipping will reach nearly 2.5 times its 2025 volume.



KEY FINDINGS

Sustainability and climate trends

- Since the pandemic, other major disruptions to global transport, combined with the costly impacts of extreme weather events, have increased awareness among freight transport stakeholders of the importance of network and service resilience. In 2024, shipping incidents, safety threats and droughts led to dramatic declines in vessel passages in the Red Sea (down 67%), the Suez Canal (down 42%) and the Panama Canal (down 36%). As a result, global shipping rates between continents doubled or tripled.

- Global trade continued to show remarkable resilience, with few indications of regionalisation reversing globalisation – despite continued impacts such as inflation and higher costs for consumers. However, in 2025 the new US administration announced historic tariff hikes for most of its important trading partners. The impact on global trade remained unclear, given the international nature of many supply chains and the varying impacts of trade barriers. In response to the new geopolitical tensions, Europe re-balanced its sustainable development ambitions against its efforts to maintain economic competitiveness.

- The freight transport sector accounted for an estimated 5-7% of total employment in 2023, while the logistics sector – which includes transport, warehousing, administration, and information and communications technology management – had an even higher employment share (10%).

- Some sub-sectors, such as road freight, face acute shortages of workers. Challenges affecting the transport workforce include mismatches in skill requirements, new "gig markets" for e-commerce delivery that are associated with poor social conditions, and emerging technologies for autonomous and digital logistics.

- Women have been greatly under-represented in the transport workforce, accounting for only 15.6% of workers in the sector overall, and 23% in senior leadership roles, as of 2023.

- The safety of freight transport remains a serious concern, as road crashes involving heavy-goods vehicles are associated with a higher risk of fatality.

- Globally, freight transport was responsible for around 10% of energy-related CO_2 emissions and 43% of CO_2 emissions from the transport sector (including international aviation and shipping) in 2023.

- After falling slightly during the COVID-19 pandemic (in 2020), CO_2 emissions from freight transport rose to a record high of 3.5 gigatonnes in 2023. Roughly 85% of these emissions were from freight transport itself, and the rest were from the storage and handling of goods.

- By mode, the largest contributor to freight transport emissions was road freight, responsible for 70% of freight transport-related CO_2 emissions in 2023. Despite the high volume of global trade carried via water, maritime transport was responsible for 22% of emissions. Railways contributed 2.3% of emissions, the lowest share among freight transport modes.

- Aviation (domestic and international passenger and freight) contributed nearly 950 million tonnes of CO_2 emissions in 2023; of this, close to 155 million tonnes was directly linked to air freight transport (including both belly freight and air freighter transport), representing around 6% of all freight transport-related CO_2 emissions. Air cargo demand grew 11.3% in 2024, and further growth of 5.8% was expected in 2025.

- Urban freight transport was responsible for an estimated 5% of global greenhouse gas emissions and for 28% (1.1 gigatonnes) of freight transport emissions in 2023. A 2022 study found that urban freight transport represents around 15-25% of all vehicle-kilometres travelled, occupies 20-40% of the motorised road-space, and contributes 20-40% of greenhouse gas emissions and 30-50% of air pollutants.

- Modes of transport that (until recently) have relied mostly on self-regulation for emission reduction – such as maritime and air transport – have relatively high emissions and often still use less environmentally friendly propulsion technologies.

- As a result of freight growth, both greenhouse gas emissions and local emissions are predicted to increase in the future. Moreover, as emissions from passenger transport decline, freight transport's share of overall emissions is expected to rise, from 43% in 2023 to 57% in 2050.

- According to one scenario, substantially reducing freight emissions by more than two-thirds is only possible by reducing overall demand, together with shifts in transport modes and the electrification of transport.

- Battery electric trucks that run on low-carbon electricity are considered the main technology for decarbonising

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road freight transport. As electrification accelerates, battery electric trucks are expected to reach cost parity with conventional trucks in the coming years. In contrast, cost parity between hydrogen-fuelled electric vehicles and conventional trucks is not expected anytime soon.

- Global sales of medium- and heavy-duty electric trucks remained low in 2024, with shares of around 4.4% in China, 2.3% in Europe and 1.7% globally. Meanwhile, governments and industry are targeting sales shares of 50-60% by 2030 and have supported the electric truck transition through investments in charging infrastructure.
- Industrial collaborations are taking advantage of key business opportunities to drive the shift to electric trucks, enabling new actors to enter the scene. Electric mobility also opens possibilities for new business models for freight services (such as offering fleet charging services, or flexibility services to the electricity market), while digitalisation will be key to optimising routing and charging.
- The aviation industry has made some progress in using sustainable aviation fuel (SAF), the central pillar of its near- to medium-term decarbonisation strategy; however, SAF still accounted for less than 1% of aviation's total fuel consumption in 2024.
- In the rail freight sector, electrification and efficiency improvements led to a halving of emissions (both greenhouse gas and local emissions) between 2005 and 2022, even with increases in performance. As of 2022, around one-third of all railways worldwide had been electrified, mainly in India, Japan and China. With the energy demand for freight rail transport in China and India projected to nearly double by 2050 (surpassing that for passenger rail), electrification of rail networks is expected to continue.
- For maritime transport, greenhouse gas emissions per unit of dry bulk shipping fell 4% between 2019 and 2023, whereas emissions from refrigerated transport increased. Most emission improvements in the sector are attributed to efficiency measures that have relatively low or negative abatement costs.

Policy and investment developments

- The freight transport and logistics sector has remained overlooked in countries' Nationally Determined Contributions (NDCs) towards reducing emissions under the Paris Agreement. As of 1 August 2025, only 9 of the 29 third-generation NDCs that had been submitted to the United Nations Framework Convention on Climate Change included mitigation actions covering freight or a combination of freight and passenger transport.
- To reach climate targets, industry will need strong support at the national level, and many international organisations have provided comprehensive roadmaps for decarbonising freight transport. In practice, however, the scope of policies tends to be narrower, with only limited attention to demand reduction but broad support for modal shift (despite limited success). Active, successful policies have focused on efficiency improvements and electrification.
- Due to the high volume of sea transport, efforts to achieve the International Maritime Organization's (IMO) target for net zero greenhouse gas emissions by 2050 are imperative.
- Because nearly half of air freight capacity is belly freight, emission targets for air freight are directly linked to the overall emission targets for aviation, which are supported by both industry and governments. The 41st ICAO Assembly adopted the Long Term Global Aspirational Goal in 2022 and member states aim for net zero carbon emissions from international aviation by 2050. In 2021, representatives of the world's major aviation industry associations and largest aircraft and engine makers also signed the "Commitment to Fly Net Zero 2050" declaration.
- Targets for reducing pollutants from road transport have generally been harmonised across continents, despite some variations in scope and coverage.
- Governments have shown widespread support for the electrification of road freight. While several countries have official targets for reducing greenhouse gas emissions from transport, others present visions and ambitions.

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- In some regions, green corridors are being implemented to induce a transition to sustainable, low-carbon long-haul freight transport.
- In the context of road safety, several governments and other stakeholders have adopted Vision Zero strategies to end road traffic-related fatalities. For commercial drivers, interventions include safety technology standards for vehicles, infrastructure and driver behaviour/training.
- In the EU, reporting and improvement of transport emissions will become mandatory for bigger companies from 2026 and 2028 onwards, with the introduction of the EU Corporate Sustainability Reporting Directive (CSRD) and the Corporate Sustainability Due Diligence Directive (CSDDD). Pressure for small and medium-sized enterprises to follow suit will increase in Europe.
- Industry-driven initiatives at different levels have shown that companies and organisations already gain advantages from emissions accounting and reporting. A proposed EU regulation related to freight and passenger transport emissions, CountEmissionsEU, outlines a methodology for calculating and reporting greenhouse gas emissions from transport services. Such efforts are further strengthened by mode-specific efforts to measure and control emissions.
- Three key concepts for measuring and reporting the emissions of organisations are the product carbon footprint (PCF), the corporate carbon footprint (CCF) and logistics network emissions. The key challenges faced by all three concepts are similar: emissions accounting and reporting need to be based on the primary data of the organisation.
- In addition to introducing and tightening legislation on vehicle emission standards, a growing number of governments have implemented biofuel regulations – including California's Low Carbon Fuel Standard, the EU's Renewable Energy Directive (RED III) and Canada's Clean Fuel Regulations.
- At the EU level, in 2024 the region's Emissions Trading Scheme began covering all vessels entering EU ports. FuelEU Maritime, a legislative package for the use of clean energy in the maritime sector within the EU's "Fit for 55" programme, was expected to take effect in 2025. Globally, to further expand the use of sustainable fuels, the maritime industry has highlighted the need for contributions at the regional and national levels.
- The main policies that countries have adopted for rail electrification are reducing the use of diesel trains, creating dedicated rail freight infrastructure and providing subsidies for operators. Recent major investments have focused on dedicated rail corridors over very long distances in Asia (within India, and China's Belt and Road Initiative). Although many countries offer operational subsidies, experience in Europe suggests that these are not always effective.
- To meet the challenges of rising urban populations, different urban last-mile concepts have been explored and developed, including consolidation hubs, off-peak deliveries and delivery robots.

Context, challenges and opportunities

Freight transport volumes have grown nearly continuously in recent decades, propelled by population growth, industrial development, increased global trade and the acceleration of material consumption. Technology is also a strong driver of demand for freight transport. Digitalisation is propelling e-commerce services, leading to both increased long-distance air freight transport and more pressure on last-mile delivery.[1] At the same time, digitalisation helps to consolidate freight flows through digital platforms, increasing the efficiency of movements through economies of scale, and keeping costs low.[2]

Globally, freight transport was responsible for around 10% of energy-related carbon dioxide (CO_2) emissions in 2023 and for 43% of the CO_2 emissions from transport (including international aviation and shipping).[3] Urban freight transport contributed an estimated 5% of global greenhouse gas emissions and 28% of global freight transport emissions in 2023.[4] Most progress towards sustainable freight transport has been achieved through efficiency improvements in individual modes of freight transport (i.e., rail, medium- and heavy-duty trucks, vessels), with growing attention to electrification and the use of alternative fuels.[5]

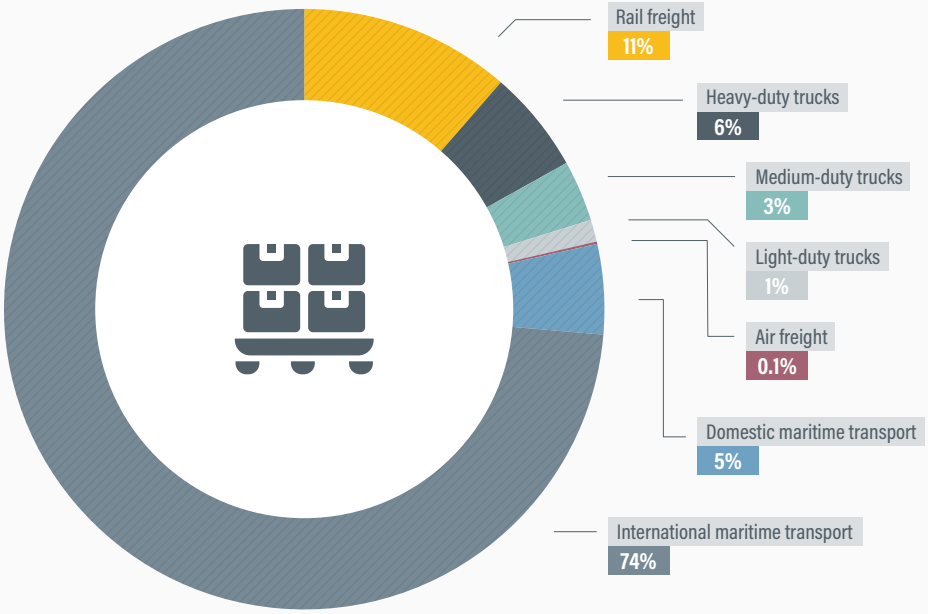
The freight transport sector supports millions of jobs worldwide and comprised an estimated 5-7% of total employment in 2023; for the whole freight transport and logistics sector, the share neared 10%.[6] Freight transport provides jobs at all training levels, including for companies and individuals that operate informally, as well as ample opportunities for upward mobility due to the strong interconnection between operations and senior management.[7] Social challenges related to rapidly evolving job markets include pressures facing logistics professionals (such as mismatches in skill requirements, rewards and absolute volumes), new "gig markets" for e-commerce delivery that are associated with poor social conditions, and emerging technologies for autonomous and digital logistics.[8]

Demand, use and access

Freight transport is intertwined with the economy. Its long-term development is driven by a growing global population, an expanding variety of products and services, and increased international trade. Efforts to deal with the climate crisis, such as rebuilding climate-damaged infrastructure and transport for carbon capture, also generate transport demand.[9]

FIGURE 1. Global freight transport by modal share, based on transport performance, 2025 estimates

Freight transport modes by freight activity in tonnes-kilometers



Most of the world's freight is carried by water – in 2025, international maritime shipping accounted for 74% of all freight tonne-kilometres, and domestic maritime shipping for 5% – followed by rail (11%), road transport (10%) and aviation (0.1%).

Note: Total = 171 trillion tonne-kilometres.

Source: See endnote 13 for this section.

Logistics services – including warehousing, administration and management – generated revenues of around USD 10 trillion in 2024, or 5-10% of the global gross domestic product (GDP), with annual growth of 6-10% depending on the region.[10] **Freight transport has grown continuously in recent decades, slowing only briefly during periods of global economic crisis.** Strong and resilient logistics performance facilitates the movement of essential goods, such as the distribution of vaccines during the COVID-19 pandemic as well as humanitarian aid, for which 14% of the cost is related to its supply chain.[11]

Global freight activity grew an estimated 8% between 2020 and 2025 to surpass 171 trillion tonne-kilometres.[12] **Most of the world's freight is carried by water – in 2025, international maritime shipping accounted for 74% of all freight tonne-kilometres, and domestic maritime shipping for 5% – followed by rail (11%), road transport (10%) and aviation (0.1%)** (Figure 1).[13] **Shares of inland freight transport have remained relatively stable for decades, although rail's share has declined in countries that have growing market economies, such as China and India, putting into question the ambition of a modal shift from road to rail** (Box 1).[14] Roughly half of global rail freight movements take place in China and the United States, 20% in the Russian Federation and 30% in other countries.[15]

Box 1. Shifting freight from road to rail?

Because rail transport is much less energy intensive than road transport, sustainability advocates have long supported shifting the movement of goods from road to rail. Yet so far, public policies and investments have had limited success, as the share of rail globally has dropped sharply. Studies indicate that the effect of rail subsidies has been limited and that greatly increasing the share of rail freight transport will require not only improved services and lower costs, but also extensions in railway networks and service capacity. It is unclear to what extent governments and industry are able and willing to successfully implement modal shift policies to help decarbonise freight transport.

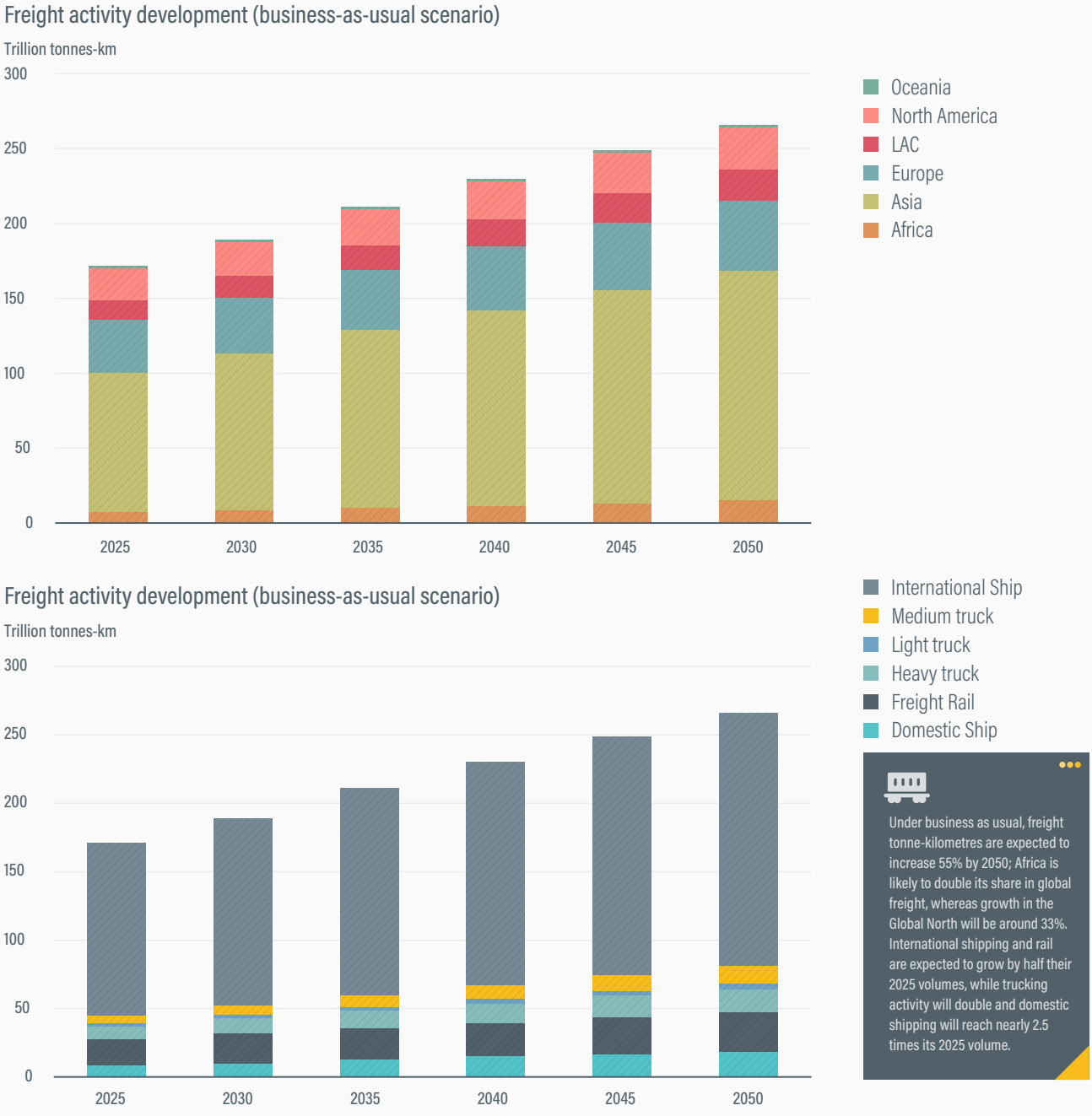
Source: See endnote 14 for this section.

As the share of the world's people living in cities surges from 55% in 2018 to a projected 68% by 2050, urban freight transport will continue to grow.[16] **Most of this urban growth is anticipated in Africa and Asia.**[17] **In 2019, urban freight activities accounted for an estimated 5% of global freight activity.**[18] Every day, cities require around 200 to 400 freight trips and deliveries per 1,000 residents, with volumes varying according to city size, economic activity and urban structure.[19] **The focus of sustainable urban freight has mainly been on technical and economic solutions, but there is a need to address pressing social issues such as health effects and social inequity.**[20]

The weight of goods moved by maritime transport tripled over a 30-year period, rising from 4 billion tonnes in 1993 to 12 billion tonnes in 2023; by comparison, e-commerce flows achieved similar growth in less than 10 years – rising from 1.3 billion to 6.5 billion tonnes between 2014 and 2023.[21]

Under business as usual, freight tonne-kilometres are expected to increase 55% by 2050; Africa is likely to double its share in global freight, whereas growth in the Global North will be around 33%.[22] **International shipping and rail are expected to grow by half their 2025 volumes, while trucking activity will double and domestic shipping will reach nearly 2.5 times its 2025 volume** (Figure 2).[23]

FIGURE 2. Freight transport growth, by region and mode, under a business-as-usual scenario, 2025-2055



Under business as usual, freight tonne-kilometres are expected to increase 55% by 2050; Africa is likely to double its share in global freight, whereas growth in the Global North will be around 33%. International shipping and rail are expected to grow by half their 2025 volumes, while trucking activity will double and domestic shipping will reach nearly 2.5 times its 2025 volume.

Source: See endnote 23 for this section.

Sustainability and climate trends

The COVID-19 pandemic, starting in 2020, increased global awareness of the importance of logistics and supply chains for everyday life. It sent severe shocks through global supply chains due to temporary changes in economic demand related to precautionary buying, online purchases and changes in consumption patterns. Consequences included dynamic acceleration (bullwhip) effects[i] in supply chains, unavailability of the labour force in manufacturing and logistics, and volatility in capacities and prices in transport chains.

Since the pandemic, other major disruptions to global transport, combined with the costly impacts of extreme weather events, have increased awareness among freight transport stakeholders of the importance of network and service resilience. In 2024, shipping incidents, safety threats and droughts led to dramatic declines in vessel passages in the Red Sea (down 67%), the Suez Canal (down 42%) and the Panama Canal (down 36%).[24] As a result, global shipping rates between continents doubled or tripled.[25]

Global trade continued to show remarkable resilience, with few indications of regionalisation reversing globalisation – despite continued impacts such as inflation and higher costs for consumers.[26] However, in 2025 the new US administration announced historic tariff hikes for most of its important trading partners. The impact on global trade remained unclear, given the international nature of many supply chains and the varying impacts of trade barriers. In response to the new geopolitical tensions, Europe re-balanced its sustainable development ambitions against its efforts to maintain economic competitiveness.[27]

The freight transport sector accounted for an estimated 5-7% of total employment in 2023, while the logistics sector – which includes transport, warehousing, administration, and information and communications technology management – had an even higher employment share (10%).[28] Some sub-sectors, such as road freight, face acute shortages of workers. Challenges affecting the transport workforce include mismatches in skill requirements, new "gig markets" for e-commerce delivery that are associated with poor social conditions, and emerging technologies for autonomous and digital logistics.[29] Despite regional variations, a global shortage of drivers could result in 3.6 million unfilled positions, a situation that is expected to worsen due to difficulties in recruiting younger drivers.[30]

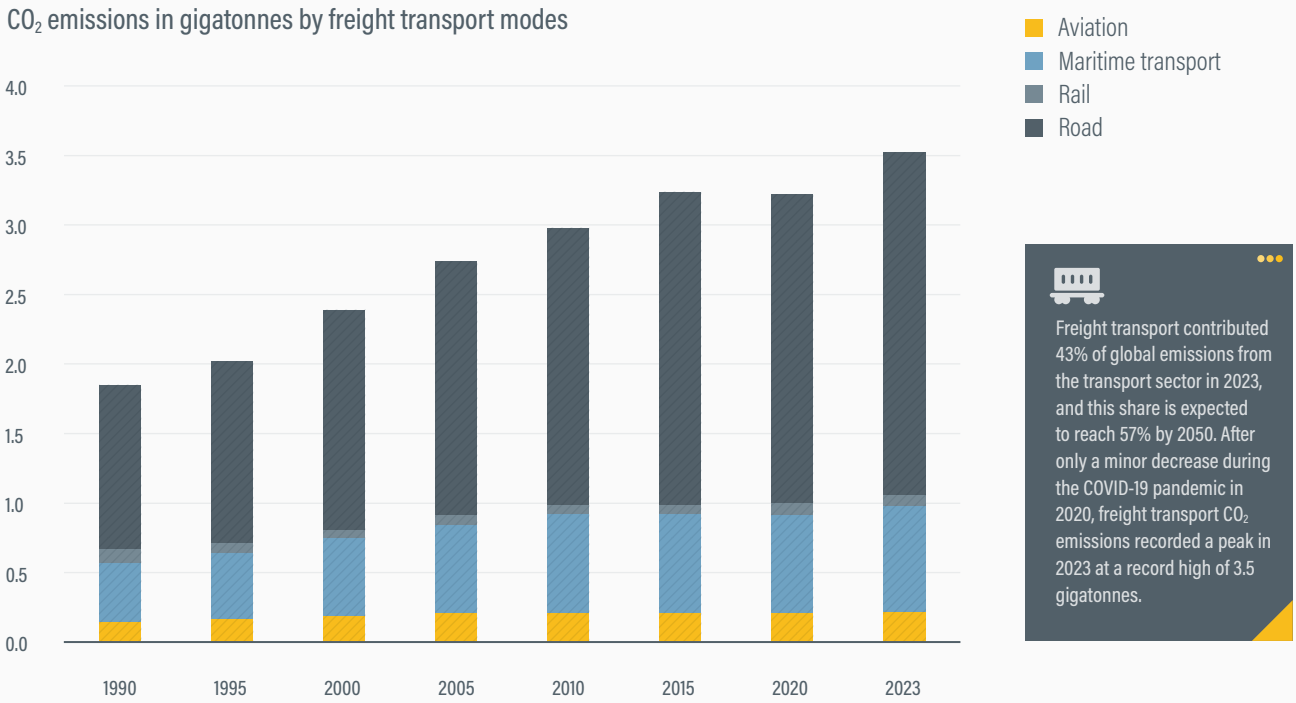
Women have been greatly under-represented in the transport workforce, accounting for only 15.6% of workers in the sector overall, and 23% in senior leadership roles, as of 2023.[31] Although increases in female participation and leadership have been linked to improved economic and environmental performance, such advancements are constrained by gender norms, security and safety challenges, and a lack of educational opportunities for women.[32]

The safety of freight transport remains a serious concern, as road crashes involving heavy-goods vehicles are associated with a higher risk of fatality. In the EU, the fatality rate for crashes with heavy-goods vehicles is 2-5 times as high as with light vehicles, and such incidents resulted in around 14% of road fatalities in 2019.[33]

Globally, freight transport was responsible for around 10% of energy-related CO_2 emissions and 43% of CO_2 emissions from the transport sector (including international aviation and shipping) in 2023.[34] After falling slightly during the COVID-19 pandemic (in 2020), CO_2 emissions from freight transport rose to a record high of 3.5 gigatonnes in 2023 (Figure 3)**.[35] Roughly 85% of these emissions were from freight**

i A dynamic acceleration (bullwhip) effect occurs when small changes in consumer demand are amplified at later stages of the supply chain. By the time manufacturers react to these shifts, the demand they face often bears little resemblance to the original customer demand. Source: A. Preston (2022), Bullwhip Effect in Supply Chain, Skill Dynamics, https://skilldynamics.com/blog/understanding-the-bullwhip-effect-in-supply-chains/.

FIGURE 3. Global CO_2 emissions by mode of transport, 1990-2023



Source: See endnote 35 for this section.

transport itself, and the rest were from the storage and handling of goods.[36]

By mode, the largest contributor to freight transport emissions was road freight, responsible for 70% of freight transport-related CO_2 emissions in 2023.[37] **Despite the high volume of global trade carried via water, maritime transport was responsible for 22% of emissions.**[38] **Railways contributed 2.3% of emissions, the lowest share among freight transport modes.**[39]

Aviation (domestic and international passenger and freight) contributed nearly 950 million tonnes of CO_2 emissions in 2023; of this, close to 155 million tonnes was directly linked to air freight transport (including both belly freight and air freighter transport), representing around 6% of all freight transport-related CO_2 emissions.[40] **Air cargo demand grew 11.3% in 2024, and further growth of 5.8% was expected in 2025.**[41] This rising demand is attributed mainly to the surge in international e-commerce: Amazon, for example, aims to double its freight transport air fleet in the coming years.[42] In addition, two-thirds of aviation's climate impact is not related to CO_2 but stems from factors such as water vapour and contrails.[43] (See 4.9 Aviation.)

Urban freight transport was responsible for an estimated 5% of global greenhouse gas emissions and for 28% (1.1 gigatonnes) of freight transport emissions in 2023.[44] **A 2022 study found that urban freight transport represents around 15-25% of all vehicle-kilometres travelled, occupies 20-40% of the motorised road-space, and contributes 20-40% of greenhouse gas emissions and 30-50% of air pollutants.**[45]

Modes of transport that (until recently) have relied mostly on self-regulation for emission reduction – such as maritime and air transport – have relatively high emissions and often still use less environmentally friendly propulsion technologies. Compared to a truck, a container ship can carry up to 25,000 times more containers, but it also can emit 1 million times more harmful substances (by volume).[46]

In addition to CO_2, harmful substances emitted by combustion engines include nitrogen oxides (NO_x); greenhouse gas agents such as methane (CH_4) and non-methane compounds like nitrous oxide (N_2O), sulphur dioxide (SO_2); and particulate matter (PM_{10} and $PM_{2.5}$). With the electrification of propulsion, non-exhaust emissions will become more relevant, especially small particulate matter originating from tyre and brake wear, as well as road abrasion. Black carbon, or soot, emitted during the incomplete combustion of fuel has negative health impacts in addition to being a potent greenhouse gas agent.[47]

As a result of freight growth, both greenhouse gas emissions and local emissions are predicted to increase in the future. Moreover, as emissions from passenger transport decline, freight transport's share of overall emissions is expected to rise, from 43% in 2023 to 57% in 2050.[48] Although various scenarios predict the effects of a radical decarbonisation of transport, only a few of these analyses are at a global level, and contexts vary widely.

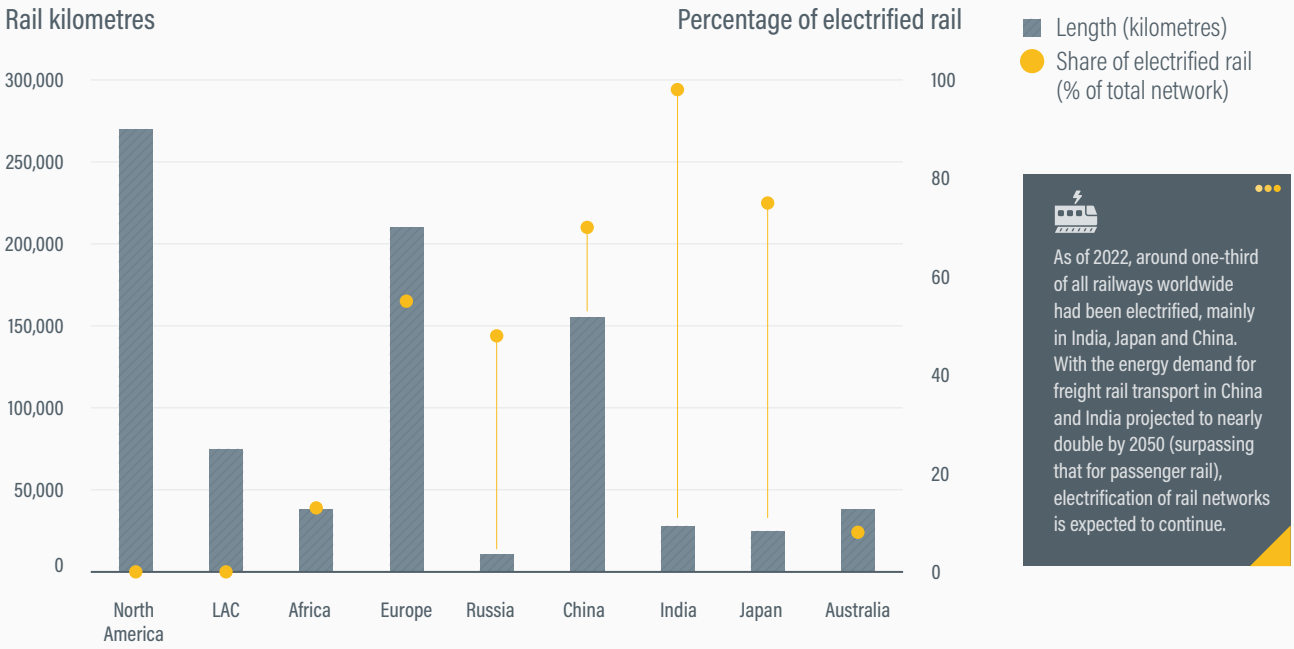
According to one scenario, substantially reducing freight emissions by more than two-thirds is only possible by reducing overall demand, together with shifts in transport modes and the electrification of transport.[49] Another key lever is reducing the carbon content of the energy used in freight transport.[50] Such analyses have enabled insights into the combined framing and global potential of measures implemented at scale, albeit with strong assumptions about their political, technological, behavioural and economic feasibility. Also, these scenarios are formulated at a high level, leaving room for many operational variants that can only be assessed jointly by stakeholders in a policy-making process. Further scrutiny and collaborative development of such roadmaps is needed.

Battery electric trucks that run on low-carbon electricity are considered the main technology for decarbonising road freight transport.[51] **As electrification accelerates, battery electric trucks are expected to reach cost parity with conventional trucks in the coming years.**[52] **In contrast, cost parity between hydrogen-fuelled electric vehicles and conventional trucks is not expected anytime soon,** as the costs of hydrogen production and distribution are prohibitive for business.[53]

Global sales of medium- and heavy-duty electric trucks remained low in 2024, with shares of around 4.4% in China, 2.3% in Europe and 1.7% globally.[54] **Meanwhile, governments and industry are targeting sales shares of 50-60% by 2030 and have supported the electric truck transition through investments in charging infrastructure.**[55] Achieving this goal will require a significant transition of the road freight sector in the coming five years. Truck manufacturers expect electric drivetrains to be the main technology in Europe in the foreseeable future, accounting for more than 60% of sales by 2030.[56]

Industrial collaborations are taking advantage of key business opportunities to drive the shift to electric

FIGURE 4. Rail length and share of electrification in selected countries, 2022



Source: See endnote 72 for this section.

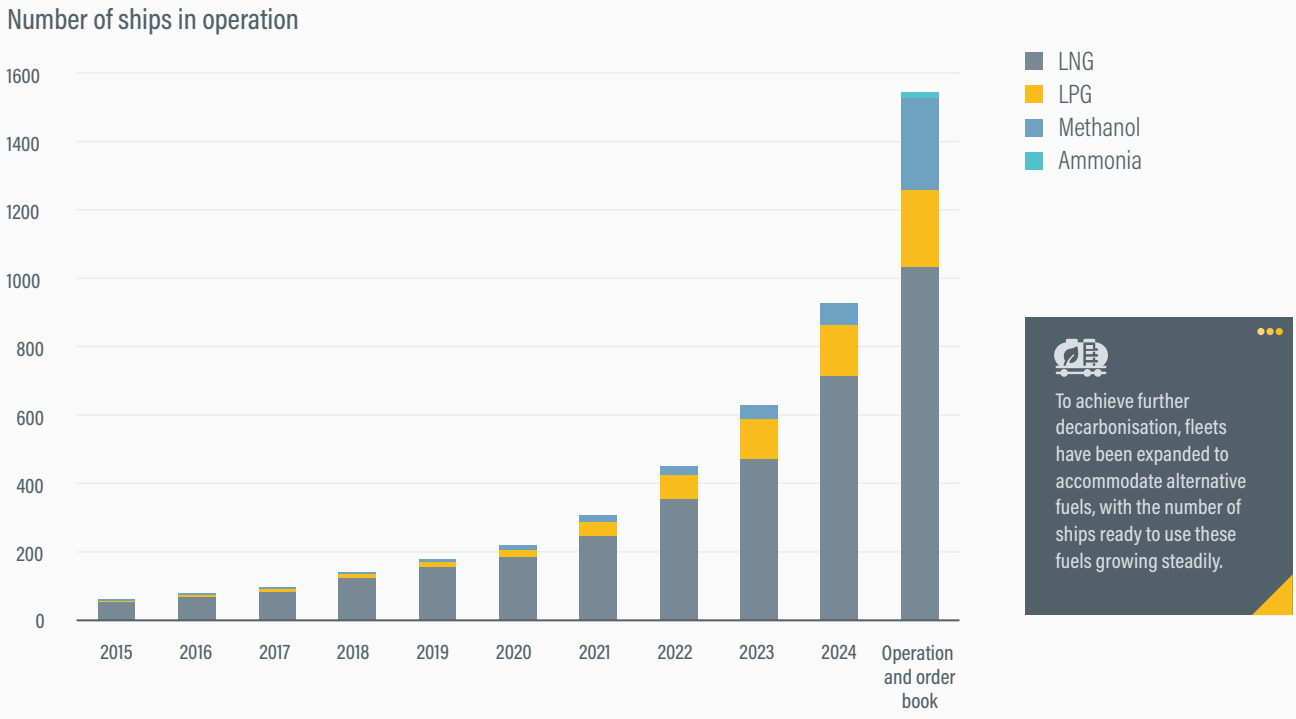
trucks, enabling new actors to enter the scene.[57] **Electric mobility also opens possibilities for new business models for freight services (such as offering fleet charging services, or flexibility services to the electricity market), while digitalisation will be key to optimising routing and charging.** Manufacturers now offer trucks with ranges of up to 600 kilometres, and Europe relies on Megawatt Charging Standards (MCS) for power above 600 kilowatts.[58] Continued development of batteries will reduce their costs and weight.[59]

- The Swedish forestry industry aims to be fossil-free by 2040 through renewable energy, electric vehicles and greater use of rail.[60]
- As of October 2024, Amazon had 10,000 electric vehicles in its delivery fleet in India.[61]
- In California (United States), as of 2025, around 500 zero-emission (electric) trucks were in service or being delivered to major ports for drayage operations (moving of shipping containers).[62]
- Europe's Alternative Fuel Infrastructure Facility incentivises the expansion of charging stations along the main freight corridors in the TEN-T road network.[63]
- The United Kingdom has adopted a scheme to boost charging infrastructure along motorways.[64]
- In South Africa, ultra-fast charging stations have been installed that are off-grid and zero-emission.[65]
- As of 2024, Germany had implemented 7 out of the 15 projects in Europe aimed at developing electric road systems for the dynamic charging of trucks.[66]
- In China, half of the electric medium- and heavy-duty trucks in operation as of 2023 relied on battery swapping.[67]

The aviation industry has made some progress in using sustainable aviation fuel (SAF), the central pillar of its near- to medium-term decarbonisation strategy; however, SAF still accounted for less than 1% of aviation's total fuel consumption in 2024.[68] Since 2016, the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) – developed by the International Civil Aviation Organization (ICAO) – has called on participating airlines to offset at least 85% of their CO_2 emission growth above 2019 levels, including by using "eligible fuels" such as SAF.[69] However, SAF faces challenges related to high costs, feedstock availability, lack of investment and slow technology uptake.[70] (See 4.9 Aviation and 5.1 Transport Energy Sources.)

In the rail freight sector, electrification and efficiency improvements led to a halving of emissions (both greenhouse gas and local emissions) between 2005 and 2022, even with increases in performance.[71] **As of 2022, around one-third of all railways worldwide had been electrified, mainly in India, Japan and China** (Figure 4)**.**[72] **With the energy demand for freight rail transport in China and India projected to nearly double by 2050 (surpassing**

FIGURE 5. Number of ships capable of using alternative fuels (excluding liquefied natural gas carriers), 2015-2024



Source: See endnote 77 for this section.

that for passenger rail), electrification of rail networks is expected to continue.[73] Alternatives to the conventional catenary-based charging of freight trains include battery electric and fuel cell trains. Projects such as the Trans-Siberian rail line show that electrification can be implemented on long-distance dedicated rail corridors.[74]

For maritime transport, greenhouse gas emissions per unit of dry bulk shipping fell 4% between 2019 and 2023, whereas emissions from refrigerated transport increased.[75] **Most emission improvements in the sector are attributed to efficiency measures that have relatively low or negative abatement costs.** These include reductions in port congestion; improved vessel construction, retrofits and capacity use; slow steaming; and advancements in marine propulsion technology.[76] To achieve further decarbonisation, fleets have been expanded to accommodate alternative fuels, with the number of ships ready to use these fuels growing steadily (Figure 5).[77]

Policy and investment developments

The freight transport and logistics sector has remained overlooked in countries' Nationally Determined Contributions (NDCs) towards reducing emissions under the Paris Agreement. As of 1 August 2025, only 9 of the 29 third-generation NDCs that had been submitted to the United Nations Framework Convention on Climate Change included mitigation actions covering freight or a combination of freight and passenger transport.[78] These included the NDCs from Brazil, Canada, Maldives, Monaco, Montenegro, Niue, the Republic of Moldova, Uruguay and the United States.

- The recent NDCs of Brazil, Canada, Maldives and Montenegro focus on vehicle efficiency and the electrification of heavy-duty vehicles.[79]
- Two of the third-generation NDCs focus on maritime transport: Monaco commits to banning fuel bunkering in its waters and to supplying electricity to ships in its ports, while Niue will pursue lower-emission energy for the fishery sector and other transport.[80]
- In its third-generation NDC of 2025, the United States aims to establish zero-emission freight hubs and corridors and to expand inter-modal freight operations through improved collaboration with stakeholders.[81]

- Uruguay's NDC includes pursuing intra-modality for freight and passenger transport.[82]

To reach climate targets, industry will need strong support at the national level, and many international organisations have provided comprehensive roadmaps for decarbonising freight transport (e.g., the European Technology Platform Alliance for Logistics Innovation through Collaboration in Europe, ALICE).[83] In practice, however, the scope of policies tends to be narrower, with only limited attention to demand reduction but broad support for modal shift (despite limited success).[84] Active, successful policies have focused on efficiency improvements and electrification.

Due to the high volume of sea transport, efforts to achieve the International Maritime Organization's (IMO) target for net zero greenhouse gas emissions by 2050 are imperative.[85] A key IMO objective for 2025 is "to support safe, secure, efficient and sustainable shipping through robust international regulations, supported by technical assistance to Member States".[86] The IMO ambitions are supported by initiatives, such as the Global Maritime Forum, the Getting-to-Zero Coalition and the Poseidon Principles for Finance and Insurance.[87] (See 4.10 Shipping.)

Because nearly half of air freight capacity is belly freight, emission targets for air freight are directly linked to the overall emission targets for aviation, which are supported by both industry and governments.[88] The 41st ICAO Assembly adopted the Long Term Global Aspirational Goal in 2022 and member states aim for net zero carbon emissions from international aviation by 2050.[89] In 2021, representatives of the world's major aviation industry associations and largest aircraft and engine makers also signed the "Commitment to Fly Net Zero 2050" declaration.[90] This builds on the Four Pillar Strategy of the IATA, which includes 1) development of new, more efficient aircraft and engines; 2) operational measures, including weight savings; 3) infrastructure measures, such as navigational improvements, and 4) market-based measures. (See 4.9 Aviation.)

Targets for reducing pollutants from road transport have generally been harmonised across continents, despite some variations in scope and coverage. As of 2025, emission standards for internal combustion engine vehicles were at comparable levels across China (Euro 6), Europe (Euro 6), India (Bharat VI), Japan (2016 Standards) and the Republic of Korea (Euro 4).[91] Europe, the United States and China planned to further reduce nitrogen oxide (NO_x) and PM emissions in their regulations around 2027-2028.[92] CO_2 emission standards are generally less stringent in the United States, Japan (fleet-level restrictions), India (vehicle-level fuel consumption restrictions) and China (vehicle-level fuel consumption restrictions).[93] (See 4.8 Road Transport.)

- EU standards aim to progressively reduce emissions from heavy-duty fleet vehicles 90% by 2040, compared to 2025 levels.[94]
- In the United States, CO_2 emission reductions from new road vehicles were targeted to reach 40-60% below 2027 levels by 2032.[95] However, in March 2025 the Trump administration revoked these targets for vehicle emission reduction.[96]
- Through its Advanced Clean Fleets regulation, California (United States) targets that state and local agencies acquire only zero-emission trucks from 2035 onwards (depending on vehicle size up to 2042).[97]

Governments have shown widespread support for the electrification of road freight. While several countries have official targets for reducing greenhouse gas emissions from transport, others present visions and ambitions. A growing number of countries (including Ghana, the Netherlands and Tonga) have signed a global memorandum of understanding for zero-emission medium- and heavy-duty vehicles, aiming for 100% zero-emission vehicle (ZEV) sales by 2040 and net zero emissions by 2050.[98] The idea is to support and accelerate the transition to ZEVs through collaboration among governments. In several cases, actions towards the adoption of electric vehicles go beyond emission reduction to also target factors such as wellbeing, health and job creation. (See 5.2 Road Vehicle Electrification.)

- Australia has a national vision to increase the uptake of electric vehicles to reduce emissions and improve wellbeing.[99]
- Chile, Pakistan and several US states have official governmental targets for the adoption of electric trucks.[100]
- In the EU, truck manufacturers are mandated to cut the average emissions of new trucks 45% by 2030, 65% by 2035 and 90% by 2040.[101]
- India's government set a target for 30% of all vehicles sold in 2030 to be electric.[102]
- Norway uses public procurement regulations to foster the adoption of zero-emission vans.[103]
- Uganda's e-mobility strategy aims to increase electric vehicle adoption to reduce emissions and create green jobs.[104]

In some regions, green corridors are being implemented to induce a transition to sustainable, low-carbon long-haul freight transport (Box 2).[105] Green corridors support the development of infrastructure and financial models, and have been deployed across many forms of transport, including maritime shipping and road freight transport.

Box 2. Green corridors to speed the transition to sustainable long-haul freight transport

Shifting long-haul freight transport to sustainable solutions requires support and commitment from many countries, including for developing the necessary infrastructure. Collaborative efforts exist for different modes of transport to align regulation and investments along critical international trade and development corridors.

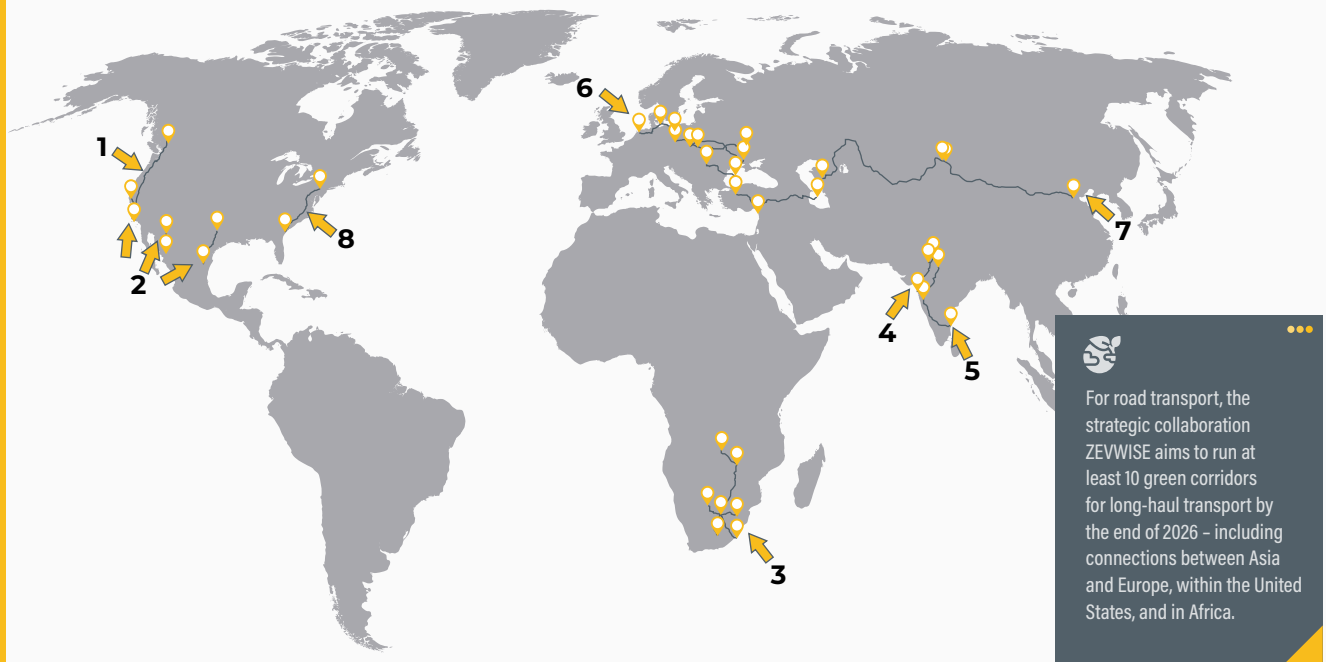
Green corridors are an approach to develop and pilot successful infrastructure and financial models, and have been deployed across many forms of transport. Pilot initiatives not only contribute to low-carbon transitions in the targeted areas, but also create blueprints and reference models for further roll-outs in other locations. By narrowing in on clearly defined corridors, public infrastructure investments can be focused, and private sector stakeholder groups can be approached, integrated and supported in targeted manner.

The International Maritime Organization (IMO) and the International Air Transport Association (IATA) have promoted green shipping corridors and the shift to low-emission solutions on a global scale for international sea and air transport, respectively. (See 4.9 Aviation and 4.10 Shipping.)

For road transport, the strategic collaboration ZEVWISE aims to run at least 10 green corridors for long-haul transport by the end of 2026 – including connections between Asia and Europe, within the United States, and in Africa (Figure 6). Co-ordinating partners include CALSTART / Drive to Zero, the Electric Vehicles Initiative, the International Council on Clean Transportation, the International Transport Forum, the Smart Freight Centre, the United Nations Environment Programme, the World Bank, and the World Business Council for Sustainable Development, as well as the Netherlands, the UK Department for Energy Securing & Net Zero and the US Department of Energy.

In China, the Shenzhen-Dongguan-Huizhou green corridor, initiated by Smart Way China in co-operation with the Smart Freight Centre, provides an example of how such pilots can be deployed successfully. The project focuses on the viability of using electric trucks (and related charging networks and battery swapping services) along this critical trading route, with the aim of addressing the operational, financial and environmental challenges of transitioning to zero-emission freight solutions.

FIGURE 6. ZEVWISE green corridors as of 2024



Source: See endnote 105 for this section

In the context of road safety, several governments and other stakeholders have adopted Vision Zero strategies to end road traffic-related fatalities.[106] **For commercial drivers, interventions include safety technology standards for vehicles, infrastructure and driver behaviour/training.**[107] As of mid-2025, 139 companies had joined the Vision Zero network maintained by the International Social Security Association.[108]

In the EU, reporting and improvement of transport emissions will become mandatory for bigger companies from 2026 and 2028 onwards, with the introduction of the EU Corporate Sustainability Reporting Directive (CSRD) and the Corporate Sustainability Due Diligence Directive (CSDDD).[109] **Pressure for small and medium-sized enterprises to follow suit will increase in Europe.** Elsewhere in the world, measuring and reporting transport emissions has been voluntary, with a few exceptions such as France, which introduced a law making it compulsory in 2010.[110]

Industry-driven initiatives at different levels have shown that companies and organisations already gain advantages from emissions accounting and reporting. The process of evaluation can help companies identify inefficiencies, realise energy savings, and strengthen brand images and customer commitment. Increasingly, more investors have judged sustainability commitments and efforts positively, recognising that the impacts of climate change can affect the stability of companies and economies in the form of credit risks, market risks, liquidity risks, operational risks and reputational risks.[111]

- The Global Logistics Emissions Council (GLEC), a voluntary partnership of companies, industry associations, and green freight programmes, has developed the GLEC Framework to help providers and users calculate and report their operating emissions from freight transport.[112]
- At the company level, Schneider Electric (2024), DHL (2025) and Procter & Gamble (2025) regularly measure and communicate their transport emissions and set reduction targets in their annual reporting.[113]

A proposed EU regulation related to freight and passenger transport emissions, CountEmissionsEU, outlines a methodology for calculating and reporting greenhouse gas emissions from transport services.[114] The regulation is aligned with ISO 14083:2023 "Greenhouse gases – Quantification and reporting of greenhouse gas emissions arising from transport chain operations", which itself builds on and is aligned with the GLEC Framework.[115] This alignment is the result of a co-operation among industry, government bodies, and non-governmental organisations to ensure continued progress in emission accounting and reporting. Such alignment, globally and across transport modes, is key, as transport chains tend to be international and multi-modal, and the industry can benefit from a single approach applicable over all transport networks.[116]

Such efforts are further strengthened by mode-specific efforts to measure and control emissions.

- For the shipping industry, the IMO introduced regulations in 2013 that require new vessels to contribute to the industry's sustainability improvement (Energy Efficiency Design Index, or EEDI); these regulations were strengthened in 2023 by an EEXI (Energy Efficiency Existing Ship Index) that requires the operational efficiency of existing vessels to be made transparent and improved (Carbon Intensity Indicator CII).[117]
- A planned amendment to the International Convention for the Prevention of Pollution from Ships (MARPOL) will require ships to comply with emission controls in new areas including the Mediterranean Sea (SO_x), Canadian Arctic (NO_x and SO_x) and Norwegian Sea (NO_x and SO_x).[118] Existing areas with NO_x and SO_x emission controls are the US Caribbean Sea, the Baltic Sea and the North Sea.[119]
- The IMO's GreenVoyage2050 provides financial support to developing countries, with the aim of achieving the IMO GHG Strategy's target of net zero emissions by 2050 at the latest.[120]

Three key concepts for measuring and reporting the emissions of organisations are the product carbon footprint (PCF), the corporate carbon footprint (CCF) and logistics network emissions.[121] The two leading global standards for calculating the greenhouse gas emissions of value chains and organisations are the Greenhouse Gas Protocol and the ISO 14000 series. Both are voluntary and rely on references and applying organisations such as CDP and the Science Based Targets initiative (SBTi).[122] With the GLEC Framework and ISO 14083:2023, standardisation covering all modes of transport is provided.[123] These two are aligned, and further alignment could be achieved with the current review of SBTi and GHG protocol Scope 3 standards.

The key challenges faced by all three concepts – PCF, CCF and logistics networks – are similar: emissions accounting and reporting need to be based on the primary data of the organisation.[124] However, the complexity of supply chains, which often include numerous sub-contractors operating in different countries and jurisdictions, can make access to primary data difficult. Secondary data, modelled data or default data can help estimate emissions from supply chains.[125] Standardisation for the development and update of a database for secondary data is key to achieving meaningful calculations and reporting.

In addition to introducing and tightening legislation on vehicle emission standards, a growing number of

governments have implemented biofuel regulations – including California's Low Carbon Fuel Standard, the EU's Renewable Energy Directive (RED III) and Canada's Clean Fuel Regulations.[126] These regulations dictate how sustainability is defined, verified, and monitored, and set targets for fuel suppliers to increase the supply share or blending of biofuel with existing fuels. The regulations aim to decrease the well-to-wheel carbon intensity of transport (at least 65% under the RED III), while ensuring that the full life cycle of the fuels is globally sustainable. They also help reduce reliance on biofuels that are produced from crops with a high risk of indirect land use, such as palm oil. (See 5.2 Transport Energy Sources.)

At the EU level, in 2024 the region's Emissions Trading Scheme began covering all vessels entering EU ports.[127] **FuelEU Maritime, a legislative package for the use of clean energy in the maritime sector within the EU's "Fit for 55" programme, was expected to take effect in 2025.**[128] **Globally, to further expand the use of sustainable fuels, the maritime industry has highlighted the need for contributions at the regional and national levels.** As in the aviation sector, the use of book and claim systems is considered an important tool for the transition to sustainable maritime fuels.[129] The development of green corridors also facilitates the use of alternative or sustainable fuels, including e- or bio-methanol, electricity, green ammonia, green hydrogen and advanced biofuels.[130]

The main policies that countries have adopted for rail electrification are reducing the use of diesel trains, creating dedicated rail freight infrastructure and providing subsidies for operators. Recent major investments have focused on dedicated rail corridors over very long distances in Asia (within India, and China's Belt and Road Initiative).[131] **Although many countries offer operational subsidies, experience in Europe suggests that these are not always effective.**[132] Electrification appears to be the most effective approach to reduce emissions for existing users. Satisfying the growing demand for rail requires an improvement of service levels, cost reductions and significant infrastructure extension. Challenges are manifold, given the poor inter-connectivity and inter-operability of networks across countries.

To meet the challenges of rising urban populations, different urban last-mile concepts have been explored and developed, including consolidation hubs, off-peak deliveries and delivery robots. These solutions are technically and socially intertwined, and each city offers its unique context.[133] Important tensions include the trade-off between using many smaller vehicles (robots, delivery bikes and motorcycles) versus fewer and more efficient larger vehicles, together with consolidation schemes and off-peak deliveries.

- Cities in China, France, the Netherlands, Sweden and the United Kingdom are implementing zero-emission zones, with a strict ban on all petrol and diesel vehicles.[134]
- Through government-supported recognition schemes, many companies commit to emission reductions and social sustainability towards their customers and employees.[135]
- Although many studies and projects showcase technological solutions (such as consolidation hubs, e-bikes and delivery robots), there is less focus on social implications, wellbeing and workforce conditions.[136]

Partnerships in action

In 2023, **C40 Cities** launched the **Laneshift** initiative to decarbonise freight transport in low- and middle-income countries, in partnership with The Climate Pledge (co-founded by Amazon and Global Optimism).[137] Electric trucks will be deployed in cities in India as well as in Latin America and the Caribbean (Brazil, Colombia, Ecuador and Mexico).[138]

The **EcoLogistics** project of **ICLEI–Local Governments for Sustainability** released a guide in 2023 on how to implement zero-freight-emission zones in cities, through a collaborative effort involving C40, the California Air Resources Board, CALSTART, Concito, Freight Matters, ICLEI, POLIS, the Transport Decarbonisation Alliance, the Transport Research Lab and the World Resources Institute.[139]

The Swedish forestry sector's **TREE** (**"transition to efficient electrified forestry transport"**) partnership is aligned around a target to have 50% of new heavy-duty long-haul trucks be electric by 2030.[140] The 23-member partnership integrates partners both horizontally and vertically in the value chain, and includes transport buyers, logistic companies, and technology and service suppliers. The partnership helps to implement heavy electric trucks (gross vehicle weight of 70 tonnes and above) in commercial operation, including solving challenges related to charging infrastructure and transport planning. It also demonstrates novel technological solutions, such as a battery electric 94-tonne truck and electric trailers.[141]

The **Ship Recycling Transparency Initiative** (**SRTI**), hosted by the Smart Freight Centre, is launching a collaborative initiative to accelerate steel decarbonisation in India by unlocking the potential of sustainable ship recycling as a reliable source of high-quality scrap.[142] Recognising the maritime industry's critical role in the circular economy, the project connects shipowners, recyclers and steelmakers to establish traceable, certified scrap supply chains that feed into India's low-carbon steel production. With more than 15,000 vessels expected to reach end-of-life in the next decade, this effort addresses an environmental imperative and an industrial opportunity, linking the decarbonisation goals of the steel sector with the growing need for responsible ship dismantling.[143] The initiative emphasises regulatory alignment, material certification, and innovative contracting mechanisms, while drawing on global best practices and active stakeholder engagement, particularly from the Global South. It seeks to deliver measurable emission reductions and systemic change across both the maritime and steel industries.

The **Zero Emission Maritime Buyers Alliance** (**ZEMBA**) is committed to accelerating sustainable, scalable and economically viable solutions for the maritime sector.[144] In 2024, Amazon and IKEA led a new ZEMBA initiative to demand green fuels to support shipping decarbonisation.[145] In 2025, a tender by ZEMBA kicked off the first-ever commercial deployment of e-fuels in the maritime sector, with the aim of aggregating 86 billion tonne-nautical miles of demand for shipping powered by e-fuels from 2027 onwards (equal to transporting around 1.5 million twenty-foot equivalent units (TEU) from Shanghai to Los Angeles).[146]

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Integrated Transport Planning

This section covers developments in integrated transport planning mainly for passenger and urban transport, with some content related to freight transport. For more on freight transport, see 4.1 Freight Transport and Logistics.

KEY FINDINGS

- Integrated transport planning supports the integration of transport, land use, and governance, with the aim of efficiently and resiliently combining low-emission transport services that are affordable, safe, accessible and sustainable for all users. It has received greater attention in recent years, particularly in rapidly urbanising low- and middle-income countries.
- As urban areas continue to expand, more than two-thirds (68%) of the global population is projected to live in cities by 2050, up from 55% in 2018. Most of this growth is anticipated in Africa and Asia. Urban transport activity is estimated to grow from 24 trillion passenger-kilometres in 2023 to 39.1 trillion passenger-kilometres in 2050.
- Urban growth is putting additional pressure on freight transport and logistics in cities. Urban freight activity accounted for an estimated 5% of global freight activity in 2023 and is projected to grow from 9.8 trillion tonne-kilometres in 2023 to 22.7 trillion tonne-kilometres by 2050.
- Meanwhile, some high-income countries have experienced a trend of urban-to-rural movement – or counter-urbanisation – typically in the periphery of large urban areas.
- Despite rising interest in integrated transport planning in the wake of the COVID-19 pandemic, more recent political shifts have resulted in reversals and slowdowns in related policies since 2023.

Demand, use and access

- Most conventional data on transport performance reflect an automobile-centric paradigm, evaluating systems based on traffic speeds, congestion and crash rates. However, some indicator sets have evolved to prioritise additional economic, social and environmental factors – in line with more sustainable and integrated transport planning.
- Transport modal shares in cities vary by world region and depend on factors such as city size (including urban density), income level and access to transport options. A 2024 analysis of nearly 800 cities across 61 countries found that, on average, 51% of journeys are by car, compared with 26% by public transport and 22% by active transport (walking and cycling), with trends varying by region.
- However, global data on urban modal shares has tended to oversimplify trends: clustering walking and cycling under "active transport"; neglecting freight transport; and overlooking important regional variables, such as informal transport in Africa and the wide use of two- and three-wheelers for moving goods and people in many low- and middle-income countries.
- Walking and cycling remain far more common than most transport statistics indicate. In a 2022 survey of more than 45,000 people across 48 countries, large majorities of respondents identified as pedestrians, including 94.9% in Europe, 93.8% in Asia and Oceania, 94.4% in Africa, and 86% in the United States, Canada and Colombia.
- The global bicycle fleet totalled an estimated 1 billion in 2022, and around 42% of households worldwide owned at least one bicycle, according to a 2015 study. Since 2023, most of the growth in the cycling sector has been in electric bicycles (e-bikes), with rising sales in the Global North.
- Ride hailing activity, another urban transport service that is often overlooked in data collection, grew an estimated 94% between 2018 and 2022, but still accounted for only 0.5% of private motorised passenger travel.
- Although working remotely increased during the COVID-19 pandemic, its decline since 2023 – especially in large urban areas – contributed to record-high traffic congestion levels in 2024. In 2024, 55% of urban areas experienced more congestion than in 2023, while only 28% of cities witnessed a reduction in delays.
- The largest increase in public transport ridership in 2024 was in the Middle East and North Africa, followed by the Asia-Pacific region, whereas rates in North America and Latin America remained low compared to 2019. The pandemic had a lasting impact in most public transport markets, with more than half of operators in 2024 still reporting ridership below 2019 levels.

KEY FINDINGS

- Some locations have focused on improving the reliability of (formal) public transport services to increase ridership, as this can play a role in commute time and is important to keep travel flowing smoothly in an integrated transport system.
- Digitalisation can contribute to more efficient and integrated transport systems; however, as of 2024 an estimated 86% of cities globally lacked published data on their public transport systems.
- Use of digital platforms has helped to consolidate freight flows, increasing the efficiency of movements through economies of scale, and keeping costs low.
- Accessibility measures in public transport have remained incomplete and fragmented. Inclusive access (also known as universal design) – accommodating diverse users such as the elderly and people with disabilities or difficulties and other special needs – remains far from the norm.
- Affordability of transport remains a concern in many places, as transport costs often comprise a large share of household budgets and place a particular burden on low-income users. Household spending for transport varies greatly by country and region.

Sustainability and climate trends

- In 2023, transport was the second largest greenhouse gas-emitting sector globally – contributing 15.9% of global emissions – with three-quarters of the sector's emissions coming from road transport. Transport emissions tend to be higher in less-dense urban areas that lack effective public transport networks.
- Transport emissions vary greatly by region, with Asia continuing to contribute the largest share (40%) in 2023, followed by North America (26%) and Europe (17%) (excluding international aviation and shipping). North America leads by far in per capita transport emissions, followed by Oceania and Europe.
- Freight transport contributed 43% of global transport CO_2 emissions in 2023. Transforming the freight and logistics sector to ensure integrated, co-ordinated and efficient goods transport is key to reducing emissions, enabling economic development and local production, supporting circularity, and increasing resilience to shocks while reducing energy consumption.
- Mass public transport, rail, walking and cycling have much lower carbon intensities over their lifetimes – and per kilometre of people transported and goods moved – than cars or trucks, despite recent gains in vehicle fuel efficiency and electrification.
- Compact land-use planning and transit-oriented development can greatly reduce emissions by shortening travel distances and reducing the need for car ownership and use, in addition to providing health benefits and improving social inclusion.
- Adaptation to the impacts of climate change has become increasingly important to transport and land planners at the national, sub-national and local levels. However, it is unclear whether integrated transport planning approaches for passenger and freight transport are sufficiently addressing adaptation and resilience.

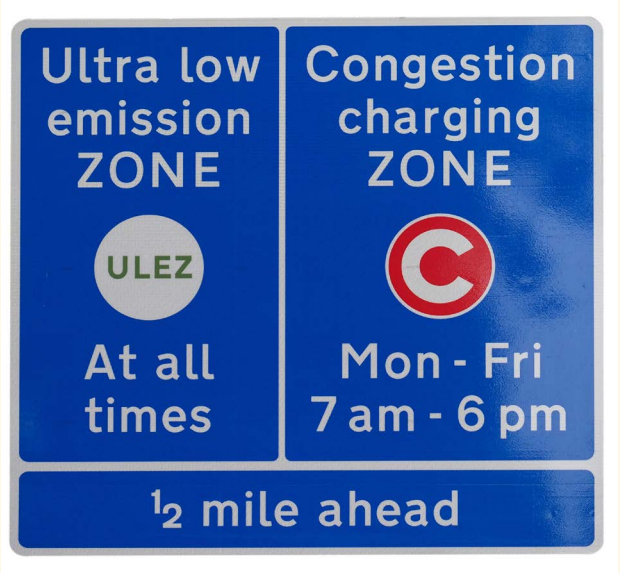
KEY FINDINGS

Policy and investment developments

- The Avoid-Shift-Improve (A-S-I) framework is key for translating integrated transport planning into a comprehensive implementation tool. A-S-I is aligned with integrated transport planning principles and amplifies the implementation of sustainable transport from multiple angles. Although policies tend to focus on "Improve" measures, "Avoid" and "Shift" measures can reduce an estimated 40-60% of transport emissions at a lower cost.
- During 2023-2025, political shifts and global geopolitical challenges led some countries to reverse policies supporting sustainable and integrated transport systems. Public and political opposition to such policies is related to perceptions around their impacts on driving behaviour and the built environment, threats to long-held habits and excessive burdens on certain populations.
- Among the numerous governance and planning strategies for integrated transport planning, a strong focus has been on National Urban Policy and Investment Programmes (NUMPs) and Sustainable Urban Mobility Plans (SUMPs).
- The development and implementation of SUMPs has expanded in most regions, although a lack of continuous global tracking impedes measurement. During 2023-2024, regional and national regulations enforced the use of SUMPs in more municipalities, enabling integrated planning of urban transport and land use.
- As of 2025, 32 SUMPs and 9 NUMPs had been developed in consultation with MobiliseYourCity across Africa, Asia, Eastern Europe, and Latin America and the Caribbean.
- Integrated transport planning has increasingly been adapted to low- and middle-income countries, in recognition of their specific institutional, social, and infrastructural conditions and of the complex urban dynamics shaped by rapid population growth, informal development patterns and limited institutional capacities.
- As of 1 August 2025, a total of 7 of the 29 third-generation Nationally Determined Contributions (NDCs) that had been submitted to the United Nations (UN) featured activities on transport demand management and enhanced integrated planning; the 7 submissions were from Brazil, Canada, Ecuador, Kenya, Moldova, United Kingdom and Uruguay.
- Several recent initiatives have adopted a corridor-based approach to infrastructure development, recognising the strategic importance of strengthening regional connectivity beyond just linking cities.
- Governments have increasingly recognised the importance of developing rural transport programmes, stimulated by their potential to boost economic growth and opportunities and improve quality of life.

KEY FINDINGS

- As part of public transport recovery measures since 2022, many cities in Asia, Europe and North America have explored free or reduced fare programmes to make services more accessible to everyone, particularly the vulnerable. However, the financial sustainability of public transport systems depends on a balance between operational costs and revenue generation.
- A handful of transport plans – such as in Scotland and some US states – have emphasised strategies to reduce vehicle travel as part of more people-centred, integrated approaches to satisfy mobility needs and improve quality of life.
- Since 2022, some European cities have revised their parking policies to adjust for the increased use of larger vehicles (mainly sport utility vehicles, or SUVs), which have been shown to take up more public space, produce more emissions and be more lethal in crashes.
- Increasing bicycle parking near public transport hubs and train stations can facilitate integrated travel. In 2019, Utrecht (Netherlands) expanded bicycle parking at its central train station by 12,500 parking spaces, for a total of 22,000 spaces, making it the largest such hub in the world.
- Several jurisdictions have taken actions to improve the road safety of pedestrians and cyclists in connection to the Vision Zero approach. The greatest improvements in road safety have been achieved in countries where the Safe System approach has been adopted.
- Digitalisation efforts have the potential to greatly reduce transport emissions by increasing efficiency. Research in Amsterdam (Netherlands) in 2022 found that Mobility-as-a-Service (MaaS) offers potential emissions savings of 3-54%, depending on the attractiveness of these services to users.
- During 2023-2025, several implementation and planning efforts around congestion pricing were in the spotlight; such efforts can have direct positive impacts on traffic, emissions and pollution levels.
- Some cities have implemented low-emission zones (LEZs), ultra-low-emission zones (ULEZs), zero-emission zones (ZEZs) and low-traffic neighbourhoods to reduce emissions, congestion, and air and noise pollution in specific areas.
- While there is typically popular support for LEZs and similar strategies, implementation can be highly contested. To reduce resistance, some governments have introduced these policies incrementally and grown them progressively over time, either increasing the strictness or expanding the geographic coverage.



- More recently, some places, such as in France and Spain, have scaled back plans to strengthen LEZs in response to intensified political debate.
- Overall, the number of LEZs in operation in Europe is estimated to have doubled between 2019 and 2025, from 228 to more than 500.
- Despite the growth of LEZs, few cities are taking the next steps towards ZEZs. Between 2023 and 2025, only Brussels (Belgium), Oslo (Norway) and Oxford (United Kingdom) were identified as new examples of cities with plans for ZEZ implementation.
- Some cities have established specific zero-emission zones for freight transport (ZEZ-Fs) – ranging from urban delivery vans to medium- and heavy-duty trucks – to address the large contribution of freight transport to air pollution and greenhouse gas emissions.
- LEZ, ULEZ and ZEZ policies can be supported by targets for 100% electric vehicle sales and mandates for phasing out internal combustion engine vehicles. By the end of 2023, at least 74 countries and 26 states/provinces across all major continents had targets promoting electric vehicles, while 49 of these jurisdictions had a 100% electric vehicle sales target or a targeted ban on internal combustion engine vehicles.

Context, challenges and opportunities

Integrated transport planning supports the integration of transport, land use, and governance, with the aim of efficiently and resiliently combining low-emission transport services that are affordable, safe, accessible and sustainable for all users. It has received greater attention in recent years, particularly in rapidly urbanising low- and middle-income countries.[1] A wide range of tools are available to enable integrated planning in the transport sector, ranging from transit-oriented development and low-emission zones to congestion pricing (Box 1).[2]

By designing integrated, multi-modal systems for moving people and goods, governments can support inclusive communities and shared prosperity.[3] In an integrated transport system, the key is to ensure both efficiency and access to mobility, enabling greater opportunity, poverty reduction, and participation in economic and social activities.[4] A holistic form of integrated transport planning – "triple access planning" – seeks to support these goals by focusing on the transport system (physical mobility), the land-use system (spatial proximity) and the telecommunications system (digital connectivity).[5]

Box 1. Overview of planning tools and approaches for integrated transport planning

A variety of planning tools are available to decision makers to address the interconnections among transport, land use and other factors to support the creation of sustainable transport systems, including:

- **Transit-oriented development** – the creation of compact, walkable, pedestrian-oriented, mixed-use communities centred around high-quality public transport systems.
- **15-minute cities and 20-minute neighbourhoods** – prioritising compact, mixed-use development and efficient land use, allowing citizens to reach necessary services within 15 to 20 minutes of walking. In both cases – transit-oriented development and 15-minute cities – dense, transit-oriented development can greatly reduce the need for long commutes and dependency on private vehicles and bring essential services closer to where people live, to reduce travel demand and improve urban resilience.
- **Transport demand management** – efforts to increase the efficiency of transport systems by promoting low-impact travel modes and shifting demand away from peak times (and for freight, shifting from road transport to rail or water transport). Strategies to reduce car dependency include "pull" strategies (e.g., mixed-use zoning and transit-oriented

development) and "push" measures (e.g., parking management and traffic restrictions).

- **Complete streets** – an approach to planning, designing, building, operating and maintaining streets that enables safe access for all people, including pedestrians, cyclists, motorists and public transport riders of all ages and abilities.
- **Low-, ultra-low and zero-emission zones** – areas that restrict access for more-polluting vehicles.
- **Parking policy reforms** – reducing parking mandates and pricing parking more efficiently so motorists pay directly for using parking facilities, with higher prices at peak times and locations.
- **Congestion pricing** – levying fees on automobile use to reduce both emissions and fuel consumption, leading to reductions in vehicle-kilometres travelled, stop-and-go traffic, urban traffic and traffic-related noise pollution – with the aim of creating a more liveable and pedestrian-friendly environment
- **Safe System approach** – designing the road system to account for human error and vulnerabilities to avoid injury and death.
- **Vision Zero** – a concept originating in Sweden in 1994 aiming for zero road deaths through the Safe System approach, which builds into planning the view that humans make mistakes.

Source: See endnote 2 for this section.

As urban areas continue to expand, more than two-thirds (68%) of the global population is projected to live in cities by 2050, up from 55% in 2018.[6] Most of this growth is anticipated in Africa and Asia.[7] Urban transport activity is estimated to grow from 24 trillion passenger-kilometres in 2023 to 39.1 trillion passenger-kilometres in 2050.[8] Cities around the world are physically expanding faster than their population growth: between 1990 and 2014, around three-quarters of the incoming urban population was accommodated in the newly built areas of cities.[9]

Urban growth is putting additional pressure on freight transport and logistics in cities. Urban freight activity accounted for an estimated 5% of global freight activity in 2023 and is projected to grow from 9.8 trillion tonne-kilometres in 2023 to 22.7 trillion tonne-kilometres by 2050.[10]

Meanwhile, some high-income countries have experienced a trend of urban-to-rural movement – or counter-urbanisation – typically in the periphery of large urban areas.[11] Factors behind this trend include amenity migration (whereby people choose to live in places based on quality of life) as well as increases in teleworking, housing costs and retirements of "baby boomers".[12]

- In 2020 and 2021, during the COVID-19 pandemic, Europe experienced counter-urbanisation in the south and west, but rising urbanisation in the north and east.[13] People in large European cities showed greater willingness to move to rural places or secondary cities, although this was mostly short-lived.[14] Overall, the European Union (EU) is projected to see a slight increase in urbanisation and a slight decrease in movement to rural areas and intermediate regions.[15]
- Following a decade of loss, the rural population of the United States grew around 0.25% annually between 2020 and 2023, adding 220,000 people between mid-2022 and mid-2023 to reach a total of 46 million rural dwellers.[16] As of 2024, people were increasingly moving more than 32 kilometres (20 miles) from US city centres, which could result in greater driving distances and increased emissions.[17] However, populations in large US cities such as Los Angeles and New York have continued to grow.[18]

Despite rising interest in integrated transport planning in the wake of the pandemic, more recent political shifts have resulted in reversals and slowdowns in related policies since 2023. Integrated transport planning received increasing attention in 2020 and 2021 and even up to 2022, which created an opportunity to rethink passenger and freight transport in both urban and rural settings.

Conventional (mostly auto-centric) transport systems have tended to be fragmented and lacking in efficiency and reliability due to traffic congestion, greenhouse gas emissions, air pollution, noise and crashes.[19] Through integrated transport planning, governments and the private sector have sought to create more seamless transport systems, particularly in locations where walking, cycling and public transport already compete with private vehicles.[20] In the freight sector, integrated planning can result in efficiency gains, operational improvements and cost reductions: in the United States alone, empty truckloads pose a high fuel burden and result in around 87 million tonnes of CO_2 emissions every year.[21]

Demand, use and access

Most conventional data on transport performance reflect an automobile-centric paradigm, evaluating systems based on traffic speeds, congestion and crash rates. However, some indicator sets have evolved to prioritise additional economic, social and environmental factors – in line with more sustainable and integrated transport planning.[22] (For a summary of such performance indicators, see 3.1 Integrated Transport Planning in SLOCAT's Transport, Climate and Sustainability Global Status Report, 3rd edition.)

Transport modal shares in cities vary by world region and depend on factors such as city size (including urban density),

income level and access to transport options.[23] **A 2024 analysis of nearly 800 cities across 61 countries found that, on average, 51% of journeys are by car, compared with 26% by public transport and 22% by active transport (walking and cycling), with trends varying by region** (Figure 1)**.**[24]

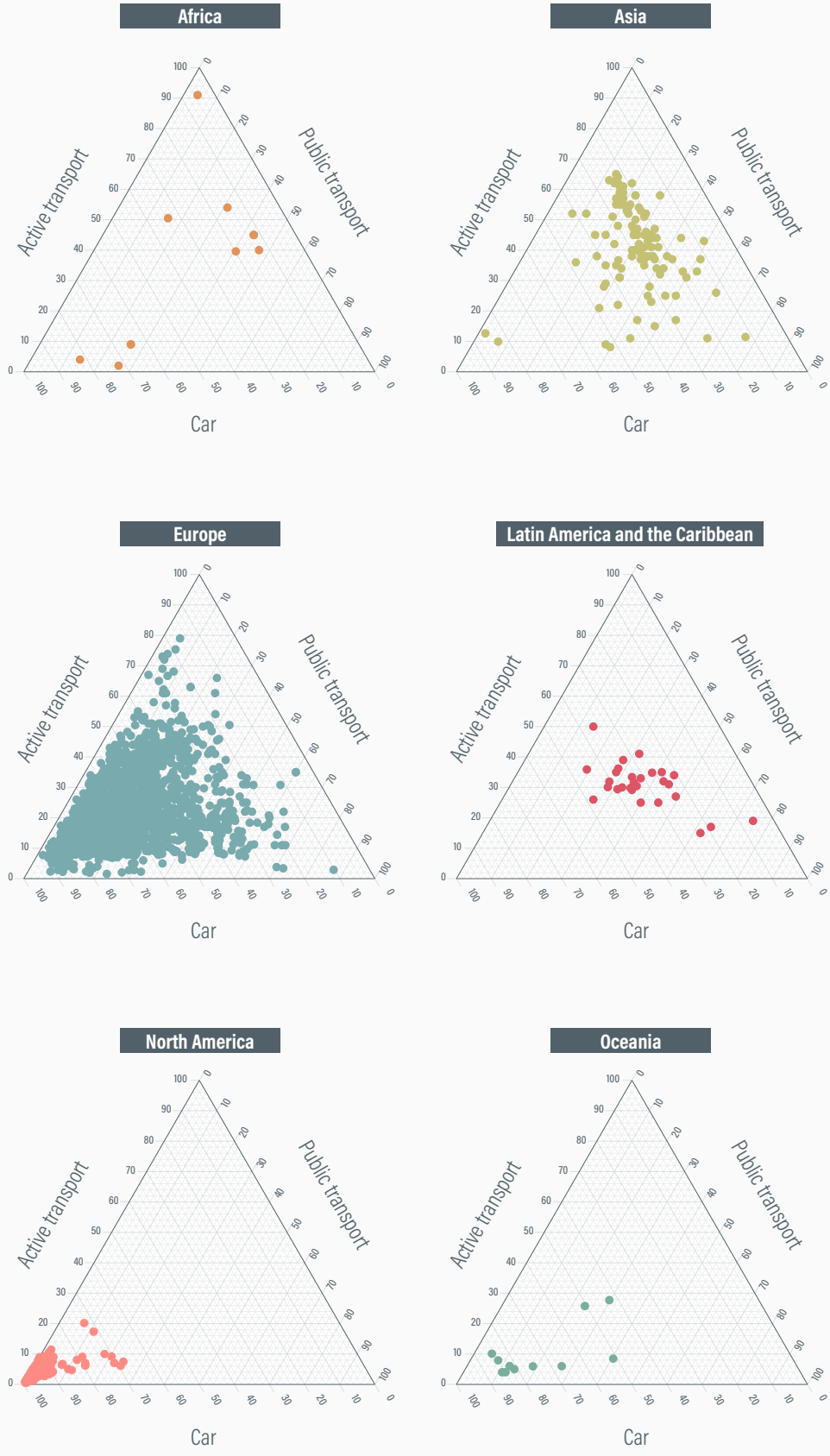
- The limited data available for Africa revealed that 5 out of 6 journeys were by public transport, walking, and cycling, whereas car use was the lowest among world regions at 22%.[25]
- Asia had the highest share of public transport use, at 43% on average, followed by walking and cycling (34%) and car use (23%); by sub-region, public transport use surpassed 46% in Eastern Asia but was only 28% in Western Asia.[26]
- In Europe, car use dominated at 45%, with near-equal shares for active mobility (28%) and public transport (27%).[27]
- In South and Central America, public transport accounted for 40-42% of trips and active mobility for 31-35%, while car use ranged from 23% in Central America to 29% in South America.[28]
- Car use dominated in North America, accounting for nearly 74% of all travel.[29]
- In Oceania (Australia and New Zealand), average modal shares were 76% by car, 18% by public transport and 6% by active mobility.[30]

However, global data on urban modal shares has tended to oversimplify trends: clustering walking and cycling under "active transport"; neglecting freight transport; and overlooking important regional variables, such as informal transport in Africa and the wide use of two- and three-wheelers for moving goods and people in many low- and middle-income countries.[31] (See 4.6 Informal Transport.)

- Data for different African cities for 2019 to 2025 showed that informal transport accounted for more than two-thirds of trips in some cities and exceeded 70% in at least five cities: Addis Ababa (Ethiopia), Gaborone (Botswana), Kinshasa (Democratic Republic of the Congo, DRC), Lagos (Nigeria) and Maseru (Lesotho).[32]
- As of 2022, informal transport systems in China were increasing rapidly in more than 300 cities, with many of these systems integrated fully with public transport to cover first-/last-mile demand, or used to replace private vehicles entirely.[33]
- In Mexico City (Mexico), where informal transport accounts for around two-thirds of all shared travel, the development of mass transit systems incentivised data collection on informal transport, revealing its critical role in providing last-mile connections where formal public transport does not reach.[34] (See 4.6 Informal Transport.)

Walking and cycling remain far more common than most transport statistics indicate. In a 2022 survey of more than 45,000 people across 48 countries, large majorities of respondents identified as pedestrians, including 94.9% in Europe, 93.8% in Asia and Oceania, 94.4% in Africa, and 86% in the United States, Canada and Colombia.[35] Most travel surveys overlook or undercount non-commute trips, longer trips, travel by children, recreational travel, and the walking and cycling links of automobile and public transport trips. For example, a commute that involves biking, public transport, and walking is generally coded as a public transport trip, and trips between parked vehicles and destinations are ignored even if they involve several blocks of walking on public streets. (See 4.3 Walking and 4.4 Cycling.)

FIGURE 1. Urban transport modal shares by region, as of 2024



Transport modal shares in cities vary by world region and depend on factors such as city size (including urban density), income level and access to transport options. A 2024 analysis of nearly 800 cities across 61 countries found that, on average, 51% of journeys are by car, compared with 26% by public transport and 22% by active transport (walking and cycling), with trends varying by region.

Source: See endnote 24 for this section.

In Africa, walking is by far the most common travel mode – either by itself or in combination with public transport – accounting for 50-90% of daily trips in many African cities as of 2021.[36] Yet most African cities are not walkable, and most of the region's walkers are low-income residents, especially women, who cannot afford bus fares and struggle to access services.[37]

- European capitals with the highest shares of walking trips in 2023 were London (United Kingdom) at 46% and Paris (France) at 42%.[38] However, walking is likely far more common than statistics indicate.

The global bicycle fleet totalled an estimated 1 billion in 2022, and around 42% of households worldwide owned at least one bicycle, according to a 2015 study.[39] Since 2023, most of the growth in the cycling sector has been in electric bicycles (e-bikes), with rising sales in the Global North.[40] (See 4.4 Cycling.)

Ride hailing activity, another urban transport service that is often overlooked in data collection, grew an estimated 94% between 2018 and 2022, but still accounted for only 0.5% of private motorised passenger travel.[41]

Although working remotely increased during the COVID-19 pandemic, its decline since 2023 - especially in large urban areas - contributed to record-high traffic congestion levels in 2024.[42] In 2024, 55% of urban areas experienced more congestion than in 2023, while only 28% of cities witnessed a reduction in delays.[43] Such challenges reveal how inefficient many current transport systems are, as commuters often travel long distances yet have few reliable and available transport options.

- In the United States, the total number of people telecommuting fell up to 33% in some major cities in 2024, such as San Jose.[44] That year, the share of US workers commuting by car increased 3%, while the share commuting by public transport increased 15%.[45]
- In Istanbul (Türkiye), London (United Kingdom), and Chicago and New York City (United States), more than 100 hours per person are lost in traffic congestion annually on average due to road congestion –the equivalent of around 2.5 work weeks, assuming a 40-hour work week.[46]
- In South Africa, commuters in Cape Town lost 94 hours in traffic per year on average in 2024, followed by 55 hours in Johannesburg and 45 hours in Pretoria.[47]
- In Asian cities, car commuters lost 89 hours in traffic in Jakarta (Indonesia) and 74 hours in Bangkok (Thailand) annually on average in 2024.[48]

The largest increase in public transport ridership in 2024 was in the Middle East and North Africa, followed by the Asia-Pacific region, whereas rates in North America and Latin America remained low compared to 2019.[49] The pandemic had a lasting impact in most public transport markets, with more than half of operators in 2024 still reporting ridership below 2019 levels.[50] However, some locations have focused on improving the reliability of (formal) public transport services to increase ridership, as this can play a role in commute time and is important to keep travel flowing smoothly in an integrated transport system. (See 4.5 Public Transport.)

- In the United States, public transport and rail passenger ridership grew 17% in 2023 but did not fully recover from pandemic-related declines.[51] New York City accounted for nearly half (46%) of all US public transport trips in 2023, although the city's ridership was at around half of its 2019 level.[52] US passenger train use grew 19% – with double-digit growth on nearly every route – yet remained 10% below 2019 levels.[53]
- In Canada, public transport trips grew 12% in 2023 but remained 29% below 2020 levels, with revenues down 20%.[54]
- In Oceania, the pandemic had profound lasting impacts on public transport ridership. Between 2019 and 2023, ridership fell 23% in New Zealand, which has the region's most developed networks, while ridership in Australia nearly recovered to pre-pandemic levels.[55]
- In 2024, public transport ridership increased 13% each in Chicago (United States) and Sydney (Australia), 9% in Toronto (Canada), 8% in Washington, D.C. (United States), 7% in Sevilla (Spain), 4% in Paris (France) and 1% in Hong Kong (China).[56] Ridership fell 4% in Rio de Janeiro (Brazil).[57]
- A 2025 study in 16 major Brazilian cities found significant disparities in public transport service quality, infrastructure, and data transparency, with citizen satisfaction remaining low and dependency on private vehicles remaining high.[58] In Brasilia, progress included the implementation of a bus rapid transit system and an integrated fare card.[59]

Digitalisation can contribute to more efficient and integrated transport systems; however, as of 2024 an estimated 86% of cities globally lacked published data on their public transport systems.[60] Mapping walking, cycling and public transport networks – as well as informal transport – is a critical step towards improving system efficiency.

- Starting in 2024, US public transport agencies were required to publish their data publicly in General Transit Feed Specification (GTFS).[61]
- The EU has been developing a legal framework for automated vehicles, aiming for uninterrupted 5G coverage on major transport routes, boosting semiconductor production and implementing greater cybersecurity standards.[62]
- Jakarta (Indonesia) has developed a smartphone app

to provide optimised bus directions, and different bus providers now accept the same smartcard with free transfers, making the city's bus network more efficient, accessible and convenient without having to add additional buses.[63]

- In Bogotá (Colombia), people use resources such as OpenStreetMap to find directions, since cycle lanes have been implemented so quickly that apps like Google Maps are not sufficiently updated.[64]
- In 2022, Rio de Janeiro (Brazil) began implementing a digital system based on cloud technologies to optimise the efficiency of its bus rapid transit network.[65]

Use of digital platforms has helped to consolidate freight flows, increasing the efficiency of movements through economies of scale, and keeping costs low.[66] Connectivity is also crucial for freight transport efficiency and resilience, as freight provides an essential lifeline for recovery during disasters or shocks.[67]

Accessibility measures in public transport have remained incomplete and fragmented.[68] **Inclusive access (also known as universal design) – accommodating diverse users such as the elderly and people with disabilities or difficulties and other special needs – remains far from the norm.**[69] Some jurisdictions might have in place directives or guidelines for the infrastructure of buildings to accommodate people with special needs, but they may lack similar directives or guidelines for road infrastructure and transport services. (For more on universal design, see 1.2 The Right to Mobility.)

- Around 15% of the world's people – more than 1 billion – live with a disability, most of them in developing countries and often also experiencing poverty, marginalisation and social exclusion.[70] This can be mitigated through inclusive integrated transport planning.
- After a study in Mekelle (Ethiopia) revealed that people with disabilities faced significant safety and mobility challenges, an accessible design and infrastructure guide was developed to support inclusive urban mobility in the city (as well as other cities in low-income countries).[71]
- According to a 2023 study, access was the second greatest theme in Sustainable Urban Mobility Plans (SUMPs) in Europe, after cycling, highlighting that equity and inclusion are important to planners in sustainable transport planning.[72]

Affordability of transport remains a concern in many places, as transport costs often comprise a large share of household budgets and place a particular burden on low-income users. Household spending for transport varies greatly by country and region. Global trends such as rising fuel prices, geopolitical tensions and uncertain economic conditions also have an impact on households. Although recent fuel price increases did not appear to impact the distances travelled in many locations, they created a higher financial burden for drivers and freight operators.[73] In some countries, rising fuel prices have led to higher public transport costs, contributing to a "cost of living crisis".[74]

- In 2023, the highest shares of household spending on transport were in Mexico (20.5%) and Türkiye (19.7%) in a study across 47 countries (mostly consisting of member countries of the Organisation for Economic Co-operation and Development).[75]
- The lowest shares of household spending on transport in 2023 among the 47 countries were in the Slovak Republic (5.6%) and Albania (6%).[76]

Sustainability and climate trends

In 2023, transport was the second largest greenhouse gas-emitting sector globally – contributing 15.9% of global emissions – with three-quarters of the sector's emissions coming from road transport.[77] **Transport emissions tend to be higher in less-dense urban areas that lack effective public transport networks.**[78] Current transport systems rely on fossil fuels to meet nearly all of their energy demand (95.4% in 2023).[79]

Transport emissions vary greatly by region, with Asia continuing to contribute the largest share (40%) in 2023, followed by North America (26%) and Europe (17%) (excluding international aviation and shipping).[80] **North America leads by far in per capita transport emissions, followed by Oceania and Europe.**[81] (See Module 3. Regional Overviews: Trends and Policy Development.)

- Africa was home to one-fifth (18%) of the world's population in 2023 yet emitted only 5.3% of global transport greenhouse gas emissions (excluding international aviation and shipping).[82] The region's per capita transport emissions, at 0.26 tonnes of CO_2 equivalent, were the lowest globally and well below the global average of 0.89 tonnes.[83]
- Asia's per capita transport emissions remained below the global average in 2023, at 0.61 tonnes of CO_2 equivalent, but disparities across countries ranged from very low to very high.[84]
- In Europe, transport is among the largest sources of greenhouse gas emissions, contributing 18% of the region's total emissions and 17.4% of global transport emissions (excluding international aviation and shipping).[85] Europe had the world's third highest per capita transport emissions in 2023, at 1.66 tonnes of CO_2 equivalent, consistent with high motorisation rates and rising emissions from aviation.[86]
- Latin America and the Caribbean contributed 8.6% of global transport emissions in 2023.[87] The region's per capita transport emissions were slightly above the global average, at 0.94 tonnes of CO_2 equivalent.[88]
- North America contributed more than a quarter (26.7%) of global transport greenhouse gas emissions (excluding international aviation and shipping) in 2023.[89] Per capita transport emissions were the highest among regions, at roughly five times than the global average.[90]
- Oceania had the lowest transport greenhouse gas emissions among regions in 2023, contributing 1.7% of the global total (excluding international aviation and shipping).[91] However, it had the second highest per capita transport emissions (2.7 tonnes of CO_2 equivalent) after North America.[92]

Freight transport contributed 43% of global transport CO_2 emissions in 2023.[93] **Transforming the freight and logistics sector to ensure integrated, co-ordinated and efficient goods transport is key to reducing emissions, enabling economic development and local production, supporting circularity, and increasing resilience to shocks while reducing energy consumption.**[94] Critical enablers for sustainable integrated freight include inter-modal, low-carbon, efficient and resilient corridors across borders; land planning

for multi-modal freight transport and facilities; and resilience and adaptation plans across freight transport and logistics systems.[95] (See 1.3 Transporting Shared Prosperity: Connecting Economies and People for a Sustainable Planet.)

Mass public transport, rail, walking and cycling have much lower carbon intensities over their lifetimes – and per kilometre of people transported and goods moved – than cars or trucks, despite recent gains in vehicle fuel efficiency and electrification.[96]

- In 2022, the CO_2 emissions per passenger-kilometre from an average fossil fuel vehicle were nearly twice those of a fossil fuel bus, nearly five times those from rail, and more than six times those of a tram.[97]
- The last mile of the logistics chain represents up to 28% of total delivery costs, 20% of energy consumption and up to 25% of emissions emitted by the transport of goods.[98] Electric cargo bikes could satisfy around 20% of urban freight demand, depending on the delivery type.[99]

Compact land-use planning and transit-oriented development can greatly reduce emissions by shortening travel distances and reducing the need for car ownership and use, in addition to providing health benefits and improving social inclusion. Similarly, land-use planning for multi-modal freight transport and facilities is critical for supporting low-carbon, efficient and resilient freight corridors.

- In 2022, the Sixth Assessment Report of the Intergovernmental Panel on Climate Change highlighted that transit-oriented development could reduce transport greenhouse gas emissions 23-26% below business-as-usual projections by 2050.[100]
- Decision makers in many regions and at different scales have implemented transit-oriented development, recognising that support for public transport, walking and cycling can greatly reduce transport emissions and create vibrant urban spaces – including in Arlington and Denver (United States), Curitiba (Brazil), Hong Kong (China), Melbourne (Australia), Seoul (Republic of Korea) and Stockholm (Sweden).[101]
- Ireland's 2024 Climate Action Plan integrates climate action and transport in spatial planning through considerations of placemaking and accessibility, and calls for the widespread development of 15-minute neighbourhoods.[102]

Adaptation to the impacts of climate change has become increasingly important to transport and land planners at the national, sub-national and local levels. However, it is unclear whether integrated transport planning approaches for passenger and freight transport are sufficiently addressing adaptation and resilience.

- The congestion pricing scheme in New York City (United States), implemented in January 2025, directs revenues from the scheme to fund infrastructure upgrades as part of a resilience roadmap.[103]
- Digital models that have mapped London and Reading (United Kingdom) estimated that multi-modal commuting systems could reduce CO_2 emissions 12.6% while improving system flexibility during disruptions.[104]

Policy and investment developments

The Avoid-Shift-Improve (A-S-I) framework[i] is key for translating integrated transport planning into a comprehensive implementation tool. A-S-I is aligned with integrated transport planning principles and amplifies the implementation of sustainable transport from multiple angles. Although policies tend to focus on "Improve" measures, "Avoid" and "Shift" measures can reduce an estimated 40-60% of transport emissions at a lower cost (Box 2)**.**[105]

Box 2. Avoid-Shift-Improve Framework

The Avoid-Shift-Improve (A-S-I) framework dates back to the 1990s, when decision makers began using it to prioritise environmental sustainability actions in the transport sector. It aims to reduce the climate impacts of transport and improve access to clean mobility. The framework contains three pillars:

- **Avoid**: encourage users to avoid or reduce the need for motorised transport; this encompasses behavioural change, supply chain optimisation and demand management.
- **Shift**: foster the transition to more sustainable modes over carbon-intensive ones; this involves strategies that promote public transport, renewable energy-powered mobility services and energy-efficient logistics solutions.
- **Improve**: improve efficiency, technology, and energy sources through technology advancement and system optimisation.

A distinctive feature of this framework is its focus on the demand side, transforming the entire transport system –

i The Avoid-Shift-Improve framework has been central to sustainable, low-carbon transport for more than a decade. It follows an implicit hierarchy, with appropriate and context-sensitive "Avoid" measures (which avoid and reduce the need for motorised travel) intended to be implemented first, followed by "Shift" measures (which shift to more sustainable modes) and finally by "Improve" measures (which improve transport modes). See https://slocat.net/asi and H. Dalkmann and C. Brannigan (2007), Transport and Climate Change, Module 5e: Sustainable Transport – A Sourcebook for Policy-Makers in Developing Cities, GIZ GmbH, https://changing-transport.org/wp-content/uploads/2007_dalkmann_brannigan_transportandclimatechange.pdf.

from vehicle models to travel patterns. Research shows that "Avoid" and "Shift" policy components could contribute to 40-60% of decarbonisation targets, while offering benefits such as reduced congestion, increased safety and mobility equity.

In recent years, the A-S-I framework has been applied in the energy sector to reduce energy needs, promote renewable energy use and increase energy efficiency. As a result, various policies based on the three pillars at different levels are designed. For instance, when considering electricity use, actions to reduce energy consumption consist of fluctuating electricity prices ("Avoid"), installing solar rooftops on buildings ("Shift"), and using efficient appliances and smart grids ("Improve"). Notably, energy experts consider feedstocks and fuels to be the core policy targets, whereas for transport they are vehicles, mode connection and efficient mobility.

Although the A-S-I framework has a positive impact on sustainability and energy efficiency, it comes at a cost, particularly in public investment and infrastructure development. For example, efficient public transport, well-planned bicycle lanes and accessible electric vehicle chargers can dramatically drive down private car use, air pollution and noise. At the same time, a huge amount of public spending is needed for improving road planning, public transport services and relevant infrastructure.

Overall, the A-S-I framework provides a holistic and effective method for sustainable development, not only in transport but also in the energy sector. By addressing demand-side solutions, it can reduce resource consumption, lower emissions and create socio-economic value. However, striking a balance between benefits and financial costs is essential for its successful implementation.

Source: See endnote 105 for this section.

During 2023-2025, political shifts and global geopolitical challenges led some countries to reverse policies supporting sustainable and integrated transport systems. Public and political opposition to such policies is related to perceptions around their impacts on driving behaviour and the built environment, threats to long-held habits and excessive burdens on certain populations.[106] In some cases, this has led to challenges in enforcement and in establishing clear policy criteria (such as determining vehicle eligibility for low-emission zones).[107]

- Nigeria reinstated fossil fuel subsidies in late 2023 after having abruptly removed them in May 2023, a move that had resulted in inflation on top of already high unemployment and poverty.[108]
- In 2023, the Swedish government reversed many climate policies – including pausing an electric road project and cutting biofuel requirements – putting the country on track to miss its 2030 climate goals.[109]
- The Netherlands reversed many climate- and environment-related policies in 2024, including removing subsidies for electric vehicles and reintroducing higher speed limits.[110]
- The Czech Republic adopted higher speed limits in 2025, as did the state of Styria in Austria, despite the positive air pollution impacts of Austria's previous reduced speed limits.[111]
- In Berlin (Germany), the expansion of cycling infrastructure, pedestrianisation and new public transport projects has slowed since 2023.[112]
- In 2025, the European Commission provided flexibility for carmakers by extending the 2025 CO_2 targets for passenger cars until 2027, which might result in carmakers selling up to 880,000 fewer electric cars between 2025-2027 and delay further transition to electric vehicles.[113]
- In 2025, the Trump administration in the United States rolled back vehicle emission standards and support for electric vehicles, and cancelled important funding streams for infrastructure development.[114]

Among the numerous governance and planning strategies for integrated transport planning, a strong focus has been on National Urban Policy and Investment Programmes (NUMPs) and Sustainable Urban Mobility Plans (SUMPs) (Box 3)**.**[115] There has been rising interest in integrated urban-rural planning to improve social inclusion and synergies among communities, particularly in light of rapid urbanisation in low- and middle-income countries.[116] Despite the inter-dependence of urban and rural areas, development has lagged in rural areas, home to 85% of the lower-income population globally.[117]

Box 3. National Urban Policy and Investment Programmes (NUMPs) and Sustainable Urban Mobility Plans (SUMPs)

NUMPs and SUMPs are strategic, action-oriented frameworks that take an integrated approach to planning, with the goal of supporting sustainable urban mobility and improving quality of life. At the country level, NUMPs serve as strategic frameworks to enhance the capabilities of cities to meet their mobility needs in a sustainable way, while at the local level SUMPs can have a significant impact in reshaping how cities approach transport planning.

The development of NUMPs and SUMPs requires efficient co-ordination across various levels of governance and sectoral responsibilities, including transport, land use, environment and finance. Some plans have begun leveraging the digitalisation of ticketing systems to mainstream data for better equity – including data disaggregated by gender and age. NUMPs and SUMPs also have proven to be powerful tools for unlocking substantial climate and infrastructure financing. (See Partnerships in Action section.) For freight, Sustainable Urban Logistics Plans (SULPs), although rare, focus on city-level logistics to achieve sustainable freight operations in urban mobility planning.

Although less common than SUMPs, the adoption of NUMPs in low- and middle-income countries has increased since 2019. NUMPs that offer a clear policy framework and practical support can enable local governments to comprehensively plan and implement projects, especially where they face limitations in authority and resources. They can promote horizontal co-ordination between national ministries and vertical co-ordination with sub-national entities, ensuring that mobility planning is aligned across sectors and levels. For example, Peru's Ministry of Transport and Communications created a programme to help cities implement the four objectives of the country's NUMP.

SUMPs seek to make cities more liveable and environmentally friendly, with benefits including reduced carbon emissions and traffic congestion and improved air quality and public health. By balancing the needs of residents, businesses, and the environment, SUMPs can help cities become more sustainable and resilient in the face of urbanisation and climate change. SUMPs also integrate emission reduction directly into scenario development and strategic planning, such as comparing future scenarios to allow stakeholders to see the emission-cutting potential of policy and investment choices early in the planning phase. SUMPs can provide a structured and inclusive approach to overcome these challenges by promoting polycentric city structures, targeted densification and corridor-based transit development that aligns land-use decisions with mobility strategies.

Source: See endnote 115 for this section.

The development and implementation of SUMPs has expanded in most regions, although a lack of continuous global tracking impedes measurement. During 2023-2024, regional and national regulations enforced the use of SUMPs in more municipalities, enabling integrated planning of urban transport and land use.

- Brazil's National Urban Mobility Policy (PNMU), amended in December 2023, mandates that all municipalities with over 20,000 inhabitants – as well as those located in metropolitan regions, designated as tourist destinations or seeking federal funding for urban mobility – prepare a Mobility Plan.[118] Although most cities had not yet submitted their plans as of mid-2025, several had finalised them.[119]
- In 2024, Peru published its Manual for the Development of SUMPs, aimed at guiding and promoting the development of SUMPs in cities across the country.[120]
- In 2024, the EU's revised Trans-European Transport Network (TEN-T) policy entered into force, designating 431 cities as urban nodes and mandating them to adopt a SUMP and to collect and regularly submit data on urban mobility indicators.[121]

As of 2025, 32 SUMPs and 9 NUMPs had been developed in consultation with MobiliseYourCity across Africa, Asia, Eastern Europe, and Latin America and the Caribbean.[122] Cities designing SUMPs in consultation with MobiliseYourCity are encouraged to reduce their transport emissions at least 50% by 2050, whereas guidance in the EU suggests a 90% reduction in transport emissions.[123] MobiliseYourCity welcomed eight new members in 2024: Aizwal (India), Davao (Philippines), Harare (Zimbabwe), Kaduna (Nigeria), Kinshasa (DRC), Nairobi (Kenya), Toamasina (Madagascar) and Antsirabe (Madagascar).[124]

Integrated transport planning has increasingly been adapted to low- and middle-income countries, in recognition of their specific institutional, social, and infrastructural conditions and of the complex urban dynamics shaped by rapid population growth, informal development patterns and limited institutional capacities.[125] Compared to high-income countries, most cities in low- and middle-income countries still have low levels of private motorisation, which offers the potential for "leapfrog" development that helps to avoid "lock-in" to an automobile-centric paradigm; however, motorisation rates are growing quickly in many of these places. (See Module 3. Regional Overviews: Trends and Policy Development.)

- Many cities in Latin America have increasingly adopted SUMPs – including Arequipa (Peru) and Baixada Santista (Brazil) during 2022-2025 – even as national transport policies lag across the region due to resource and other constraints. (See 3.4 Latin America and the Caribbean Regional Overview.)
- Many cities have acknowledged informal transport as part of SUMPs and NUMPs – such as Antofagasta (Chile),

Bouaké (Côte d'Ivoire), Dire Dawa (Tanzania), Havana (Cuba), Medan (Indonesia) and Trujillo (Peru).[126]

As of 1 August 2025, a total of 7 of the 29 third-generation Nationally Determined Contributions (NDCs) that had been submitted to the UN Framework Convention on Climate Change (UNFCCC) featured activities on transport demand management and enhanced integrated planning; the 7 submissions were from Brazil, Canada, Ecuador, Kenya, Moldova, United Kingdom and Uruguay.[127]

- Brazil's third-generation NDC commits to reducing dependency on individual transport through sustainable urban development and the expansion of public transport and active mobility; the country's Green and Resilient Cities Plan aims to ensure integrated and sustainable urban planning.[128]
- Kenya's NDC commits to promoting low-carbon, climate-resilient and efficient transport systems with a strong emphasis on gender-responsiveness and accessibility for all; it will be achieved through, through electrification, modal shifts, public transport and other sustainable transport activities.[129]

Several recent initiatives have adopted a corridor-based approach to infrastructure development, recognising the strategic importance of strengthening regional connectivity beyond just linking cities.

- Starting in 2025, a new railway in Tanzania spanning more than 2,500 kilometres will enable a rail freight corridor for several East African countries, connecting key Tanzanian ports (from Dar es Salaam on the Indian Ocean to Mwanza on Lake Victoria) as well as Burundi, the DRC and Rwanda.[130]
- In West Africa, the 393-kilometre Kano-Maradi single-track rail line between Kano (Nigeria) and Maradi (Niger) is set for completion in 2025, with a capacity to transport 9,300 passengers and 3,000 tonnes of freight per day.[131]
- In Europe, the TEN-T programme connects urban and rural areas through multi-modal networks to foster sustainable economic growth.[132] One TEN-T project, the Fehmarnbelt tunnel between Denmark and Germany, is a combined rail and road link built using low-carbon technologies that aims to greatly reduce travel times, promoting rail travel and supporting integrated transport across the region.[133]
- The EU's Global Gateway Strategy, aligned with the African Union's Agenda 2063 and the ambitions of the African Continental Free Trade Area, seeks to support quality connectivity infrastructure across Africa through Strategic Corridors.[134] These corridors aim to facilitate sustainable, efficient, and secure mobility and trade – linking urban and rural areas, creating jobs and supporting value chains that benefit industries on both continents.

Governments have increasingly recognised the importance of developing rural transport programmes, stimulated by their potential to boost economic growth and opportunities and improve quality of life. Because rural areas face different challenges than urban areas, rural transport plans must take a different approach. Rural populations are typically more spread out, with greater travel distances, smaller roads and challenging geographical features. Some countries have specific rural plans that seek to increase access to electric vehicles and charging infrastructure, public transport, and walking and cycling infrastructure, although consolidated data on this trend are lacking.

- Ireland launched a five-year rural mobility plan in 2022 that prioritises connectivity and is focused on public transport, specifically an increase in electric buses.[135]
- In 2023, Rwanda adopted a rural road programme to better connect rural populations to broader transport networks, including integrating trail bridges for pedestrians and cyclists to more easily cross rivers, thereby connecting more isolated communities to larger towns and cities to allow for better access to jobs, education and other services.[136] Also in 2023, Rwanda began exempting electric vehicles from import duties to make them more accessible for the general population, following earlier examples from Togo and Tunisia; it previously adopted a plan to convert the more than 100,000 motorbikes on its roads to e-bikes.[137]
- According to the United Kingdom's updated rural transport plan, between 2019 and 2023 the country invested roughly half of the allocated USD 9.05 billion (GBP 7.2 billion) to walking, cycling and public transport infrastructure, mainly for walking and cycling but also to re-open rail lines and stations, increase zero-emission buses, and develop specific zones to trial Mobility-as-a-Service (MaaS), micromobility and demand-responsive transport.[138] The other half of the funding went to private road vehicles, nearly all of it to local highway maintenance, with smaller amounts for expanding electric vehicle charging networks and developing automated vehicle technologies.[139]
- In 2024, Uzbekistan expanded its integrated rural development plan, which includes improving roads and transport infrastructure alongside other areas such as education and health care.[140]

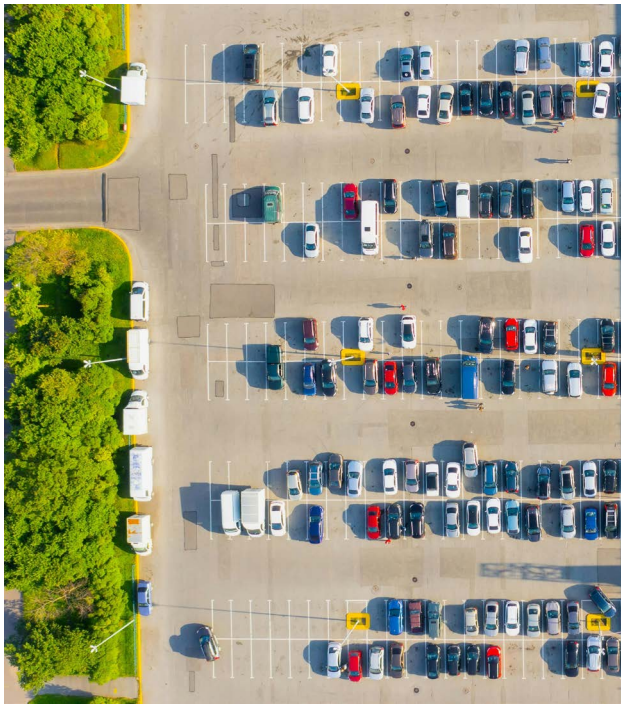
As part of public transport recovery measures since 2022, many cities in Asia, Europe and North America have explored free or reduced fare programmes to make services more accessible to everyone, particularly the vulnerable. However, the financial sustainability of public transport systems depends on a balance between operational costs and revenue generation. (See 4.5 Public Transport.)

- Mumbai (India) was among the cities with the cheapest monthly public transport passes in 2023, at USD 15.[141] In 2019, Delhi became the first Indian city to initiate fare-free bus transport for women of all ages and social classes.[142] By 2025, many Indian states were offering free bus fares for women, and a 2023 study showed that the money saved was spent mainly on family welfare needs.[143] Almost all Indian states offer public transport discounts to disadvantaged groups and those with disabilities.[144]
- By early 2024, 106 cities in Brazil were offering universal zero-cost public transport fares, up from less than 20 a decade earlier (in 2023 alone, 36 Brazilian cities adopted the policy).[145] The policy has increased in popularity and has increasingly been supported by political leaders.[146]
- As of 2024, at least 10 cities globally were offering free public transport for all, including Mariehamm (Finland) since 2000, Samokov (Bulgaria) since 2008, Dewsbury (United Kingdom) since 2009, Avesta (Sweden) and Chambly (Canada) since 2012, Tallinn (Estonia) since 2013, Aubagne and Dunkirk (France) since 2018, Luxembourg since 2020 and Valletta (Malta) since 2022.[147]
- In 2024, Mexico adopted the National Public Collective Urban Transport Policy (PNTPCU), with a commitment to cleaner transport alternatives that reduce environmental impact, decrease car dependence, and improve accessibility, sustainability, safety and governance.[148] The goal is to enhance public transport infrastructure and services, reduce inequality and combat climate change while fostering strategic planning for long-term urban mobility improvements.[149]

While these local efforts are important, more-transformative transport demand management actions – such as adjusting work schedules and promoting telecommuting – often fall outside local jurisdictions and are thus under-represented in city-level plans.

A handful of transport plans – such as in Scotland and some US states – have emphasised strategies to reduce vehicle travel as part of more people-centred, integrated approaches to satisfy mobility needs and improve quality of life.[150]

Since 2022, some European cities have revised their parking policies to adjust for the increased use of larger vehicles (mainly sport utility vehicles, or SUVs), which have been shown to take up more public space, produce more emissions and be more lethal in crashes.[151] French cities have been at the forefront of these "auto obesity" laws, with strong public support for reclaiming space for people by



imposing higher parking charges for larger vehicles. A growing number of cities in developing countries, such as Bogotá (Colombia) and Santiago (Chile), have implemented paid parking policies, and the World Bank has provided training on parking planning and management and guidance for increasing public transport.[152] Parking price reform can have positive impacts on the use of public transport.[153]

- Among French cities, Bordeaux in 2025 adopted a 30% higher parking rate for larger vehicles, with an exemption for professional vehicles, while Lyon in 2024 adopted a similar policy, with rates for large vehicles 1.5 to 3 times higher than for smaller vehicles, with exceptions for professional vehicles and for lower-income or multi-child households.[154]
- In a 2024 poll, 61% of residents in Paris (France) supported higher parking charges for vehicles that are large, heavy, or more polluting, with 56% of residents viewing SUVs negatively (mainly because they take up too much public space).[155]
- Paris charges large vehicles higher parking fees of USD 18.75 (EUR 18) per hour in the city and USD 12.50 (EUR 12) in the outskirts – compared with USD 6.25 (EUR 6) and USD 4.17 (EUR 4), respectively, for smaller vehicles.[156] The rates apply only to visitors, as local residents and professional vehicles are exempt.[157]
- In the 2024 poll, 68% of Paris residents supported strengthening the city's low-emission zone regulations to include vehicle weight, and 67% supported requiring manufacturers to increase the share of smaller vehicles on offer.[158]
- In 2023, Dublin (Ireland) was considering a parking policy with higher fees for larger vehicles, while also removing all free on-street parking in the city centre; however, as of 2024 the city had only raised overall parking fees.[159]
- Germany has charged higher rates for large vehicles since 2022, with the Association of German Cities supporting wider application of the policy.[160]
- In the United Kingdom, parking policies for large vehicles are in place in Bath and some London boroughs; Cardiff and Bristol launched public consultations in 2024 for such policies, and a proposal was put forward in Oxford.[161]
- Similar parking proposals in Brussels (Belgium) were at a standstill as of late 2024 due to political transition, although the city was considering a full ban on SUVs within city limits.[162]
- Outside of Europe, San Francisco (United States) has since 2018 imposed a USD 4 per hour parking charge for larger vehicles (compared to USD 2 per hour for smaller vehicles).[163]

Increasing bicycle parking near public transport hubs and train stations can facilitate integrated travel. In 2019, Utrecht (Netherlands) expanded bicycle parking at its central train station by 12,500 parking spaces, for a total of 22,000 spaces, making it the largest such hub in the world.[164]

- The previous record for bike parking was 9,400 spaces, held by a station in Tokyo (Japan).[165]
- In 2024, Buenos Aires (Argentina) was ranked as the sixth best city in the world for cycling.[166] From 2009 to 2023, as the city built bike lanes and installed more bike parking, the share of bicycle trips grew from 0.4% to 7.0%.[167]

Several jurisdictions have taken actions to improve the road safety of pedestrians and cyclists in connection to the Vision Zero approach.[168] **The greatest improvements in road safety have been achieved in countries where the Safe System approach has been adopted.**[169] (See 4.3 Walking.)

- Sweden remains a global leader in road safety, with just 2.8 deaths per 100,000 inhabitants in 2020, while Oslo (Norway) and Helsinki (Finland) achieved zero pedestrian deaths in 2019.[170]
- Kenya's Road Safety Action Plan 2024-2028 includes a commitment to reduce road fatalities 50% by 2030, which is aligned with Sustainable Development Goal 3.6 on road safety and with the Second United Nation Decade of Action for Road Safety 2021-2030.[171]
- In 2025, Malaysia committed to Vision Zero, in connection with its Road Safety Plan 2022–2030.[172]
- The Global Ministerial Conference of Road Safety held in Morocco in February 2025, and the associated Marrakech Declaration, urged UN Member States and related actors

to accelerate and scale up efforts to implement the Global Plan and associated Global Road Safety Performance Targets.[173] (See 1.7 Driving Health and Wellbeing Forward: The Critical Link with Transport.)

Digitalisation efforts have the potential to greatly reduce transport emissions by increasing efficiency. The emission savings could be even larger when such services focus on collective and integrated transport.

- **Research in Amsterdam (Netherlands) in 2022 found that Mobility-as-a-Service (MaaS) offers potential emissions savings of 3-54%, depending on the attractiveness of these services to users.**[174]
- In Merida (Mexico), ridership grew and emissions per passenger fell 9% after the city implemented digital monitoring of bus operators to improve maintenance and scheduling, without adding any buses.[175]

During 2023-2025, several implementation and planning efforts around congestion pricing were in the spotlight; such efforts can have direct positive impacts on traffic, emissions and pollution levels.

- In January 2025, New York City became the first US city to implement a congestion pricing policy, with strong initial results, although the policy has faced political challenges by the federal government.[176]
- Seoul (Republic of Korea) rolled back part of its congestion charging scheme after 27 years, opting to instead exempt traffic in one direction starting in January 2024; this was despite findings that traffic rates increased more than 5% during an experimental phase in 2023 when the city did not collect the toll fee from southbound vehicles.[177]
- In early 2025, the Malaysian government announced that studies were under way to assess the feasibility and potential impacts on traffic and public transport use of implementing congestion charges in Kuala Lumpur, George Town and Johor Bahru; findings were expected by year's end.[178]
- The Ministry of Transport in Bangkok (Thailand) announced plans in 2024 to implement a USD 1.16-1.45 (THB 40-50) congestion charge for motorists entering the inner city, which it says could generate an estimated USD 290 million (THB 10 billion) annually to help subsidise a flat-fare policy for all electric rail lines in Greater Bangkok of USD 0.58 (THB 20).[179] Officials emphasised the need for improved public transport systems and other sustainable alternatives before full implementation.

Some cities have implemented low-emission zones (LEZs), ultra-low-emission zones (ULEZs), zero-emission[ii] zones (ZEZs) and low-traffic neighbourhoods to reduce emissions, congestion, and air and noise pollution in specific areas. The aim is often to mitigate congestion and poor air quality, although the zones also lead to reduced CO_2 emissions and improved health and equity, as urban air pollution often disproportionately impacts the most vulnerable.[180] LEZs have also become an important revenue source for cities. Low-traffic neighbourhoods, although less common, involve installing traffic filters and have been shown to reduce traffic volumes and nitrogen dioxide (NO_2) emissions (without displacing either to other areas), while also promoting social equity, local businesses, inclusion, safety, walking and cycling.[181]

- By 2025, implementation and expansion of the ULEZ in London (United Kingdom) in 2019 had resulted in CO_2 reductions equivalent to the removal of 3 million flights between London and New York City, as well as significant reductions in particulate matter ($PM_{2.5}$) and in NO_2 (by 27% city-wide and 54% in central London).[182] London's LEZ generated an estimated USD 1.26 billion (GBP 1 billion) between 2019 and 2024.[183]
- Elsewhere in Europe, low-emission zones in some cities have led to NO_2 reductions of around 20%.[184] Fewer reductions occurred in older zones – based on the Euro 4 and 5 emission standards for diesel vehicles – due mainly to the mismatch between the emissions for these vehicles in test conditions versus real-world use.[185]
- In 2025, Ahmedabad (India) began exploring implementation of an LEZ, which was projected to reduce pollutants up to 40%, following a model designed by the High Volume Transport Applied Research Programme.[186]
- New York City's congestion pricing policy is projected to decrease daily vehicle traffic more than 4% and CO_2 emissions more than 10% by 2045, alongside decreases in fine particulate matter, nitrogen oxides and carbon monoxide.[187]
- In 2024, the People's Council in Hanoi (Viet Nam) approved a resolution to implement pilot LEZs in Hoàn Kiếm and Ba Đình districts starting in 2025.[188] Within LEZ areas, Hanoi's strategy explicitly aims for public transport to account for 45-50% of passenger trips; all new and replacement buses must be electric or use green energy, with a target of a fully green bus fleet by 2030.[189]

While there is typically popular support for LEZs and similar strategies, implementation can be highly contested.[190] **To reduce resistance, some governments have introduced these policies incrementally and grown them progressively over time, either increasing the strictness or expanding the geographic coverage. More recently, some places, such as in France and Spain, have scaled back plans to strengthen LEZs in response to intensified political debate.**

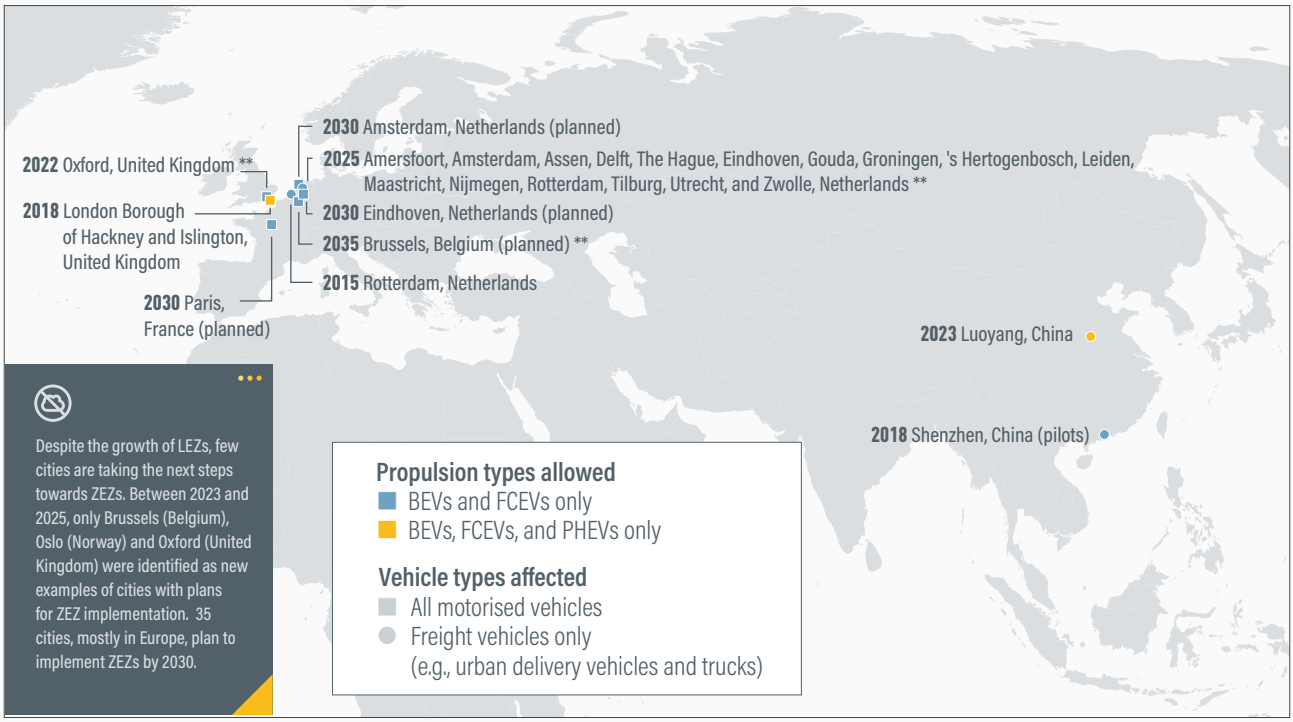
ii Limiting traffic to only vehicles that emit zero tailpipe emissions.

- **Overall, the number of LEZs in operation in Europe is estimated to have doubled between 2019 and 2025, from 228 to more than 500.**[191]
- Some of the newest LEZs include those in Palma (Spain) in 2025 and Dundee (Scotland) in 2024.[192]
- In May 2025, France's National Assembly – with support from right and far-right groups – voted to abolish low-emission zones.[193]
- By 2025, at least 27 European cities were expected to expand or strengthen their existing LEZs.[194]

Despite the growth of LEZs, few cities are taking the next steps towards ZEZs. Between 2023 and 2025, only Brussels (Belgium), Oslo (Norway) and Oxford (United Kingdom) were identified as new examples of cities with plans for ZEZ implementation (Figure 2)**.**[195] **35 cities, mostly in Europe, plan to implement ZEZs by 2030.**[196]

- Several dozen cities worldwide had implemented or planned to implement ZEZs or near-ZEZs by the early 2020s – or earlier, as in Shenzhen (China) in 2018.[197] They were mostly in Europe but also in China, India and the United States.[198]
- The ZEZ in Oslo (Norway) entered into force in 2023 – starting with a "Car-Free City Life" area where pedestrians and cyclists have priority over private cars – and aims to expand to other areas of the city by 2026.[199]
- The ZEZ in Oxford is supported by the city's SUMP, which also includes implementing low-traffic neighbourhoods and traffic filters, measures for walking, cycling and public transport, and sustainable freight policies.[200]
- Brussels' LEZ, introduced in 2018 and tightened in 2022, led to a halving in the number of diesel vehicles in the city between 2018 and 2022, as well as a 30% reduction in particulate matter emissions and 62% less black carbon.[201]

FIGURE 2. Implemented and planned zero-emission zones and variants as of April 2025



Source: See endnote 195 for this section.

* Note: Zero-emission zones (ZEZs) allow battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs) only; near-ZEZs also allow plug-in hybrid electric vehicles (PHEVs). Affected areas of
zones range from a single street to an entire city or metropolitan area. The map includes cities that have committed in an offcial policy document or announcement to introduce a ZEZ or near-ZEZ,
set a date of introduction/start date, indicated the vehicle types affected, and set binding requirements for access (such as minimum emissions standard certification). For ZEZs and near-ZEZs
covering all motorized vehicles, the applicability to all vehicle types must be clearly stated in the offcial document.

** For cities in the Netherlands with an implemented ZEZ, a transitional phase for some types of freight vehicles exist until up to 2030 e.g., newer vans and trucks with high Euro emission standards.
Oxford has a charge-based scheme which allows non-zero emission vehicles to enter when paying a charge. Brussels has not set a date for buses, coaches, and heavy goods vehicles.

By 2035, the LEZ will be upgraded to a ZEZ by banning all internal combustion engine vehicles except for heavy goods vehicles and coaches.[202]

- In London, the existing ULEZ was expanded in 2023 to include every London borough, but a plan to implement a ZEZ starting in 2025 was put on hold.[203]

Some cities have established specific zero-emission zones for freight transport (ZEZ-Fs) – ranging from urban delivery vans to medium- and heavy-duty trucks – to address the large contribution of freight transport to air pollution and greenhouse gas emissions.[204]

- By late 2024, at least 35 cities globally were planning to introduce ZEZ-Fs, most of them in the Netherlands, where a national law mandated such zones by 2025.[205]
- In 2025, ZEZ-Fs came into force in 14 Dutch cities, including Amsterdam, Rotterdam, Utrecht, and The Hague, with an additional 16 cities expected to follow suit.[206]

LEZ, ULEZ and ZEZ policies can be supported by targets for 100% electric vehicle sales and mandates for phasing out internal combustion engine vehicles. By the end of 2023, at least 74 countries and 26 states/provinces across all major continents had targets promoting electric vehicles, while 49 of these jurisdictions had a 100% electric vehicle sales target or a targeted ban on internal combustion engine vehicles.[207] In 2025, to further strengthen its LEZ policies, Norway announced plans to allow cities to ban fossil fuel-powered cars entirely from their ZEZs.[208] (See 5.2 Road Vehicle Electrification.)

Partnerships in action

- **Bridges for Prosperity** connects rural communities through proven infrastructure solutions, such as trail bridges. It advocates for rural mobility as a policy and investment priority and ensures a long-lasting impact by combining local capacity building, community ownership, evidence-based planning and long-term systems change. In 2024 alone, the organisation built 130 bridges across Bolivia, Eswatini, Ethiopia, Rwanda and Uganda, directly serving more than 1.4 million people.[209]
- **UN-Habitat** has developed guidelines for rural-urban connections for key stakeholders, including national and local governments; as of 2023, 11 developing countries had adopted the guidelines as part of their planning and 20 had strengthened urban-rural connections.[210]
- **Clear Air Asia's** mission is to improve air quality and foster healthier, more liveable cities across Asia, particularly through providing policy guidance, building capacity and making the case for action among stakeholders.[211]
- The **High Volume Transport (HVT) Applied Research Programme**, funded by UKAID through the UK Foreign, Commonwealth & Development Office, has undertaken many activities to support integrated transport planning, including an initiative through its Pan-African Capacity Building Programme to increase inclusivity, resilience, and walking and cycling in low- and middle-income countries in Africa.[212] The HVT programme released a guide on "quick wins" for low-carbon transport highlighting opportunities for low-income countries in Asia and Africa to increase resilience in transport while reducing emissions, increasing liveability, improving living conditions and supporting economic prosperity, as well as a planning framework for implementing LEZs in Indian cities.[213] It also produced a compendium of the 188 reports and documents from the over 100 projects that were funded.[214]
- **ICLEI–Local Governments for Sustainability** leads the global **EcoMobility** agenda, prioritising active and shared travel, as well as the **EcoLogistics** community, which focuses on advancing sustainable urban freight.[215] It has more than 100 participating cities accounting for a combined 239 million people, where 60% of the residents use active and shared modes and 75% of the cities report their greenhouse gas emissions.[216]

- The **Institute for Transportation and Development Policy** (**ITDP**) uses technical expertise, advocacy, and policy guidance to mitigate climate change impacts, improve air quality and support more sustainable and equitable cities.[217] Its focus is on high-quality public transport, safe and pleasant active travel infrastructure, transit-oriented development and people-centred inclusive policies.[218]
- Through the **MobiliseYourCity Partnership**, 19 SUMPs and 6 NUMPs had been completed as of 2023, of which 13 SUMPs and 4 NUMPs were linked to financing, directly contributing to mobilising more than USD 1.82 billion (EUR 1.75 billion) in secured funding (primarily through international loans) for public transport infrastructure, walking and cycling facilities, and urban space improvements.[219] The total identified investment needs through these plans exceed USD 28.75 billion (EUR 27.6 billion), highlighting their potential to scale climate-aligned mobility investments across cities and countries.[220] The partnership – implemented by AFD, GIZ, ADEME, Cerema, CODATU, the European Bank for Reconstruction and Development, KFW and the Wuppertal Institute – also has created a dedicated calculator to help cities quantify the emission reduction potential of proposed measures.[221]
- In 2023, in the lead-up to the UN Climate Change Conference in Dubai, United Arab Emirates (COP 28), a group of organisations launched a **call to double the share of energy-efficient and fossil-free forms of land transport by 2030, with the goal of fossil-free land transport by 2050.**[222] The call emphasises shifts towards public transport, walking, cycling, and rail freight, as well as electric vehicles and railways, while drastically scaling up the use of renewable and zero-emission energy sources.[223] While each country will adopt a nationally determined approach, the call to action outlines a series of universal enablers to meet this target. The call was issued by SLOCAT and REN21, jointly with the Institute for Sustainable Development and International Relations (IDDRI), ITDP, the International Union of Railways (UIC), the International Association of Public Transport (UITP) and the World Resources Institute, and is supported by over 60 multi-stakeholder signatories (including Chile and Colombia).
- Building on the call to action and other multi-stakeholder efforts, the **Climate Champions Team** launched the Avoid and Shift Breakthrough at the 2024 UN Climate Change Conference in Baku, Azerbaijan (COP 29).[224] The Breakthrough features the same doubling goal for land transport and seeks to strengthen transport targets that focus on "Avoid" and "Shift" measures in complementarity with other initiatives that favour "Improve" measures.[225]
- The **Transformative Urban Mobility Initiative** (**TUMI**) is a leading global implementation initiative on sustainable transport that aims to change mobility for the benefit of people and the environment. It is supported by the German Federal Ministry for Economic Cooperation and Development (BMZ) and implemented through GIZ. In 2024, under TUMI's leadership, the Hamburg Charter for Inclusive and Just Mobility was officially launched at the inaugural Hamburg Sustainability Conference. The Charter emphasises the social dimension of the mobility transition, with central components being climate action, gender equity, safety and access. The Charter was signed by 23 cities and organisations, including Hamburg (Germany), Malmö (Sweden), Tirana (Albania) and the World Bank.[226]
- The **World Bank** published a guide for planning for transit-oriented development in emerging cities to rapidly transform urban areas into vibrant communities, stressing the importance of integrating land use regulations and transport planning.[227]
- In 2024, the **World Resources Institute** – working in 12 countries with partners in more than 50 – published a report demonstrating how public transport agencies worldwide can adjust their funding portfolios for operational costs, considering changes since the pandemic.[228]

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Walking

KEY FINDINGS

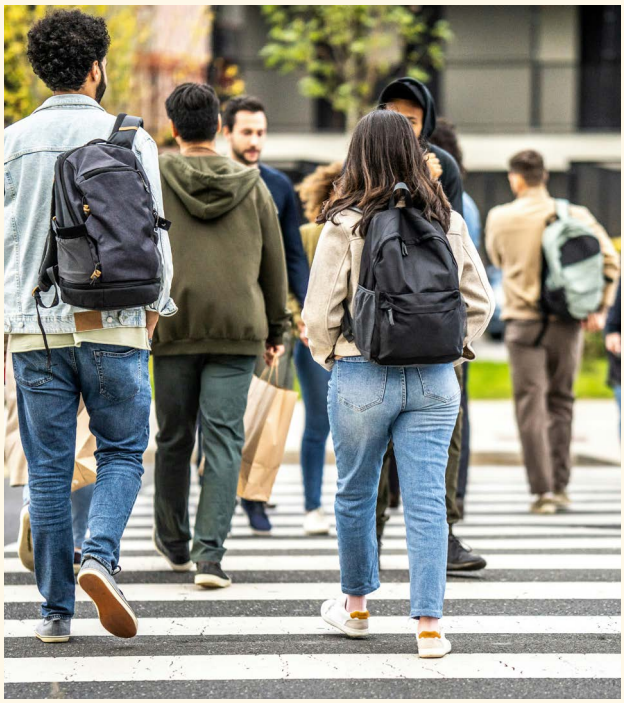
Demand, use and access

- Most of the world's population identifies as pedestrians, and nearly all transport trips made globally include a walking stage if not walked all the way. A 2022 survey of more than 45,000 people in 48 countries found that 94% of respondents identified themselves as pedestrians.
- In Africa, walking is the primary mode of transport, with more than three-quarters (78%) of people travelling on foot every day to access health care, education, shops, jobs and public transport as of 2022.
- In the European Union (EU), 61% of the population reported having walked for 10 minutes or more on at least four days in the previous week in 2022.
- In the United States, walking accounted for only 7% of all trips in 2022, while 87% of trips were made using private motorised transport.
- Walking has been undervalued due to its undercounting as a transport mode. Traditional surveys of modal shares capture only around one-quarter of the actual walking that takes place because they tend to underrepresent the walking done by public transport users and to overlook many short but essential trips made by young people, older adults, women and people with disabilities.
- Research on public transport in 12 cities across Australia, Austria, Germany, the Netherlands, Switzerland, and the United Kingdom found that, as of 2024, more than 90% of passengers walked to public transport, 50% of their total travel time was spent as a pedestrian, and 70% of their reported memories included the walking experience.
- In 2022, just half (52%) of the world's urban population lived within convenient access (walking distance) of public transport.
- Women make more frequent walking trips than men, due mainly to their caregiving tasks; yet because many of these trips are undercounted, planning and policies do not cater to women's needs.
- Promoting walking and cycling has been identified as a potential solution to boost physical activity levels and counter the persistent burden of inactivity. As of 2016, an estimated 81% of adolescents and 27.5% of adults globally were not meeting the recommended physical activity levels of 60 minutes or more daily for adolescents and 150 minutes or more weekly for adults.
- Studies have shown that walking for 30 minutes or cycling for 20 minutes regularly can reduce mortality risk by 10%.
- Walking for transport can play an important role in supporting active lifestyles. In a global study of 104 countries, walking and cycling for travel accounted for 36% of the total physical activity of adults who reported undertaking physical activity.

KEY FINDINGS

Sustainability and climate trends

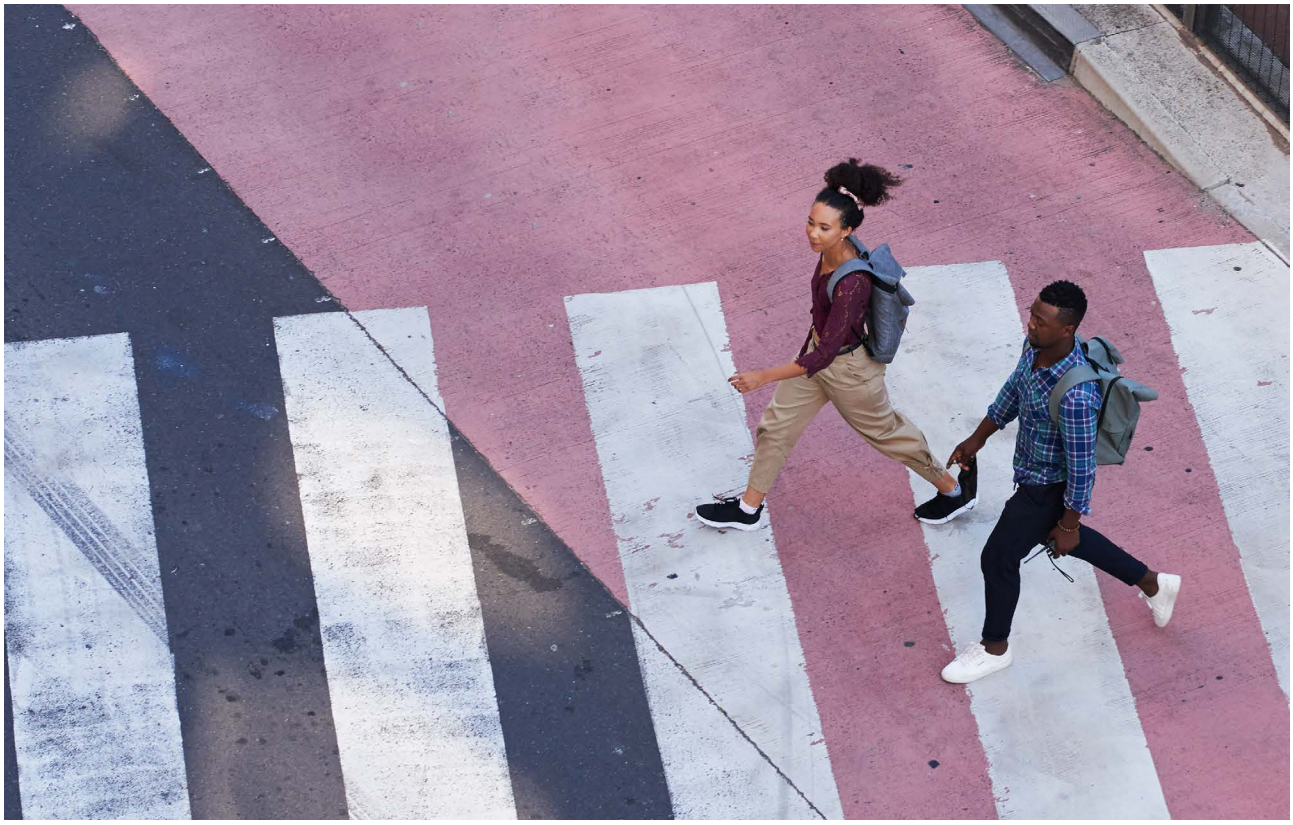
- Traditional transport planning often overlooks women's mobility patterns, resulting in infrastructure that benefits motorised travel and does not serve women's needs or protect them. Inadequately lit pedestrian environments expose people (especially women) to an elevated risk of harassment and violence, while the absence of sidewalks and pedestrian crossings puts everyone (especially people with disabilities, children and older people) at higher risk from road crashes.
- Among the 17 UN Sustainable Development Goals, only one – SDG 16 on Peace, Justice and Strong Institutions – has an indicator that refers directly to walking (specifically, perceived safety while walking).
- In all regions, women feel less safe than men when walking alone at night where they live. For the period 2020-2022, this difference ranged between 9 percentage points in Sub-Saharan Africa and 18 percentage points in Northern Africa and Western Asia.
- Latin America and the Caribbean was the region where both women and men felt the least safe walking alone in their neighbourhood after dark (37-52% safe).
- The need for inclusive pedestrian environments that are gender responsive and accessible for all users is increasingly recognised.
- SDG Target 11.7 – on access to public space – could be adapted to provide more information about women's experiences when walking, to help improve these experiences and to enable women to exercise their right to the city.
- Road traffic deaths overall fell 5% between 2010 and 2021, but fatalities among pedestrians rose 3%. Road traffic crashes claimed an estimated 1.19 million lives worldwide in 2021, with pedestrians representing 21% of all fatalities.
- The highest shares of pedestrian fatalities among road traffic deaths in 2021 were in Africa (33%) and the Eastern Mediterranean (26%), whereas South-East Asia and the Americas had the lowest shares (17% each).
- In 2021, the annual economic cost to society from pedestrian road casualties exceeded an estimated USD 940 billion globally. Low- and middle-income countries accounted for 89% of the victims and 68% of the economic cost.
- Although Africa had only 3% of the world's registered vehicles in 2021, it suffered 20% of global road traffic deaths that year.
- As of May 2025, only 17% of assessed roads in 88 countries attained a three-star or better rating (out of five) for pedestrian safety, whereas nearly half (49%) of assessed roads met this standard for vehicle occupants.
- As of 2023, half of surveyed drivers across 48 countries reported exceeding the speed limit. Speeding was responsible for one-third of road crashes in high-income countries in 2017, and this share is likely to be even higher in low- and middle-income countries given the large proportions of deaths of pedestrians, cyclists and motorcyclists. Elevated speeds are also directly associated with increased greenhouse gas emissions and noise levels.
- Providing safe walking and cycling infrastructure is a quick, affordable and reliable way to reduce transport emissions by 20-50%. A modal shift study in Australia estimated that substituting just 1% of automobile travel with walking (or cycling) could result in a 2-4% reduction in motor vehicle emissions.



KEY FINDINGS

Policy and investment developments

- Despite their decarbonisation benefits, walking and cycling remain underrepresented in climate change policies and in countries' Nationally Determined Contributions (NDCs) towards reducing emissions under the Paris Agreement. Integrating walking into national policies and improving data collection are crucial steps towards enhancing public health, reducing environmental impact and achieving various SDG targets.
- In 2022, the WHO identified significant gaps in data collection and monitoring of walking and cycling, including a lack of global indicators and data on the provision of related infrastructure and networks.
- More than 100 countries worldwide have utilised the WHO's Global Physical Activity Questionnaire, which is designed to provide a more accurate measurement of walking and to help authorities assess the extent to which walking and cycling for travel occur on a typical day.
- As of 2018, fewer than half (73) of 174 countries analysed had national policies to promote or support walking and/or cycling (mostly high-income countries), and only 27 countries had sub-national policies.
- By contrast, 127 countries had national policies and funding for public transport as of 2018. While this investment in public transport is promising, it underscores the need to recognise that every public transport user is also a pedestrian.
- As of 2023, a total of 124 of the 197 member countries of the UN Framework Convention on Climate Change had integrated walking into a national policy and/or an NDC aimed at reducing greenhouse gas emissions. However, only 17% of these policies had a visible, dedicated budget, and less than 30% had an evaluation mechanism, revealing a significant gap between stated commitments and actionable delivery.
- As of 2023, 80 countries (41%) addressed walking in their national policies but not in their NDCs, and 13 countries (7%) integrated walking in their NDCs but not in national policies. These countries have an opportunity to reinforce policy coherence. There is a need for a common system to develop climate policies that address walking.
- Only 31 UNFCCC member countries (16%) as of 2023 had both a national policy and an NDC addressing walking.
- The most common objectives in national policies addressing walking as of 2023 were to increase physical activity (36%), to improve road safety (32%), and to mitigate climate change (28%), followed by aims to improve accessibility (23%) and comfort (14%).
- Most of the NDCs that mentioned walking and cycling as of 2023 aimed to increase the share of people using these modes; only 6% had a goal to increase physical activity, and less than 3% mentioned road safety and other objectives.
- As of August 2025, 29 countries had submitted new (third-generation) NDCs to the UNFCCC. The third-generation NDCs of nine countries – Brazil, Canada, Lesotho, Monaco, Nepal, Singapore, the United Arab Emirates, the United States and Uruguay – featured climate action in relation to walking (often subsumed under active transport) to mitigate greenhouse gas emissions in the transport sector.
- Regional plans for walking have also begun to emerge. The first Pan-European Master Plan on walking, released in 2024, has the potential to put walking at the forefront of mobility policies in 56 countries.
- Walking has often been overlooked in urban planning, although some countries and cities have integrated efforts to improve pedestrian infrastructure in their plans.
- In NDCs and other strategies, policy makers have increasingly adopted more systemic, multi-disciplinary approaches to walking that connect across departments; prioritise the safety, comfort and enjoyment of the pedestrian; and deliver immediate, measurable benefits (which can often be reported using existing datasets). However, datasets on walking continue to show gaps and limitations, which can be improved through additional local data collection.
- The greatest improvements in road safety have been achieved in countries where the Safe System approach has been adopted. This approach shifts the responsibility from road users to road designers and operators and puts people and safety at the heart of mobility systems through four core areas: safe roads, safe speeds, safe road users and safe vehicles.
- As of 2022, only 57 countries met the WHO's recommended speed limit for urban roads of 50 kilometres per hour, just 9 more countries than in 2018. Implementing reduced speeds for people to safely walk or cycle is an important measure to improve global road safety trends and promote active mobility.



Context, challenges and opportunities

Billions of people walk every day. Whether heading to work, school, shops, or public spaces, every journey begins and ends on foot. Yet despite walking's universality, pedestrians around the world face safety, security, and accessibility challenges, ranging from poor or non-existent walking infrastructure and street harassment to inadequate integration with public transport systems. These barriers not only endanger lives but also discourage walking, especially for the more vulnerable (children, women, older persons and persons with disabilities).

The lack of walkable environments reduces active commuting by foot or bicycle, increasing the reliance on motorised transport and exacerbating air pollution and greenhouse gas emissions.[1] Enhancing the walking conditions and experience for the people who travel by foot every day represents the quickest, most cost-effective, dependable and equitable way to keep people walking.

As the most accessible and equitable form of mobility, walking supports progress on multiple Sustainable Development Goals (SDGs). The impacts of walking are positive in many areas, including on emissions, congestion, road crashes, gender equity, accessibility, social justice, public transport ridership and public health. Walkability is associated with the reduction of non-communicable diseases and better health conditions.

Globally, 80% of all roads failed to meet minimum three-star (out of five) or better safety standards for pedestrians as of mid-2025, and in 2023 half of all drivers across 48 countries reported exceeding the speed limit.[2] The Safe System approach to road safety and the improvement of public transport systems with better walking (and cycling) access are all ways to improve walking conditions and support more walking. Often, the low-cost, high-return interventions that are needed represent good value for the money and can underpin a stronger return on investment for public transport systems.[3]

Although progress is being made, significant work remains to ensure that walking is fully embedded in both transport and climate policies. Across countries, gaps remain in the policy delivery system for Nationally Determined Contributions (NDCs) towards reducing greenhouse gas emissions under the Paris Agreement. As of 2023, only 16% (31) of the member countries of the United Nations Framework Convention on Climate Change (UNFCCC) had both a national policy and an NDC that addressed walking, 41% (80 countries) had only a national policy addressing walking, and 7% (13 countries) had only an NDC addressing walking.[4] There is an urgent need for a common system to develop climate policies that support and promote walking as well as the infrastructure that facilitates it.

Demand, use and access

Most of the world's population identifies as pedestrians, and nearly all transport trips made globally include a walking stage if not walked all the way.[5] **A 2022 survey of more than 45,000 people in 48 countries found that 94% of respondents identified themselves as pedestrians.**[6] Regionally, this share reached 94.9% in Europe (24 countries), 94.4% in Africa (12 countries), 93.8% in Asia and Oceania (9 countries) and 86% in the Americas (3 countries: Canada, Colombia and the United States).[7]

In Africa, walking is the primary mode of transport, with more than three-quarters (78%) of people travelling on foot every day to access health care, education, shops, jobs and public transport as of 2022.[8] On average, the region's population spent 56 minutes per day walking or cycling for transport in 2022, with women showing 29% higher rates of engagement in these forms of transport than men.[9]

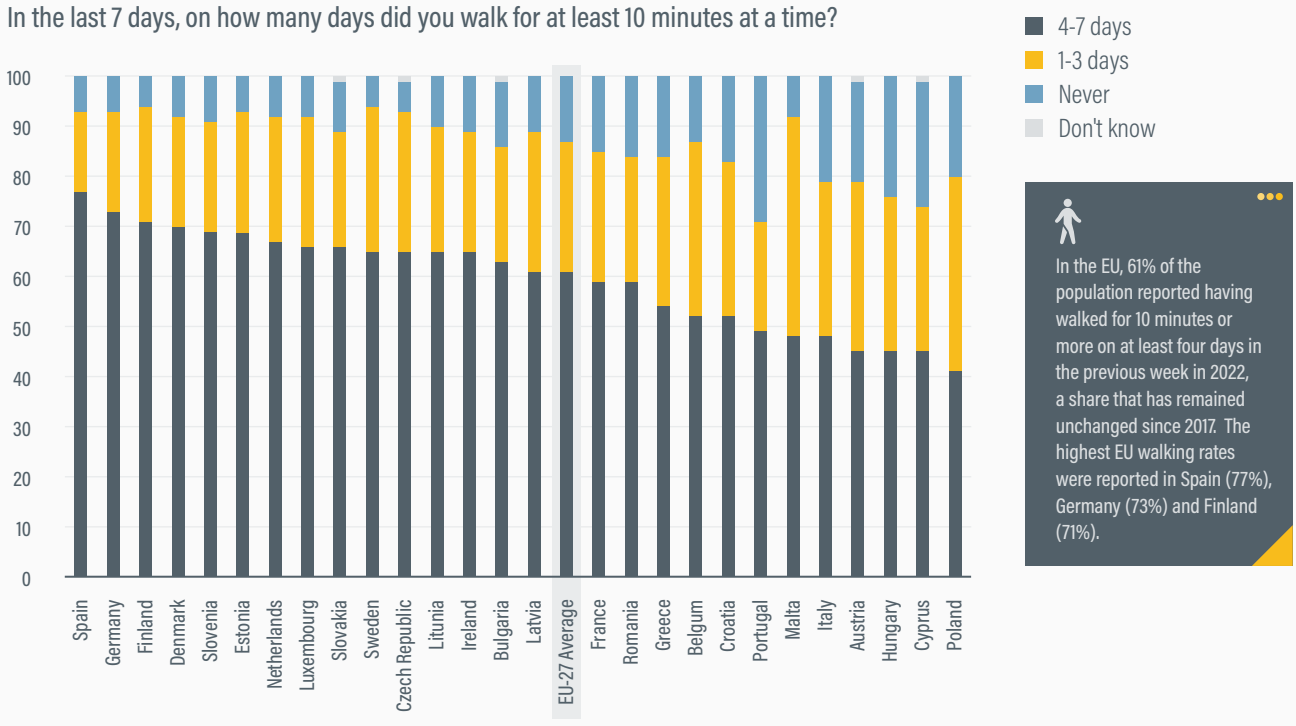
In the European Union (EU), 61% of the population reported having walked for 10 minutes or more on at least four days in the previous week in 2022 (Figure 1), a share that has remained unchanged since 2017.[10] The highest EU walking rates were reported in Spain (77%), Germany (73%) and Finland (71%).[11]

- In Germany, walking's share grew from 22% in 2017 to 26% in 2023.[12]
- EU respondents aged 15-24 walked the most (71%), a share that decreased with age.[13]
- Globally, the share of older adults walking in urban areas fell from 34% in 2012 to 28% in 2022, with much of this decline occurring in high-income and ageing countries.[14]

In the United States, walking accounted for only 7% of all trips in 2022, while 87% of trips were made using private motorised transport.[15] Although regional data for Latin America were unavailable, walking-only trips represented 38% of all weekly trips in Bogota (Colombia) and 23% in São Paulo (Brazil), as of 2021.[16] A study of 2,000 students in Rio de Janeiro (Brazil) found that nearly half (46.5%) of all children walked to school in 2023, with a higher share of girls (50%) walking to school than boys (43%).[17]

Walking has been undervalued due to its undercounting as a transport mode. Traditional surveys of modal shares capture only around one-quarter of the actual walking that takes place because they tend to underrepresent the walking done by public transport users and to overlook many short but essential trips made by young people, older adults, women and people with disabilities.[18] Most travel

FIGURE 1. Survey results on walking for at least 10 minutes at a time for EU countries, 2022



In the EU, 61% of the population reported having walked for 10 minutes or more on at least four days in the previous week in 2022, a share that has remained unchanged since 2017. The highest EU walking rates were reported in Spain (77%), Germany (73%) and Finland (71%).

Source: See endnote 10 for this section.

surveys focus mainly on journey-to-work trips and record only the primary mode of transport, typically excluding journeys shorter than 500 metres.[19]

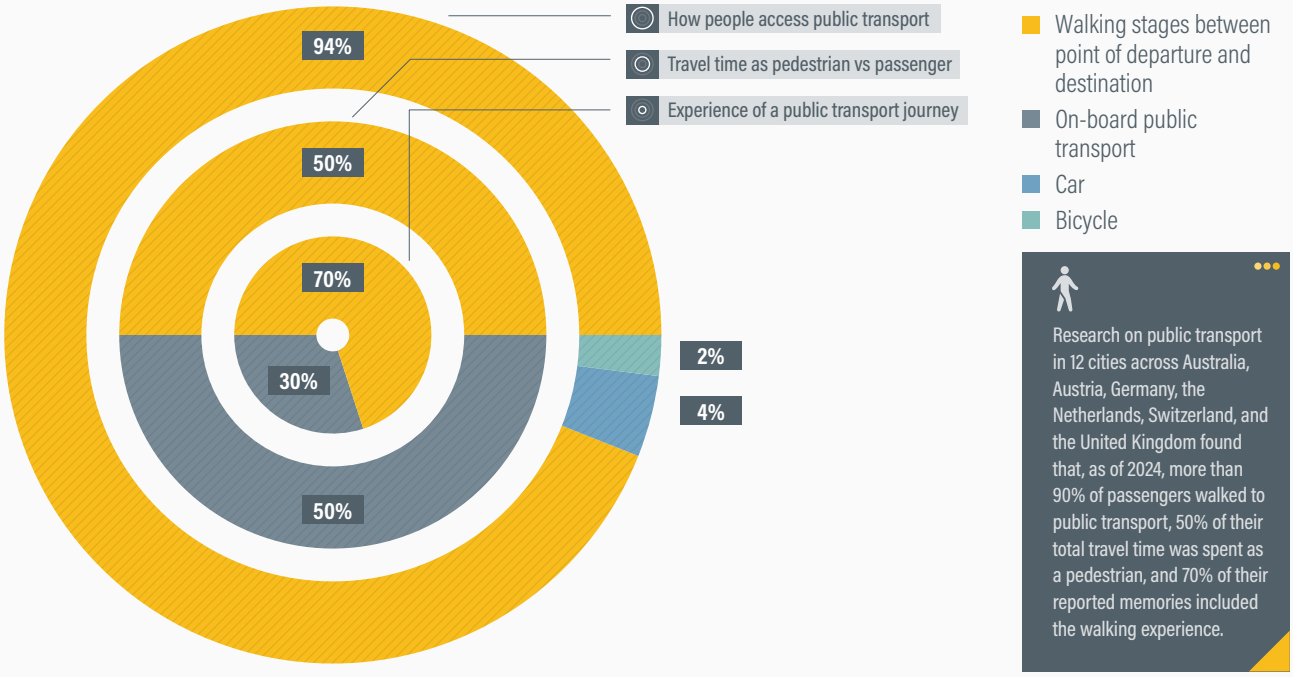
Research on public transport in 12 cities across Australia, Austria, Germany, the Netherlands, Switzerland, and the United Kingdom found that, as of 2024, more than 90% of passengers walked to public transport, 50% of their total travel time was spent as a pedestrian, and 70% of their reported memories included the walking experience (Figure 2).[20] Thus, any improvements to public transport will also require enhancements to the walking experience – which can ultimately support more walking. Realising these improvements necessitates greater acknowledgement of walking as a fundamental element of public transport journeys, as well as the inclusion of walking data in statistics on public transport trips.

In 2022, just half (52%) of the world's urban population lived within convenient access (walking distance) of public transport.[21] "Convenience of access" is defined in SDG 11.2, which aims for urban populations to live within reach of public transport.[22]

- The regions with the lowest shares of access to public transport in 2021 were Western Asia and Africa, where only a third (33%) of the population lived within walking distance of a public transport stop.[23]
- In a 2024 multi-day survey of the walking experiences of 503 people across five public transport hubs in Ulm (Germany), 53% of participants reported these trips as positive, although respondents requested safer crossings, more greenery and better footpaths.[24] By comparing people's positive and negative experiences, the city was able to gain clarity on the types of interventions needed and where to ensure a more seamless and integrated sustainable transport experience.[25]

Women make more frequent walking trips than men, due mainly to their caregiving tasks; yet because many of these trips are undercounted, planning and policies do not cater to women's needs.[26] In major cities, women have a 23% higher likelihood to walk than men, and a 25% higher likelihood to walk to work than men.[27]

FIGURE 2. Surveys related to the walking component of a public transport journey



Source: See endnote 20 for this section.

- A 2022 study of 19 cities across 13 countries found that in the 3 cities with the highest levels of walking – Accra (Ghana), Delhi (India) and Kisumu (Kenya) – 59% of women's trips were on foot, compared to 45% of men's trips.[28]
- In the main cities of Bihar state (eastern India), women accounted for 61% of all walking trips in 2020.[29]

Promoting walking and cycling has been identified as a potential solution to boost physical activity levels and counter the persistent burden of inactivity.[30] **As of 2016, an estimated 81% of adolescents and 27.5% of adults globally were not meeting the recommended physical activity levels of 60 minutes or more daily for adolescents and 150 minutes or more weekly for adults.**[31] In 2022, women were less active than men by 5 percentage points at a global level, and by more than 10 percentage points in 61 assessed countries.[32]

Studies have shown that walking for 30 minutes or cycling for 20 minutes regularly can reduce mortality risk by 10%.[33]

- An estimated 3-5 million premature deaths per year could be prevented if a greater proportion of the population were to engage in regular walking and cycling.[34]
- The World Health Organization's (WHO) global target is to reduce physical inactivity in adults and adolescents 15% by 2030.[35]

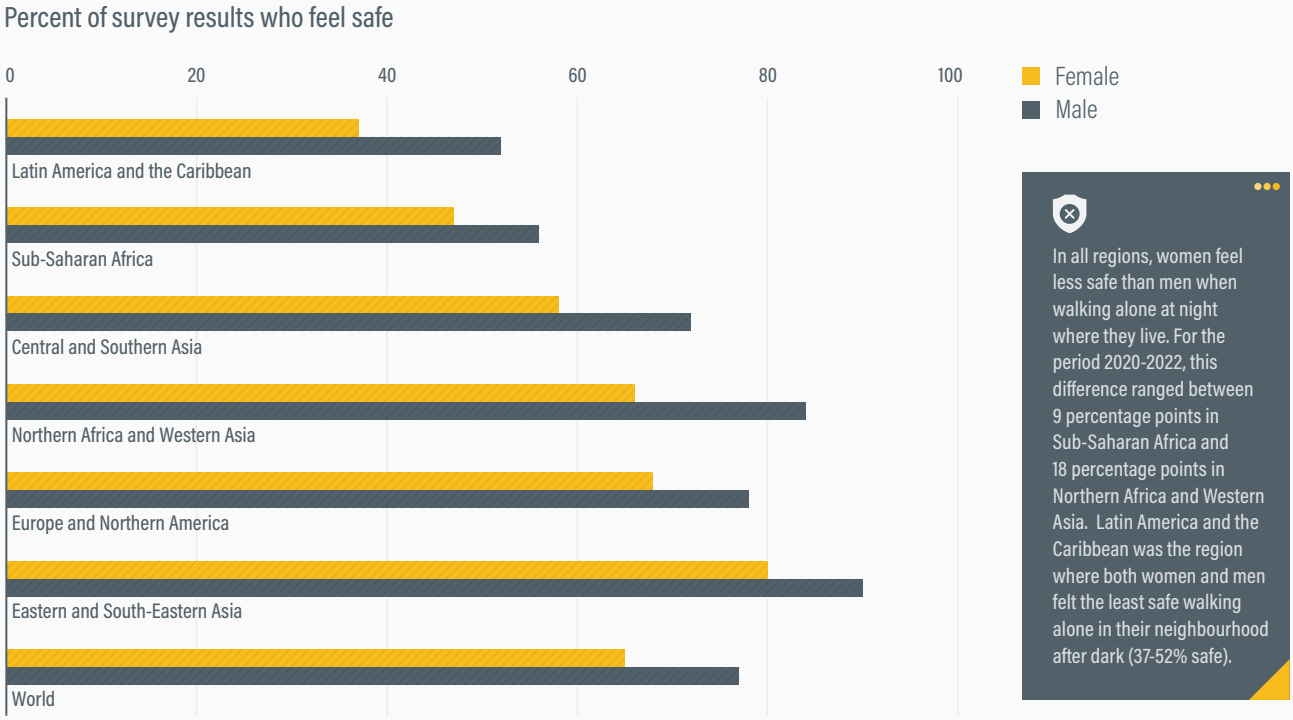
Walking for transport can play an important role in supporting active lifestyles. In a global study of 104 countries, walking and cycling for travel accounted for 36% of the total physical activity of adults who reported undertaking physical activity.[36] As of 2021, 19-25% of residents across five major Latin American cities were able to achieve the recommended physical activity levels through walking for transport alone.[37]

Sustainability and climate trends

Traditional transport planning often overlooks women's mobility patterns, resulting in infrastructure that benefits motorised travel and does not serve women's needs or protect them.[38] **Inadequately lit pedestrian environments expose people (especially women) to an elevated risk of harassment and violence, while the absence of sidewalks and pedestrian crossings puts everyone (especially people with disabilities, children and older people) at higher risk from road crashes.**[39]

Among the 17 UN Sustainable Development Goals, only one – SDG 16 on Peace, Justice and Strong Institutions – has an indicator that refers directly to walking (specifically, perceived safety while walking). Target 16.1 aims to reduce violence and related death rates, and Indicator 16.1.4 measures the share of people who feel safe walking alone in their neighbourhood after dark.[40] However, this indicator was

FIGURE 3. Share of people who feel safe walking alone at night where they live, by region and gender, 2020-2022



Source: See endnote 42 for this section.

not part of the 2024 SDG global progress report, despite 23 countries reporting it in 2022 and 15 in 2023.[41]

In all regions, women feel less safe than men when walking alone at night where they live. For the period 2020-2022, this difference ranged between 9 percentage points in Sub-Saharan Africa and 18 percentage points in Northern Africa and Western Asia (Figure 3)**.**[42] **Latin America and the Caribbean was the region where both women and men felt the least safe walking alone in their neighbourhood after dark (37-52% safe).**[43]

- People felt the most safe walking alone at night in Eastern and South-Eastern Asia (80-90% safe).[44]
- The discrepancies in perceived safety between women and men totalled 14 percentage points in Central and Southern Asia, 15 in Latin America and the Caribbean, and 18 in Northern Africa and Western Asia.[45]
- Only six countries have reported this indicator for women since 2022, limiting the availability of updated data.[46]

The need for inclusive pedestrian environments that are gender responsive and accessible for all users is increasingly recognised. Research shows that when gender is not part of the planning process, the solutions likely benefit men more than women.[47] Integrating a gender perspective into mobility systems involves understanding the daily travel patterns of women and their diverse needs, addressing gender-based violence to improve women's security and their perception of it, and incorporating women into the planning and policy processes.[48] People with mobility limitations need specific and careful interventions in the environment to enable them to independently access their communities.

SDG Target 11.7 – on access to public space – could be adapted to provide more information about women's experiences when walking, to help improve these experiences and to enable women to exercise their right to the city. Target 11.7 aims to "provide universal access to safe, inclusive, accessible and green public spaces, particularly for women, children, older persons and persons with disabilities, by 2030".[49] It includes an indicator (11.7.2) on the share of people who have been victims of non-sexual or sexual harassment in the previous 12 months (disaggregated by sex, age, disability status and place of occurrence).[50]

Road traffic deaths overall fell 5% between 2010 and 2021, but fatalities among pedestrians rose 3%.[51] **Road traffic crashes claimed an estimated 1.19 million lives worldwide in 2021, with pedestrians representing 21% of all fatalities.**[52] Young pedestrians are more at risk in low- and middle-income countries – where 92% of all road traffic fatalities occurred in 2021 – than in high-income countries.[53]

The highest shares of pedestrian fatalities among road traffic deaths in 2021 were in Africa (33%) and the Eastern Mediterranean (26%), whereas South-East Asia and the Americas had the lowest shares (17% each).[54] However, between 2018 and 2021 the share of pedestrian fatalities increased from 14% to 17% in South-East Asia, while declining in all other regions.[55]

- In the EU, where pedestrians are the most vulnerable urban road users, the number of road crash victims increased 4% in 2022.[56]
- One-third (33%) of all EU fatalities in urban areas in 2022 were people walking, and more than half (65%) of these deaths were from collisions involving private vehicles.[57]

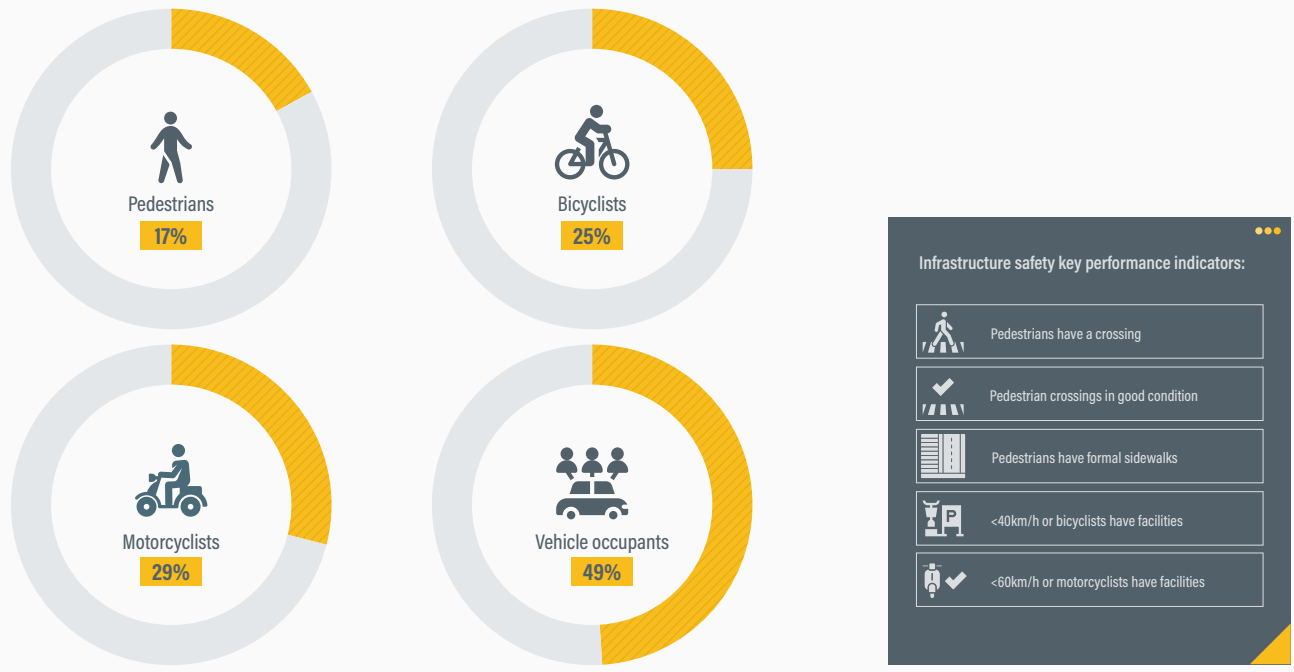
In 2021, the annual economic cost to society from pedestrian road casualties exceeded an estimated USD 940 billion globally.[58] **Low- and middle-income countries accounted for 89% of the victims and 68% of the economic cost.**[59] **Although Africa had only 3% of the world's registered vehicles in 2021, it suffered almost 20% of global road traffic deaths that year.**[60]

As of May 2025, only 17% of assessed roads in 88 countries attained a three-star or better rating (out of five) for pedestrian safety, whereas nearly half (49%) of assessed roads met this standard for vehicle occupants (Figure 4)**.**[61] This highlights the urgency of providing safe infrastructure for pedestrians.

- In urban areas, 34% of roads attained a three-star or better rating for pedestrians, compared to 65% for vehicles.[62]
- Of the assessed roads globally, only 7% had adequate sidewalks (17% in urban areas) and 8% had safe crossings (13% in urban areas).[63]

As of 2023, half of surveyed drivers across 48 countries reported exceeding the speed limit.[64] **Speeding was responsible for one-third of road crashes in high-income countries in 2017, and this share is likely to be even higher in low- and middle-income countries given the large proportions of deaths of pedestrians, cyclists and motorcyclists.**[65] **Elevated speeds are also directly associated with increased greenhouse gas emissions and noise levels.**[66] Consequently, implementing a speed management strategy can yield favourable outcomes in environmental quality and the creation of liveable communities.[67]

FIGURE 4. Assessed quality of the world's roads for safety, as of May 2025



Source: See endnote 61 for this section.

Providing safe walking and cycling infrastructure is a quick, affordable and reliable way to reduce transport emissions by 20-50%.[68]

- **A modal shift study in Australia estimated that substituting just 1% of automobile travel with walking (or cycling) could result in a 2-4% reduction in motor vehicle emissions.**[69]
- A UK study found that walking (or cycling) had the potential to replace 41-69% of short car trips and to save 5-10% of carbon dioxide (CO_2) emissions from car travel.[70]

Policy and investment developments

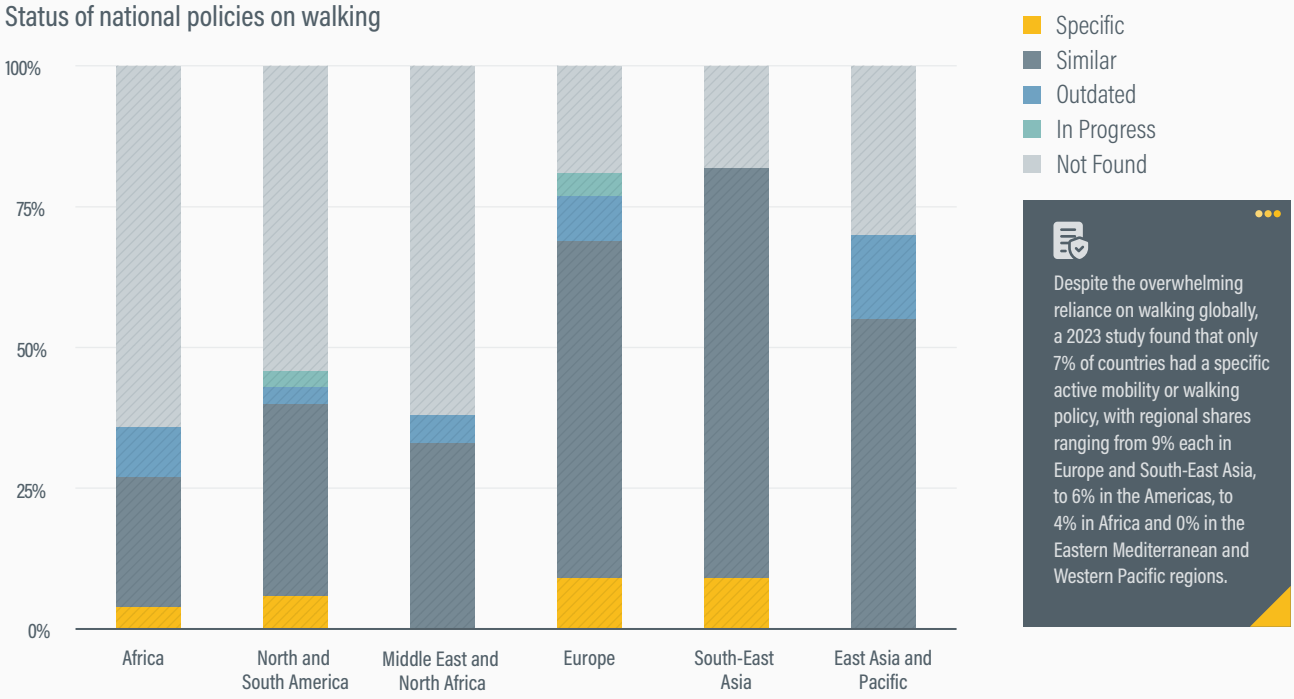
Despite their decarbonisation benefits, walking and cycling remain underrepresented in climate change policies and in countries' Nationally Determined Contributions (NDCs) towards reducing emissions under the Paris Agreement.[71] **Integrating walking into national policies and improving data collection are crucial steps towards enhancing public health, reducing environmental impact and achieving various SDG targets.**

In 2022, the WHO identified significant gaps in data collection and monitoring of walking and cycling, including a lack of global indicators and data on the provision of related infrastructure and networks.[72] Understanding the number of minutes spent in active mobility can help in accurately ascertaining the health benefits from walking.

More than 100 countries worldwide have utilised the WHO's Global Physical Activity Questionnaire, which is designed to provide a more accurate measurement of walking and to help authorities assess the extent to which walking and cycling for travel occur on a typical day.[73] The survey offers a standardised, valid, reliable, relatively inexpensive and easily administered protocol that identifies transport-related physical activity. In some cases, respondents are equipped with accelerometers (activity watches), pedometers (step-counters) or global positioning system (GPS) units to validate their responses.

As of 2018, fewer than half (73) of 174 countries analysed had national policies to promote or support walking and/or cycling (mostly high-income countries), and only 27 countries had sub-national policies.[74] Despite the overwhelming reliance on walking globally, a 2023 study

FIGURE 5. Status of national policies on walking by region, 2023



Source: See endnote 75 for this section.

found that only 7% of countries had a specific active mobility or walking policy, with regional shares ranging from 9% each in Europe and South-East Asia, to 6% in the Americas, to 4% in Africa and 0% in the Eastern Mediterranean and Western Pacific regions (Figure 5).[75]

By contrast, 127 countries had national policies and funding for public transport as of 2018.[76] While this investment in public transport is promising, it underscores the need to recognise that every public transport user is also a pedestrian. Improved understanding of this experience could result in more effective investment strategies for public transport, such as the potential to enhance its efficacy and to greatly boost ridership, helping to optimise the financial return. A policy brief outlining the benefits of integrating walking and public transport has inspired several countries to collect data on the walkability of catchment areas around public transport stops to increase ridership and customer satisfaction.[77]

As of 2023, a total of 124 of the 197 member countries of the UN Framework Convention on Climate Change had integrated walking into a national policy and/or a NDC aimed at reducing greenhouse gas emissions.[78] However, only 17% of these policies had a visible, dedicated budget, and less than 30% had an evaluation mechanism, revealing a significant gap between stated commitments and actionable delivery.[79] Enhancing funding and evaluation mechanisms would help translate policies into measurable progress.

As of 2023, 80 countries (41%) addressed walking in their national policies but not in their NDCs, and 13 countries (7%) integrated walking in their NDCs but not in national policies.[80] These countries have an opportunity to reinforce policy coherence. There is a need for a common system to develop climate policies that address walking.

Only 31 UNFCCC member countries (16%) as of 2023 had both a national policy and an NDC addressing walking.[81] Many of these strategies have been published since the COVID-19 pandemic began in 2020. A total of 73 countries had yet to develop a national policy or NDC integrating walking.[82]

The most common objectives in national policies addressing walking as of 2023 were to increase physical activity (36%), to improve road safety (32%), and to mitigate climate change (28%), followed by aims to improve accessibility (23%) and comfort (14%).[83] The most common actions in policies were: providing infrastructure (35%),

developing campaigns (29%), integrating walking in public transport (28%) and land-use planning (28%), and building capacity (22%).[84]

Most of the NDCs that mentioned walking and cycling as of 2023 aimed to increase the share of people using these modes; only 6% had a goal to increase physical activity, and less than 3% mentioned road safety and other objectives.[85] In terms of actions, 13% of the NDCs mentioned the need to provide infrastructure, while fewer than 4% included actions such as campaigns, land-use planning, integration of public transport and capacity building for walking.[86]

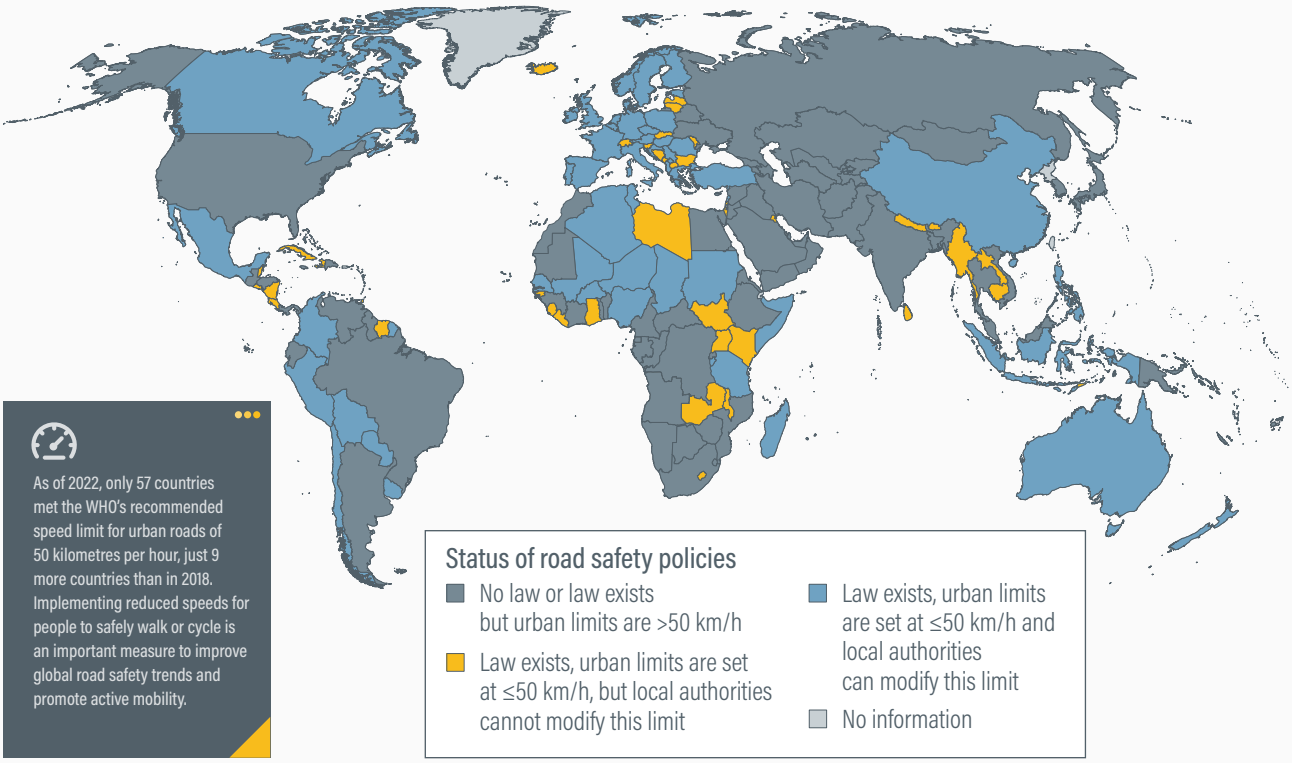
As of August 2025, 29 countries had submitted new (third-generation) NDCs to the UNFCCC (see Spotlight on Transport Ambition in NDCs 3.0).[87] **The third-generation NDCs of nine countries – Brazil, Canada, Lesotho, Monaco, Nepal, Singapore, the United Arab Emirates, the United States and Uruguay – featured climate action in relation to walking (often subsumed under active transport) to mitigate greenhouse gas emissions in the transport sector.**[88]

- Canada's third-generation NDC highlights the Canada Public Transit Fund, which starting in 2026, will provide an average of USD 2.1 billion (CAD 3 billion) per year to support active and public transport.[89]
- Nepal's new NDC commits to the development of an active mobility transport policy by 2030.[90]
- The third-generation NDC of the United Arab Emirates outlines plans by Abu Dhabi, Dubai, and other cities to pursue sustainable urban planning, with a focus on mixed land use and the development of walking and cycling infrastructure.[91]

Regional plans for walking have also begun to emerge. The first Pan-European Master Plan on walking, released in 2024, has the potential to put walking at the forefront of mobility policies in 56 countries.[92] The first Pan-African Action Plan for Active Mobility (PAAPAM) was also launched in 2024 and provides a framework to prioritise the needs of pedestrians and cyclists across the region (see section on Partnerships in action).[93]

Walking has often been overlooked in urban planning, although some countries and cities have integrated efforts to improve pedestrian infrastructure in their plans. In low- and middle-income countries, improved footpaths are a highly cost-effective means to mitigate greenhouse gas emissions and enhance public health and safety in cities.[94] Globally, work is under way to quantify the value of walking in transport appraisal methodologies, including for public transport, but much remains to be done.[95]

FIGURE 6. Status of speed laws by country, 2022



Source: See endnote 102 for this section.

- In Brazil, where walking accounted for 27% of trips and cycling for 3% as of 2024, 67 cities had committed to building more bike lanes, but only 23 cities reported plans to extend sidewalks.[96]
- In Chennai (India), more than 100 kilometres of sidewalks were built between 2013 and 2019, promoting a 9-29% shift to walking, avoiding an estimated 4,200-12,000 tonnes of CO_2 emissions annually, and improving the perception of road safety and personal security to 95%.[97]

In NDCs and other strategies, policy makers have increasingly adopted more systemic, multi-disciplinary approaches to walking that connect across departments; prioritise the safety, comfort and enjoyment of the pedestrian; and deliver immediate, measurable benefits (which can often be reported using existing datasets).[98] However, datasets on walking continue to show gaps and limitations, which can be improved through additional local data collection. The systemisation of knowledge into action and understanding of the impact is emerging, giving practitioners confidence and creating momentum for action.

The greatest improvements in road safety have been achieved in countries where the Safe System approach has been adopted.[99] This approach shifts the responsibility from road users to road designers and operators and puts people and safety at the heart of mobility systems through four core areas: safe roads, safe speeds, safe road users and safe vehicles.[100] Reducing pedestrian injuries and fatalities on roads leads to safer and healthier environments that can in turn increase the number of pedestrians and cyclists and reduce motorised travel and related emissions.[101]

As of 2022, only 57 countries met the WHO's recommended speed limit for urban roads of 50 kilometres per hour, just 9 more countries than in 2018 (Figure 6).[102] **Implementing reduced speeds for people to safely walk or cycle is an important measure to improve global road safety trends and promote active mobility.[103]** Further steps to reduce road crashes and improve safety include minimising the environmental impacts and implementing enforcement measures.[104]

Box 1. Useful tools to gain insights on walking

The WHO's **Health Economic Assessment Tool** (**HEAT**) for walking and cycling is designed to quantify the health and economic benefits of active mobility. By providing evidence-based estimates, HEAT supports informed decision making that promotes healthier, more sustainable and economically beneficial transport systems. HEAT calculates the effect that walking has on premature mortality considering physical activity levels, exposure to air pollution, the risk of road crashes and changes in carbon emissions resulting from shifts from motorised modes.

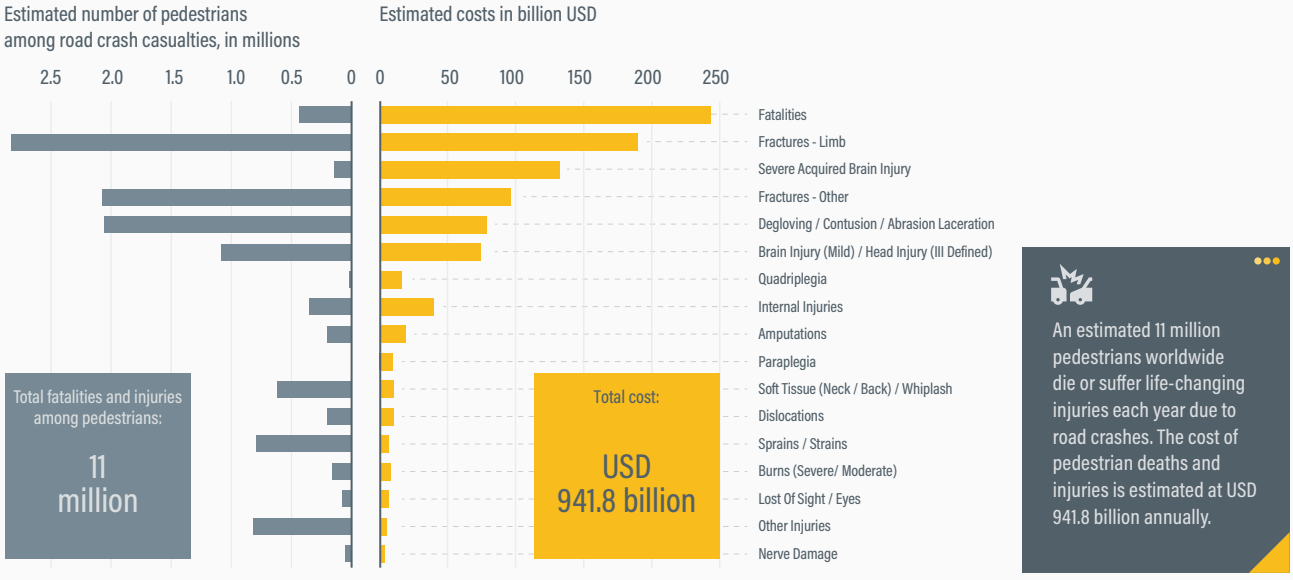
The **Star Rating for Schools** programme and associated **Youth Engagement App**, hosted by the International Road Assessment Programme (iRAP) and delivered by partners worldwide, provides a practical and objective tool to measure the risk of pedestrian journeys to school and inform speed changes and infrastructure upgrades to improve safety.

The iRAP **Safety Insights Explorer** provides insights on the scale of pedestrian casualties and the widespread lack of infrastructure investment (Figure 7).

- The **Walkability App** is a crowdsourcing tool designed to gather real-time insights into walking experiences across diverse communities, ages and abilities – helping communities and authorities understand walkable places and identify areas that need improvement based on people's perceptions. In Lisbon (Portugal), the app is being used to validate existing investments in public spaces, evaluate their success and inform future decision making. In 2024, more than 600 people were interviewed to gain insight into how public spaces influence people's experiences and on how best to ensure consideration of the needs and concerns of people with different abilities. The preliminary results found that children, older adults, women and people with reduced mobility had more negative experiences in public spaces because of specific needs and concerns. The final report aims to help the municipality prioritise interventions and assess their impact, so that future policies are effective for everyone.

Source: See endnote 105 for this section.

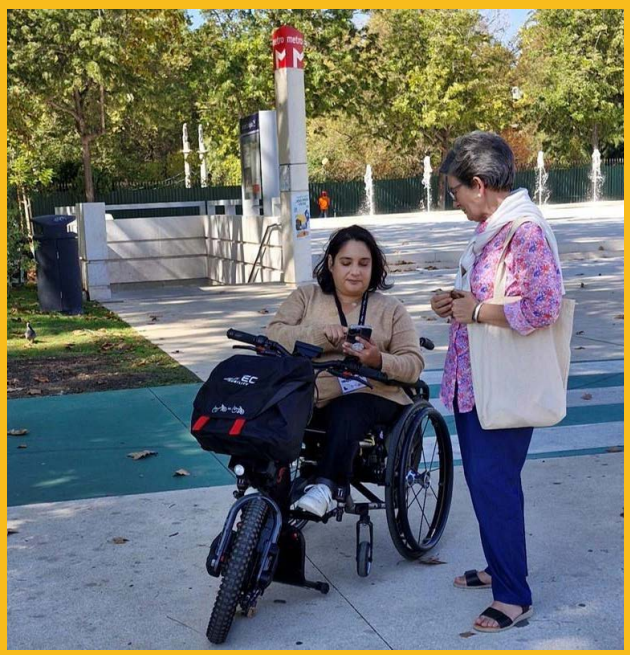
FIGURE 7. Estimated pedestrian road crash casualties and costs, 2021



Partnerships in action

Global, regional and national partnerships are essential for creating momentum around walking, enabling knowledge sharing, policy alignment and co-ordinated action across multiple scales. These collaborative efforts facilitate the exchange of best practices and create synergies that amplify action through broader networks. These partnerships are developing policy frameworks and toolkits, creating data collection tools, conducting research and putting walking at the centre of the conversation.

- The **Partnership for Active Travel and Health (PATH)** is a global coalition advocating for walking and cycling as essential solutions to address climate change, improve public health and advance social equity. More than 400 organisations worldwide are part of the PATH network, funded and led by FIA Foundation along with Walk21, the European Cyclists' Federation and the UN Environment Programme.[106] PATH calls on governments to make substantial commitments to active travel and publishes reports with data and actions to support the integration of walking into national policies and strengthen road safety.[107]
- PATH's **Active Travel NDC Template**, developed in 2024, assists national governments in integrating walking and cycling into their climate commitments, include their third-generation NDCs. In 2025, PATH planned to review these latest NDC submissions to evaluate if more countries have recognised the value of supporting and encouraging walking as a quick, affordable and reliable way to reduce transport emissions.[108] The template has a people-centred vision and can be used to steer transport, health, and environmental policies, where enabling walking and cycling is an ambition.[109]
- In February 2024, PATH co-ordinated the **Global Blind Spot** report to draw attention to the lack of policy commitment and investment for essential infrastructure, and the subsequent impact on people walking and cycling.[110] The report was launched at the **Global Ministerial on Road Safety**, where 25 countries made new commitments to road safety, including mentions to improve pedestrian safety by the Philippines, Tanzania and Thailand.[111]
- The **Pan-African Plan for Active Mobility** (PAAPAM), developed with more than 1,300 stakeholders across the region, presents a pathway of principles, goals and actions to place the needs of pedestrians and cyclists at the centre of transport planning for the coming decade.[112] The framework's three action areas are focused on advocating and creating places, policies and investment processes that promote walking and cycling in 54 countries.[113]
- The **Pan-European Master Plan on Walking**, embedded in the Vienna Declaration and adopted in 2024, sets a framework to prioritise walking by developing and implementing national walking policies and plans; integrating walking into other national policies, encouraging walking; improving safety and security; and providing and improving walking infrastructure.[114]
- A 2024 **policy brief on the importance of walking and public transport** provides recommendations to increase walking activity and public transport ridership by creating and promoting safe, accessible and comfortable walkable catchments to and from public transport stops and stations.[115] Further research in this area includes studies in Egypt with **Transport for Cairo** as well as European initiatives through **Active2Public Transport**, **Unleashing the Potential of Public Transport in Europe** and **Active Cities**.[116]
- In 2025, the WHO hosted the **8th UN Global Road Safety Week**, focused on the theme "Make walking and cycling safe".[117] The campaign emphasised concrete and specific interventions at the national and local levels to improve road safety for pedestrians and cyclists.[118]
- A **WHO toolkit** aims to promote safe walking and cycling at a policy level and is focused on integrating active mobility into all relevant policies, building safe infrastructure, setting and enforcing safe speed limits, promoting safe road use and using financial incentives to promote walking and cycling.[119]



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Cycling

KEY FINDINGS

Context, challenges and opportunities

- After a strong boom in bicycle sales during the COVID-19 pandemic in 2020 and 2021, sales stagnated in 2023. In 2022, the global bicycle fleet totalled some 1 billion units, including around 450 million in China and 100 million in the United States.
- E-bikes are the primary growth driver in the bicycle industry, representing 10% of global bicycle sales in 2021 and 30% of the European market in 2023. In 2022, Asia continued to lead the world's e-bike market, followed by Europe and North America. The e-bike market is projected to grow 10-15% annually by 2030.
- Shared bike systems – an impactful alternative to private motorised transport – have expanded greatly, setting new record highs in Europe and North America in 2024 and 2023 respectively. Technology improvements and easier access to services in recent years have helped spur growth.
- The rising demand for cycling for transport since 2020, in combination with the impacts of the COVID-19 pandemic, led to expansion of cycling infrastructure in many areas.

- Although a consistent global methodology is lacking for measuring cycling's share of overall trips, a 2024 analysis of 800 cities found that this share was highest in Asia and Europe.
- Cycling has increased dramatically in cities that have invested in cycling infrastructure. In 2023, New York City (United States) experienced all-time highs in cycling levels, with much of the growth linked to the increase in safe cycle infrastructure.
- The average cycling distance varies widely by country and city, reflecting differences in culture, infrastructure quality, demographics, urban form, topography and weather. As of 2021, most cycling trips globally were 5 kilometres or less, suggesting that cycling can be a reliable alternative for short journeys and can thus greatly reduce CO_2 emissions from urban transport. To achieve these benefits, integrated land use efforts and urban and transport planning should ensure that residents can access services within this distance, particularly in places with high urban sprawl.
- A substantial gender gap in cycling persists in cities across the world, although in some northern European countries (Denmark, Germany, the Netherlands), levels of cycling are generally balanced between women and men.
- Globally, the most important enabler of a high modal share for cycling continues to be the presence of good-quality paved roads and safe cycling infrastructure, particularly with features that separate cyclists from vehicle traffic.
- As of 2023, only 5% of the global population had access to a protected bike lane within 300 metres. Regional disparities were significant: whereas 27.6% of people in Europe had access to protected bike lanes, just 0.7% in Africa did.
- Cycling as a way to transport goods – known as cycle logistics – has continued to gain traction among bicycle manufacturers as well as owners of small and medium-sized businesses, entrepreneurs and gig workers. The cargo bike market was valued at USD 7.9 million in 2024, and big companies have increasingly caught on, often through the use of electric cargo bicycles.

KEY FINDINGS

Sustainability and climate trends

- Cycling brings numerous benefits for the economy and employment. The economic case for cycling has been demonstrated by studies showing an average benefit-cost ratio ranging from 2:1 to 19:1.
- The multi-modal combination of cycling and public transport is a powerful alternative to individual car use, boosting sustainable mobility as well as a range of benefits to society, the economy and environment in nearly any city, region and country.
- Economic appraisals based on broad sustainability criteria demonstrate that public transport, in combination with cycling and walking, offers a high return on investments. An inter-modal transport system based on these modes requires half the transport spending from governments and individuals compared to a car-centric system, even without accounting for the health and productivity benefits related to improved air quality and reduced traffic congestion.
- Studies have shown that people with e-bikes ride more frequently because the bikes are increasingly seen as genuine car replacers. Riding an e-bike, a person can cover longer distances than traditional pedal bikes with less effort, contributing to large reductions in traffic congestion, noise and air pollution, and transport emissions.
- Cyclists accounted for 5% of the 1.2 million people killed from road crashes in 2021, although these deaths vary widely by country income level. In countries with high motorisation levels but a lack of sufficient quality of cycling infrastructure, cyclists make up a higher share of road fatalities. In 2021, cyclists represented nearly 8% of road deaths in upper-middle-income countries, but only around 3% in low-income and lower-middle-income countries.
- Despite these trends, research indicates that the health benefits of cycling outweigh any kind of negative impacts related to cycling. A 2023 study found that increasing cycling activity 50% over current levels can result in a 12% net reduction in overall mortality. A study of urban populations aged 20 to 64 years in 17 countries globally found that a scenario of high bike use – where 100% of bike trips replace car trips – could prevent 205,424 premature deaths annually by 2050 (considering road traffic fatalities, air pollution and physical activity impacts).
- Due to their flexibility and low cost, bicycles have helped various cities and communities respond to sudden shocks and crises, from natural disasters to armed conflict.
- Cycling is the most energy-efficient mobility mode, using 27 times less energy per kilometre than a battery-electric car. People who cycle every day emit 84% fewer carbon emissions from their daily travel than those who do not. Even though the bulk of the greenhouse gas emissions from transport are caused by long-distance travel, regular bicycle use and substituting a car trip per day would reduce per capita CO_2 emissions 7% per year in the European context.

KEY FINDINGS

Policy and investment developments

- Cycling has gained growing recognition as a vital tool for climate action, including at the highest levels of global climate talks. From the annual United Nations Climate Change Conferences to national climate strategies, policy makers have highlighted cycling not just as a mode of transport, but as a low-cost, low-emission solution with wide-ranging benefits for health, equity and urban resilience.
- At the regional level, in 2024 the European Union adopted the European Declaration on Cycling, its highest-level political strategy to integrate cycling in transport systems at all levels of governance.
- As of 1 August 2025, only 8 (28%) of the 29 countries that had submitted third-generation Nationally Determined Contributions (NDCs) towards reducing emissions under the Paris Agreement mentioned cycling among their greenhouse gas mitigation actions for transport (Brazil, Canada, Lesotho, Monaco, Nepal, Singapore, the United States and Uruguay). In general, NDCs have undervalued active travel.
- As of 2023, only 10 (5%) out of 197 countries assessed had both a national cycling policy and an NDC addressing cycling: Bangladesh, Bhutan, Chile, Colombia, Costa Rica, Ethiopia, Rwanda, Singapore, Uganda and Venezuela. Meanwhile, 17% of the assessed countries had a national cycling policy but their NDC did not include cycling, while the majority of countries (59%) had neither a national policy nor an NDC on cycling.
- Even so, national cycling strategies have been on the rise since 2023, with more countries adopting dedicated plans that prioritise active mobility, integrate cycling into transport and climate policies, and invest in safer, more connected infrastructure. Countries that have new or updated national cycling promotion strategies include Croatia, Germany, Japan, Lithuania and the Netherlands.
- Sub-national governments – including regions, provinces and cities – are also increasingly launching cycling strategies and infrastructure initiatives, often in co-ordination with or even outpacing national efforts.
- Greater recognition of the economic benefits of cycling has generally led to rising investment in cycling, as well as plans for increased investments in the sector.
- Cycling expenditure varies greatly by country, with higher values in areas with high levels of cycling.

Context, challenges and opportunities

Cycling's prominence as a transport mode has grown substantially in the past few years, boosted by the effects of the COVID-19 pandemic and by growing recognition of cycling's role in combating climate change, improving health and fostering economic growth.[1] Since the pandemic, countries have integrated temporary cycling infrastructure into long-term networks and adopted cycling strategies at the national, sub-national and international levels – amid a steadily expanding global bicycle market.

Although bicycle sales and exports flattened in 2022 and 2023, the popularity of electric bikes (e-bikes) continued to rise, especially in Global North cities, where they accounted for most of the growth in bicycle sales and use.[2] The global e-bike market is projected to expand 10-15% annually to 2030.[3] In 2022, Asia remained the e-bike market leader, home to more than 64% (30 million) of the 47 million e-bikes sold worldwide, followed by Europe (12 million) and North America (5 million).[4]

Global data on cycling activity remain fragmented, making it difficult to track trends across countries and cities. Cycling rates vary widely by region, with growth in many countries constrained by limited protected bike lanes, gaps in policy implementation, insufficient support for emerging uses such as urban freight delivery, and a lack of standardised methodologies for cost-benefit analysis of investments.[5] In cities that have invested in safe cycling infrastructure, growth has been exponential, with New York City reaching record cycling levels in 2023.[6] Globally, the strongest enabler of a high modal share for cycling is the presence of safe infrastructure that separates cyclists from motor traffic.[7] Yet as of 2023, only 5% of the global population had access to a protected bike lane within 300 metres; in Europe, 27.6% of people had such access, whereas only 0.7% in Africa did.[8]

Studies show that cycling can greatly cut carbon dioxide (CO_2) emissions, particularly for urban trips under five kilometres.[9] Investing in cycling networks is among the most cost-effective ways to reduce greenhouse gas emissions per dollar spent, outperforming even bus rapid transit and metro systems.[10] Cycling also delivers substantial health benefits and provides resilience during shocks such as natural disasters and armed conflict.[11] Overall, cycling's health benefits outweigh any associated risks.[12] Transport systems based on public transport, walking and cycling have been found to deliver higher returns on investment than car-centric models – requiring roughly half the spending, even before accounting for the gains from cleaner air, reduced congestion and improved productivity.[13]

Political attention to cycling has grown. In 2024, the European Union (EU) launched the European Declaration on Cycling, a high-level strategic plan to integrate cycling into transport systems at all levels of government.[14] Cycling – often paired with walking as "active mobility" – has also been featured in several national climate action plans, and efforts to develop national cycling strategies are under way in all world regions. However, progress towards mainstreaming cycling as a daily transport mode remains limited in low- and middle-income countries.

Demand, use and access

After a strong boom in bicycle sales during the COVID-19 pandemic in 2020 and 2021, sales stagnated in 2023.[15] The global bicycle fleet totalled some 1 billion units, including around 450 million in China and 100 million in the United States.[16]

- Asia-Pacific recorded very high levels of bicycle exports in 2020 and 2021; however, overall regional trade in bicycles (imports and exports) fell 12% between 2015 and 2023.[17]
- EU bicycle sales fell 5.5% in 2023; overall, they declined from all-time high of 19.7 million in 2021 to 18.8 million in 2022 and 17.7 million in 2023.[18]
- Bicycle production in the EU decreased 24% in 2023 to 9.7 million units; the greatest decline was in Romania, which produced 1 million fewer bicycles that year.[19]

E-bikes are the primary growth driver in the bicycle industry, representing 10% of global bicycle sales in 2021 and 30% of the European market in 2023.[20] In 2022, Asia continued to lead the world's e-bike market, followed by Europe and North America.[21] The e-bike market is projected to grow 10-15% annually by 2030.[22] E-bikes range in size and form from single-rider urban and racing bikes, to e-cargo bikes that can carry people and goods, to larger e-cargo cycles that can carry freight.

- In 2022, around 47 million e-bikes were sold worldwide, with China selling around 30 million units, Europe selling 12 million and North America selling 5 million.[23]
- China, the largest e-bike market, had a reported 350 million units nationwide in 2021, including more than 183 million units in urban areas.[24] After several Chinese cities banned motorcycle licensing in the early 2000s, many riders adopted lower-cost e-bikes that look like motorcycles but have less weight and power.[25]
- In 2023, for the first time, more e-bikes were sold in Germany than conventional bicycles.[26] E-bikes have outsold electric cars in Germany at a rate of 4 to 1, with 2.1 million units sold in 2024.[27]

Shared bike systems – an impactful way to encourage people to rely less on private motorised transport – have expanded greatly, setting new record highs in Europe and North America in 2024 and 2023.[28] Technology improvements and easier access to services in recent years have helped spur growth.

- In the United States, shared micromobility (bicycles and electric scooters) reached a new record high of 157 million rides in 2023, surpassing the 147 million rides recorded in 2019.[29]
- As of June 2024, the United States had more than 50 docked bike share systems with nearly 9,000 stations; major providers included Bluebikes (Boston), Capital Bikeshare (Washington, D.C.), Citi Bike (New York) and Divvy (Chicago).[30]
- In Europe, 640 million shared mobility trips were recorded in 2024; London and Paris accounted for a third of these trips.[31]
- China led the global bike sharing market in 2022 with companies such as Meituan Bike (formerly Mobike) contributing to a domestic market totalling USD 5.7 billion.[32] As of October 2020, dockless bike sharing systems in China had 287 million users and 19.45 million bikes.[33]
- Bike share systems in India and South-East Asia, particularly in Singapore and Malaysia, have expanded to a large number of stations and market share.[34]
- As of 2024, South America had more than 90 bike share systems in 11 countries, notably in Brazil, Chile and Colombia.[35]
- In Africa, small-scale or pilot bike share systems have been introduced in cities such as Cairo (Egypt), Kigali (Rwanda) and Marrakech (Morocco).[36]

The rising demand for cycling for transport since 2020, in combination with the impacts of the COVID-19 pandemic, led to expansion of cycling infrastructure in many areas.

- Between 2021 and 2025, 2,000 kilometres of protected and unprotected cycling lanes were built in the 34 cities globally that are part of the Cycling Cities campaign.[37]
- As of 2025, 37 European countries provided an estimated combined 467,000 kilometres of cycling infrastructure, of which 378,000 kilometres were physically separated from the main road.[38]

Although a consistent global methodology is lacking for measuring cycling's share of overall trips, a 2024 analysis of 800 cities found that this share was highest in Asia and Europe.[39] The study found that higher-income cities recorded fewer journeys by walking, bicycle or public transport.[40]

- In Asia, cycling had a modal share of 14.8% in 2024, with sub-regional shares of 16.6% in Eastern Asia, 16.5% in Southern Asia and 13% in Western Asia.[41] However, cycling is on the decline in Asian cities and a shift to motorcycles and cars has occurred, based on data from 2018 to 2023.[42]
- In Europe, cycling's modal share was 6.9% overall in 2024 but reached 11.2% in Western Europe.[43]
- In Germany, a 2023 survey found that cycling's modal share has held steady at 11% since 2017, although its share of total passenger-kilometres increased from 3% to 4% during this period.[44]

- Cycling accounted for an estimated 1.7% of all trips in Africa as of 2025; however, this low value is likely due to undercounting, and the lack of data prevents insights for every sub-region.[45]

Cycling has increased dramatically in cities that have invested in cycling infrastructure. In 2023, New York City (United States) experienced all-time highs in cycling levels, with much of the growth linked to the increase in safe cycle infrastructure.[46]

- Around 28% of New Yorkers (nearly 2 million people) cycled in 2023, with more than 762,000 people doing so regularly; on a typical day, more than 620,000 cycling trips occurred city-wide.[47] Daily cycling in New York grew 64% between 2013 and 2023, and 16% between 2018 and 2023.[48]
- In Paris (France), cycling's modal share surpassed that of car driving in 2024: 11.2% of trips in the city were made by bicycle, whereas only 4.3% of trips were made by car.[49]
- Cycling in Bogotá (Colombia) grew 44% between 2011 and 2015, 38% between 2015 and 2019, and 6-8% between 2020 and 2022.[50]

The average cycling distance varies widely by country and city, reflecting differences in culture, infrastructure quality, demographics, urban form, topography and weather.[51] **As of 2021, most cycling trips globally were 5 kilometres or less, suggesting that cycling can be a reliable alternative for short journeys and can thus greatly reduce CO_2 emissions from urban transport.**[52] **To achieve these benefits, integrated land use efforts and urban and transport planning should ensure that residents can access services within this distance, particularly in places with high urban sprawl.** (See SLOCAT's Transport, Climate and Sustainability Global Status Report - 3rd Edition for more on cycling distances.)

A substantial gender gap in cycling persists in cities across the world, although in some northern European countries (Denmark, Germany, the Netherlands), levels of cycling are generally balanced between women and men.[53] A 2019 study found that, at a country level, women's cycling levels are lower than men's across every age group.[54] (See SLOCAT's Transport, Climate and Sustainability Global Status Report - 3rd Edition for more on the gender gap in cycling.)

Globally, the most important enabler of a high modal share for cycling continues to be the presence of good-quality paved roads and safe cycling infrastructure, particularly with features that separate cyclists from vehicle traffic (Figure 1).[55] Other enablers include secure bicycle storage, economic incentives or factors, environmental and health benefits, and seeing other people ride bicycles. Street lighting also impacts cycling, with a cyclist likely to forego a trip if the access road is not well-lit. Other barriers to cycling include being too close to vehicle traffic, perceptions of poor physical fitness and negative perceptions of cyclist communities.[56]

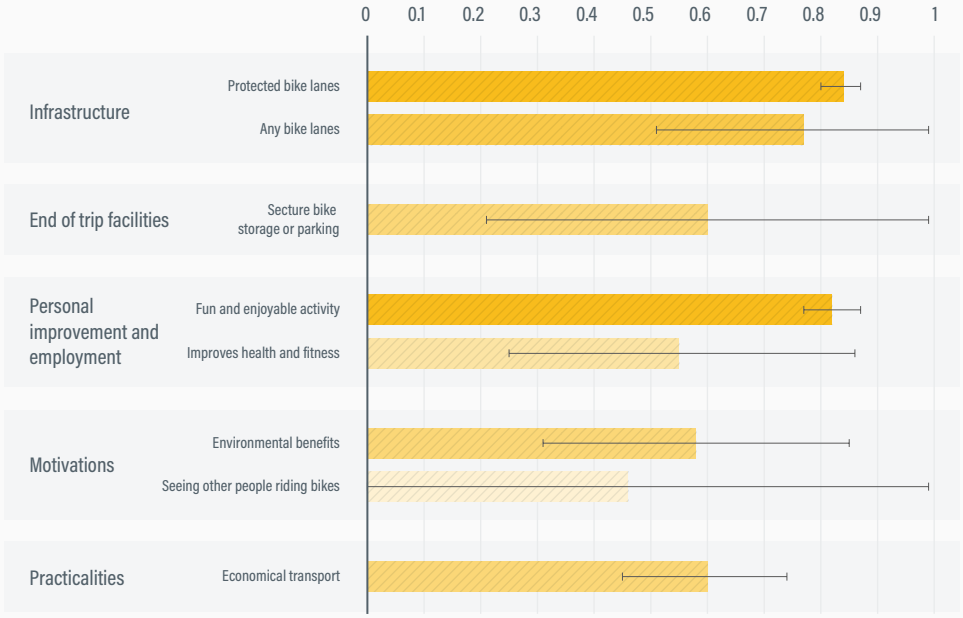
- In a 2022 online survey across 28 countries globally, 52% of respondents said cycling was too dangerous in their area; there was a moderate correlation between perceptions of safety and the share of people cycling for transport.[57]
- A 2025 survey in the United Kingdom found that more than half of women's cycling journeys were constrained by safety concerns.[58] In a UK study from 2023, half of women surveyed cited a fear of cycling at night due to poorly lit roads, isolated cycle routes, anti-social behaviour and fear of harassment from other road users.[59]

As of 2023, only 5% of the global population had access to a protected bike lane within 300 metres.[60] **Regional disparities were significant: whereas 27.6% of people in Europe had access to protected bike lanes, just 0.7% in Africa did** (Figure 2).[61]

Cycling as a way to transport goods - known as cycle logistics - has continued to gain traction among bicycle manufacturers as well as owners of small and medium-sized businesses, entrepreneurs and gig workers.[62] **The cargo bike market was valued at USD 7.9 million in 2024, and big companies have increasingly caught on, often through the use of electric cargo bicycles.**[63]

- Belgium's cycle logistics sector has grown significantly, with deliveries doubling in 2023 to 3.1 million parcels, although these still represented only 1.5% of the country's total parcel deliveries.[64] The Belgian cycle logistics sector reduced an estimated 3,078 tonnes of CO_2 emissions and saved up to USD 11.4 million (EUR 11 million) in congestion-related and societal costs that year.[65]
- The Ich entlaste Städte ("I relieve cities") project in Germany is conducting real-world cargo cycle testing with commercial and public sector users to reduce urban freight transport and service trips by internal combustion engine vehicles, and to alleviate congestion in cities.[66]
- In 2023, numbers of cargo cycles increased 73% in inner London and 63% city-wide; cargo bicycles were estimated to replace up to 17% of van kilometres in central London, improving air quality and road safety and removing 30,000 metric tonnes of carbon emissions annually.[67]

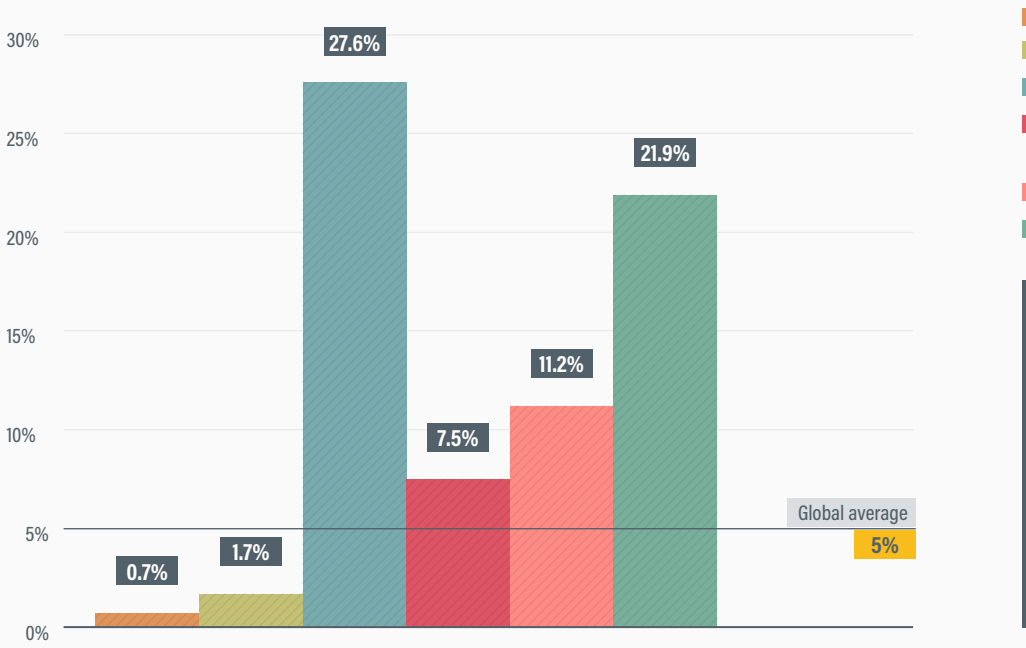
FIGURE 1. Enablers to cycling for transport, based on a 2022 study



Globally, the most important enabler for a high cycling mode share is still the good-quality of paved roads and the presence of safe cycling infrastructure, especially features that separate cyclists from car traffic.

Source: See endnote 56 for this section.

FIGURE 2. Share of population with access to protected bike lanes, by region, 2023



While access to protected cycling infrastructure is a key enabler of cycling for transport, as of 2023, only 5% of the global population had access to a protected bike lane within 300 metres. Regional disparities are significant: 27.6% of people in Europe and have access to protected bike lanes, compared with just 0.7% in Africa.

Source: See endnote 62 for this section.

Sustainability and climate trends

Cycling brings numerous benefits for the economy and employment.[68] The economic case for cycling has been demonstrated by studies showing an average benefit-cost ratio ranging from 2:1 to 19:1.[69] Major economic opportunities can be found in bicycle and parts manufacturing, bicycle retail (sales, repair and services), bicycle tourism and infrastructure development (including shared services).

- In Germany, the cycling industry directly employed 76,700 people in 2024; indirectly, up to 205,000 jobs in the country are linked to the cycling industry, sales and tourism.[70]
- In 2022, Belgium's cycling industry supported 17,434 jobs (up 147% compared to 2015) and generated total revenue of USD 984 million (EUR 951 million) – up 90% compared to 2015.[71]
- The cycling industry in the Netherlands employed 13,000 people across 3,350 companies in 2020; the total added value was USD 1.14 billion (EUR 1.1 billion), and the total export value was USD 2 billion (EUR 1.9 billion).[72]

The multi-modal combination of cycling and public transport is a powerful alternative to individual car use, boosting sustainable mobility as well as a range of benefits to society, the economy and environment in nearly any city, region and country.[73] Cycling, as an alternative to walking to reach public transport stations, helps improve the accessibility and flexibility of public transport by broadening its reach to a wider catchment area.[74] Cycling as an alternative to motor vehicles helps avoid the negative environmental impacts of cars, while freeing up funding for cycling infrastructure.

- Brest (France) has integrated shared bike systems into public services contracts, with a service level requirement similar to other means of transport. This enables users to engage in long-term bike rentals (up to 12 months), use shared bike systems, bring bikes on trams during off-peak hours and secure bike parking at station hubs.[75]
- After a survey found that people in Singapore wanted more seamless connections in their journeys, the country developed a "Walk-Cycle-Ride" strategy. Singapore's land transport authority is considering how to incorporate cycle networks into public transport infrastructure and planning.[76]
- Mexico City (Mexico) is integrating cycling with public transport by providing 10 free mass bicycle parking facilities (ranging from 80 to 408 spaces) in subway stations or modal transfer centres.[77]

Economic appraisals based on broad sustainability criteria demonstrate that public transport, in combination with cycling and walking, offers a high return on investments.[78]

An inter-modal transport system based on these modes requires half the transport spending from governments and individuals compared to a car-centric system, even without accounting for the health and productivity benefits related to improved air quality and reduced traffic congestion. (See Spotlight on Economic Appraisals.)

Studies have shown that people with e-bikes ride more frequently because the bikes are increasingly seen as genuine car replacers.[79] Riding an e-bike, a person can cover longer distances than traditional pedal bikes with less effort, contributing to large reductions in traffic congestion, noise and air pollution, and transport emissions.[80] E-bikes are normal bicycles in that they require human power, but they have an electric motor that assists with pedalling. The most widely used e-bikes have a motor of up to 250 watts, and the electric assist shuts off when the bike reaches a maximum speed of 25 kilometres per hour in Europe and 32 kilometres per hour in the United States.[81]

Cyclists accounted for 5% of the 1.2 million people killed from road crashes in 2021, although these deaths vary widely by country income level.[82] In countries with high motorisation levels but a lack of sufficient quality of cycling infrastructure, cyclists make up a higher share of road fatalities.[83]

- **In 2021, cyclists represented nearly 8% of road deaths in upper middle-income countries, but only around 3% in low-income and lower-middle income countries.[84]**
- Between 2010 and 2021, cyclist deaths rose 50% in Europe (accounting for 6% of fatalities) and 88% in the Western Pacific region, where cyclists represented up to 15% of road fatalities in 2021.[85]

Despite these trends, research indicates that the health benefits of cycling outweigh any kind of negative impacts related to cycling. A 2023 study found that increasing cycling activity 50% over current levels can result in a 12% net reduction in overall mortality.[86] A study of urban populations aged 20 to 64 years in 17 countries globally found that a scenario of high bike use - where 100% of bike trips replace car trips - could prevent 205,424 premature deaths annually by 2050 (considering road traffic fatalities, air pollution and physical activity impacts).[87] (See 1.7 Driving Health and Wellbeing Forward: The Critical Link with Transport.)

- A more conservative scenario – where only 8% of bike trips replace car trips – could prevent an estimated 18,589 premature deaths annually by 2050.[88]
- In all countries and scenarios, the mortality benefits from bike use (compared to car use) outweighed the mortality risks.[89]
- The biggest impact would be in India (where even in the

conservative scenario 6,957 premature deaths could be avoided), followed by China (4,127 avoidable premature deaths).[90]

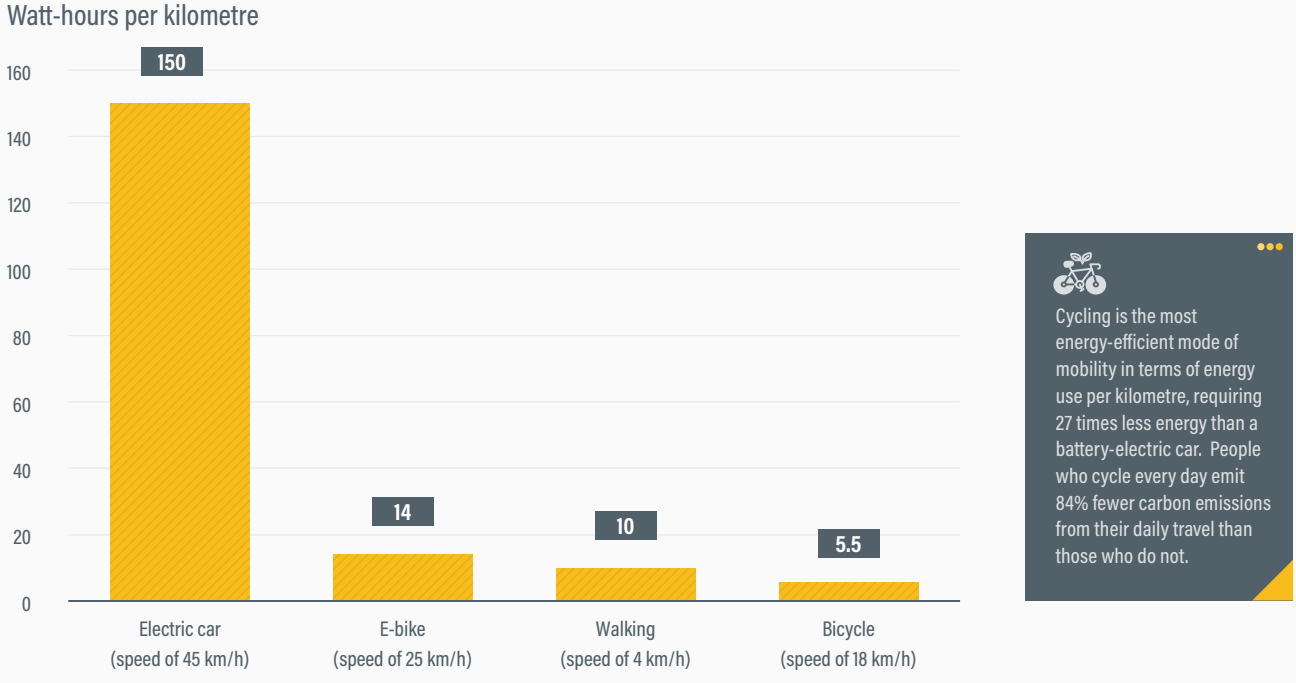
- In high bike-use scenarios, more than 1,000 premature deaths could be avoided in Austria, the United States and Indonesia.[91]

Due to their flexibility and low cost, bicycles have helped various cities and communities respond to sudden shocks and crises, from natural disasters to armed conflict. A 2024 study found that bicycles and other forms of micromobility have the potential to aid short-term response and longer-term recovery from natural disasters due to their flexibility, low cost and ability to navigate small spaces that cannot be reached by larger motor vehicles.[92]

- In Ukraine, bicycles have been an important emergency response resource during attacks and bombardments from the Russian Federation, and for delivering humanitarian relief. Between 2022 and 2024, the #BikesForUkraine campaign implemented by the local cycling association U-Cycle delivered nearly 3,000 bicycles to more than 85 communities, including to youth centres, volunteers, social workers, medical staff, local governments, internally displaced persons and children.[93] U-Cycle has also partnered with local governments to integrate bicycle planning and infrastructure into reconstruction efforts aimed at boosting resilience in Ukrainian communities.[94]
- Cycling helped Valencia (Spain) cope with catastrophic flooding after parts of eastern Spain were hit with torrential rain in October 2024, with some areas experiencing a year's worth of rainfall in just one day.[95] The floods killed more than 200 people and destroyed homes and critical mobility infrastructure, and bicycles emerged as a crucial solution for flexible commuting and for emergency workers and volunteers to distribute basic goods and food supplies.[96]

Cycling is the most energy-efficient mobility mode, using 27 times less energy per kilometre than a battery-electric car (Figure 3)**.**[97] **People who cycle every day emit 84% fewer carbon emissions from their daily travel than those who do not.**[98] **Even though the bulk of the greenhouse gas emissions from transport are caused by long-distance travel, regular bicycle use and substituting a car trip per day would reduce per capita CO_2 emissions 7% per year in the European context.**[99]

FIGURE 3. Energy efficiency of different modes of transport



Source: See endnote 99 for this section.

- In 2024, Germany's biggest cycling association, the Allgemeiner Deutscher Fahrrad-Club e.V., estimated that even in a moderate scenario (with some improvements in cycling infrastructure), 8-12 million tonnes of CO_2 could be saved annually by 2035 – or around 8-9% of Germany's total transport emissions.[100]
- A 2024 study found that a shared e-bike emits just 46 grams of CO_2 per passenger-kilometre, compared to 160 grams for an EU-based fossil-fuel car and 91 grams for an electric car.[101]
- A non-electric shared bike provides an even better benefit for the climate, emitting just 15 grams of CO_2 per passenger-kilometre, making it the most efficient form of shared vehicle.[102]
- In Sweden, e-bikes could replace up to 56.7% of car trips, leading to a possible 22.8% reduction in emissions.[103]
- Compared to individual public transport initiatives, projects that integrate public transport with cycling and walking solutions can greatly reduce emissions at a much lower cost per unit of CO_2.[104]

Policy and investment developments

Cycling has gained growing recognition as a vital tool for climate action, including at the highest levels of global climate talks. From the annual United Nations (UN) Climate Change Conferences to national climate strategies, policy makers have highlighted cycling not just as a mode of transport, but as a low-cost, low-emission solution with wide-ranging benefits for health, equity and urban resilience.

- At the 2021 UN Climate Change Conference (COP 26) in Scotland, a global transport declaration incorporated active travel (walking and cycling) for the first time ever at the COP level.[105] The last paragraph, added during the final negotiations thanks to persistent lobbying by non-governmental organisations, states: "*We recognise that alongside the shift to zero emissions vehicles, a sustainable future for road transport will require wider system transformation, including support for active travel, public and shared transport, as well as addressing the full value chain impacts from vehicle production, use and disposal.*"[106]
- The COP 29 meeting in Azerbaijan built on the progress made at COP 26 with the new "Transport Avoid & Shift 2030 Breakthrough" launched by the UN High-Level Champions.[107] The Breakthrough promotes the inclusion of walking and cycling and urges governments to: "Double the share of energy efficient and fossil-free forms of land transport for people and goods by 2030, by focusing on shifts to public transport, walking and cycling and rail freight, as well as electric vehicles and railways."[108] The effort was initiated in response to a call to action to double the share of energy efficient and fossil-free forms of land transport by 2030' launched by SLOCAT and REN21, in partnership with the Institute for Sustainable Development and International Relations (IDDRI), the Institute for Transportation and Development Policy (ITDP), the International Union of Railways (UIC), the International Association of Public Transport (UITP) and the World Resources Institute (WRI).[109]

At the regional level, in 2024 the EU adopted the European Declaration on Cycling, its highest-level political strategy to integrate cycling in transport systems at all levels of governance.[110] The Declaration commits EU, national and local resources to increase cycling infrastructure, allocate more financing to cycling projects and improve methodologies for collecting cycling data across the region. The adoption of the Declaration was a major breakthrough for pro-cycling advocates in the EU.[111]

- As a result of the European Declaration on Cycling, the EU created a network of National Cycling Contact Points comprising representatives of national transport ministries from nearly every EU Member State.[112] The purpose of this group is to share knowledge and catalyse implementation of the various commitments in the cycling declaration.
- Another direct result of the cycling declaration was an EU-funded study to define and assess cycling data throughout the EU, for example by quantifying the type and length of cycling infrastructure and producing better data on use. The study, to be finished by the end of 2025, is being implemented by a consortium of civil society, city networks and research organisations.[113]

As of 1 August 2025, only 8 (28%) of the 29 countries that had submitted third-generation Nationally Determined Contributions (NDCs) towards reducing emissions under the Paris Agreement mentioned cycling among their greenhouse gas mitigation actions for transport (Brazil, Canada, Lesotho, Monaco, Nepal, Singapore, the United States and Uruguay).[114] **In general, NDCs have undervalued active travel.**[115] Among the eight submissions, only Lesotho, Nepal and Singapore included a specific target for cycling infrastructure and modal share.[116] (See Spotlight on Transport Ambition in NDCs 3.0.)

- In its third-generation NDC, Lesotho aims to build 30 kilometres of bicycle lanes by 2030.[117]
- Nepal outlines in its NDC the ambition to establish bike sharing services in three cities by 2030.[118]
- Singapore's third-generation NDC includes the Walk-Cycle-Ride (WCR) strategy for active mobility and prioritises public and shared transport as the primary modes of travel.

The NDC calls for expanding cycling infrastructure from 600 kilometres in 2025 to 1,300 kilometres by 2030; for all journeys to the nearest neighbourhood centre using WCR modes to take no more than 20 minutes by 2040; and for 9 out of 10 peak-period WCR journeys to take less than 45 minutes by 2040.[119]

- In 2024, the PATH (Partnership for Active Travel and Health) coalition developed an Active Travel NDC template as a step-by-step guide for national governments to be more ambitious and to strengthen commitments to walking and cycling within their NDCs.[120]

As of 2023, only 10 (5%) out of 197 countries assessed had both a national cycling policy and an NDC addressing cycling: Bangladesh, Bhutan, Chile, Colombia, Costa Rica, Ethiopia, Rwanda, Singapore, Uganda and Venezuela.[121] **Meanwhile, 17% of the assessed countries had a national cycling policy but their NDC did not include cycling, while the majority of countries (59%) had neither a national policy nor an NDC on cycling.**[122] Although fewer high-income countries have cycling in their NDCs, more higher-income countries have national cycling policies than do lower-income countries.

- Cycling-related objectives included in national policies and NDCs include increasing activity, road safety, accessibility, comfort and climate change mitigation through interventions such as infrastructure, campaigns, land-use planning, integration with public transport and capacity building.[123]
- Only 16% of the national polices and 2% of the NDCs that include cycling identify specific financial budgets for delivery, highlighting a crucial limitation for policy implementation.[124] Additionally, only 13% of national cycling policies indicate a time frame for policy implementation.[125]

Even so, national cycling strategies have been on the rise since 2023, with more countries adopting dedicated plans that prioritise active mobility, integrate cycling into transport and climate policies, and invest in safer, more connected infrastructure.[126] As of mid-2025, at least 25 European countries either have a national cycling strategy or a similar plan to promote active and sustainable mobility.[127]

- In 2024, Croatia adopted its first-ever cycling strategy, which envisions an increase in the use of bicycles for daily commuting and travel and an improvement in the safety of cyclists in traffic.[128]
- Colombia is advancing the development of its National Strategy for Active Mobility, which has a specific focus on gender and getting more women to choose active travel.[129]

- Germany's national cycling plan for 2021-2030 is one of the most complete in Europe, with objectives to create seamless cycling infrastructure, become a country of cycling commuters and cyclists, and put cycling at the heart of mobility systems.[130]
- In 2024, Lithuania adopted its first-ever national cycling strategy, setting out comprehensive goals to increase the modal share of cycling in the country by 2035.[131] It accompanied this with a new regulation for the planning and design of bicycle infrastructure that establishes national standards for high-quality cycling facilities.[132]
- In 2023, the Waka Kotahi New Zealand Transport Agency launched a Cycling Action Plan that envisions people of all ages and abilities, in major towns and cities, to be able to get to where they need to go using connected networks of safe, attractive cycleways and quiet streets within 10 years.[133]
- In 2023, Argentina published its first national guide for cycling infrastructure design as part of its National Plan for Sustainable Transport; the guide sets technical standards for safe, inclusive and connected infrastructure in urban areas.[134]
- Chile released an updated national cycling infrastructure manual in 2024 that incorporates equity and sustainability principles and is expected to inform sub-national policies and investment priorities.[135]
- In 2020, India launched the India Cycles4Change Challenge to inspire more than 100 cities to become cycling havens, which led to the piloting of cycling-friendly solutions on 400 kilometres of main roads and 3,500 kilometres of neighbourhood streets.[136] The 25 most successful cities are receiving support to further integrate cycling in their streets through new cycling plans.[137]
- Spain's Ministry of Transport allocated USD 4.9 million (EUR 4.7 million) to various municipalities to expand high-quality cycle infrastructure and bike parking facilities.[138]

Sub-national governments – including regions, provinces and cities – are also increasingly launching cycling strategies and infrastructure initiatives, often in co-ordination with or even outpacing national efforts.

- Abu Dhabi (United Arab Emirates) launched the Bike Abu Dhabi platform to encourage people to cycle to stay healthy and fit. Abu Dhabi provides 300 kilometres of dedicated cycle tracks, including a 20-kilometre urban cycle track that is fully separated from car and pedestrian traffic. The government plans to build cycling infrastructure to link with Dubai and connect all city hubs in an uninterrupted loop free of interference from other transport modes.[139]
- In 2018, Addis Ababa (Ethiopia) published a Non-Motorised Transport (NMT) Strategy that called for a 200-kilometre cycle network in 10 years.[140] Since 2022, efforts such as the Addis Ababa Cycle Network Plan 2023-2032 and the City Action Plan have led to rapid expansion

of the cycle network, including more than 60 kilometres of walkways and protected cycle tracks, with plans for another 76 kilometres of cycle tracks and 200 kilometres of walkways in the next phase.[141]

- Fayetteville (United States) published an update to its previous Active Transportation Plan, with a vision to "develop and promote an interconnected and universally accessible network of sidewalks, trails and on-street bicycle facilities that encourage citizens to use active/non-automotive modes of transport to safely and efficiently reach any destination."[142]
- Wollongong (Australia) developed a comprehensive 2030 cycling strategy with a 10-year vision to make cycling the preferred option for local transport.[143] The strategy includes commitments to build 50 kilometres of on-street cycling routes and 30 kilometres of off-street cycling routes through partnerships with state and federal partners; this would expand the city's cycle infrastructure from 130 kilometres to 215 kilometres.[144]
- Additional cities with sub-national cycling strategies include Chennai (India), Lagos (Nigeria), Nairobi (Kenya) and Seoul (Republic of Korea)[145]

Greater recognition of the economic benefits of cycling has generally led to rising investment in cycling, as well as plans for increased investments in the sector.

- Buenos Aires (Argentina) had a total of 300 kilometres of bike lanes and 5,000 bike parking spots as of 2022; between 2009 and 2023, the share of cycling trips in the city grew from 0.4% to 7.0%, to total 400,000 trips per day.[146]
- In 2024, British Columbia (Canada) agreed to invest an additional USD 35 million (CAD 50 million) in walking and cycling over three years, adding to the USD 70 million (CAD 100 million) allocated in 2023.[147] The new funds are aimed at closing gaps in the active transport network by building new bicycle lanes and enhancing the safety of people walking and cycling.[148]
- In 2023, Kenya's Transport Cabinet Secretary announced mandatory plans for all road construction in major cities to have a corridor that will accommodate non-motorised transport.[149]
- Among Pacific islands, Kiribati offers financial incentives for bicycles and e-bikes, and Tuvalu is exploring the possibility of introducing solar-powered e-bikes.[150]
- Rio de Janeiro (Brazil) changed its building code in 2019 to restrict off-street parking and to promote walking and cycling by removing parking minimums, among other measures.[151]
- The US Department of Transportation's strategic plan for fiscal year 2022-2026, released prior to the second Trump administration, aims to increase the share of trips by public transport, walking, and cycling 50% by 2026, compared to 2020 levels.[152]

Cycling expenditure varies greatly by country, with higher values in areas with high levels of cycling.

- In Europe, analysis of central government capital investments in cycling (which is in some cases grouped with walking) showed that in 2024, Ireland led with USD 74.5 (EUR 72) per capita, followed by Luxembourg with USD 54.9 (EUR 53) per capita, Flanders (Belgium) with USD 49.7 (EUR 48) per capita and Scotland with EUR 40 per capita.[153]
- Between 2016 and 2021, London (United Kingdom) spent USD 30 (GBP 24) per person annually on its Healthy Streets programme.[154]
- Germany has an annual spending target of USD 31 (EUR 30) per person in its National Cycling Plan 3.0.[155]

Partnerships in action

- In 2024, more than 370 non-profit organisations from 70 countries signed a joint open letter by the **Partnership for Active Travel and Health (PATH)** urging government and city leaders at the UN Climate Change Conference (COP 29) to invest more in walking and cycling to achieve climate goals and improve life quality.[156] PATH members include the FIA Foundation, the European Cyclists' Federation, Walk21, the UN Environment Programme, the Africa Network for Walking and Cycling, ITDP, BYCS, the Dutch Cycling Embassy, SLOCAT, the Transport Decarbonisation Alliance, Union Cycliste Internationale (UCI), the World Cycling Alliance and WRI.
- The **Bloomberg Initiative for Cycling Infrastructure**, a collaboration between Bloomberg Philanthropies and the Global Designing Cities Initiative, was launched in October 2022, targeting cities with more than 100,000 residents and receiving 275 applications from cities in 66 countries.[157] In 2023, the initiative announced the 10 selected cities, which were slated to receive between USD 400,000 and USD 1 million in funding and work with technical experts on project development, cycling facility design, data collection and resident engagement.[158]
- The **European Cyclists' Federation's (ECF) 2024 annual review** of national cycling strategies in 54 European countries provides good examples of national strategies and plans (and what makes good plans), while also demonstrating that many countries need to improve the process of implementing more cycling measures.[159]
- In 2021, **ITDP** launched **Cycling Cities**, a major global campaign that aims to influence 250 cities to design, adopt and implement more cycling-friendly plans by 2050. Since 2021, the campaign has reached 34 cohort cities and more than 50 partners at the local, national and international levels working to make streets safer and urban spaces more welcome for cyclists.[160] In 2024, the Cycling Cities cohort built 213 kilometres of protected bicycle lanes, for a total of more than 630 kilometres of protected and unprotected lanes.[161] They held more than 320 kilometres of bicycle training and learn-to-ride activities, and more than 1,000 car-free days or open streets events.[162]
- In 2023, **Union Cycliste Internationale (UCI)** launched a revised sustainability strategy – aligned with its Cycling Agenda 2030 – as part of its first ever Sustainability Report (2021-2023).[163] The strategy adheres to UCI's vision to "make cycling one of the world's most sustainable sports and promote the bicycle as a key transport mode in combating climate change, improving population health and building a more sustainable future for all".[164] This publication was followed by UCI's Bike City Pathway, a strategic guide supporting cities globally to develop sustainable and active mobility.[165] The guide offers a roadmap for city planners, policy makers, and cycling advocates to create bike-friendly environments, helping build healthier, safer and more resilient communities.
- These publication launches were closely linked to UCI's **Cycling for All Programme** and its objective to get more people to ride bicycles as a daily mode of transport. This includes the UCI Bike City label network (which in 2024 grew to 28 cities and regions in 15 countries on four continents), advocacy partnerships and resources developed to promote cycling at the international level, particularly in connection to the UN Sustainable Development Goals.[166]
- The **Ecologistics project, led by ICLEI-Local Governments for Sustainability** in collaboration with Despacio, the Smart Freight Centre and the Zaragoza Logistics Center, is critical in helping develop roadmaps for efficient and sustainable freight transport.[167] The project promotes low-emission transport of goods that prioritises public health and safety and people-centred urban development, to enable circular and regional economies and limit the growth of freight transport.[168] Principle 1 is the shift to alternative mode options, including electric bicycles.[169]
- In 2023, **SLOCAT and the Transformative Urban Mobility Initiative (TUMI), in collaboration with ECF, the International Institute for Sustainable Development, MobiliseYourCity, and Walk21**, released a policy paper on **evolving economic appraisals for land transport investments towards broader sustainability criteria.** The aim is to enable more accurate valuation of the financial and economic case for investing in integrated public transport, walking and cycling solutions.[170] The paper sets out four recommendations regarding the context or enabling environment needed to consistently apply economic appraisals based on broad sustainability criteria, and evolving the economic appraisal methods.[171]
- At the 2023 UN Climate Change Conference (COP 28), the **Alliance for Cycling and Walking Towards International Vitality and Empowerment (ACTIVE)** was unveiled by Belgium, Luxembourg and the Netherlands. The programme was spurred by a COP 27 Call for Action on Active Mobility and aims to train 10,000 mobility experts in the Global South over a decade, through a coalition of countries and organisations, to stimulate active mobility globally.[172]

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Public Transport

KEY FINDINGS

- Public transport presents one of the most powerful and cost-effective solutions available to tackle our pressing climate crisis and development challenges. The environmental benefits are substantial: buses and trains can slash greenhouse gas emissions by around two-thirds per passenger-kilometre when compared with private vehicle use.

- Beyond environmental impact, public transport serves as a vital catalyst for economic opportunity and social equity. Public transport can generate economic returns that are about five times greater than the initial investment made in it, making it one of the most cost-effective ways to improve urban accessibility and economic productivity, and reduce traffic and parking congestion problems. When properly implemented, these systems provide affordable access to essential activities and services such as employment, education, health care and urban amenities for diverse populations.

- The window for capitalising on post-pandemic mobility transitions is narrowing.

- Successful public transport uptake requires unified urban visions that integrate public transport with land-use planning, governance that discourages car dependency, sustained funding and bold political leadership. Transport agencies must quickly adapt service patterns to reflect changing community needs, focusing on improving service frequency, reliability and safety to attract riders.

Demand, use and access

- Public transport serves as the connective tissue to help people realise their capabilities, getting them to where they need to be and directly contributing to more liveable, healthy and economically viable communities. At its core, "access" is a matter of transport justice, distributive in nature and wrestling with the question of how fairly transport systems serve different population segments and areas.

- In 2022, convenient access to public transport services – as captured through Sustainable Development Goal (SDG) indicator 11.2.1 – ranged widely across regions, with the lowest access (0-40%) in Africa, South Asia, and Central America, and the highest access (80-100%) in western Europe, Australia and Canada.

- Average access to public transport can be misleading even for urban areas when socio-economic and individual factors – such as income, gender, disability status, race and ethnicity – create systematic barriers to public transport use. Public transport affordability is commonly measured by examining the cost of a monthly pass relative to household income.

- Safety concerns result in curtailed access, especially for vulnerable travellers such as women, children and people with disabilities who make trips during off-peak hours or in isolated areas. These challenges are compounded by distinct patterns of "trip chaining": women generally make shorter but more complex journeys as they balance employment, caregiving responsibilities and household duties. Traditional transit network services often poorly accommodate such linking of multiple destinations in a single trip.

- Improving travellers' comfort, safety and security is a key way to increase mobility and economic productivity, and reduce traffic problems. This includes redirecting funding from urban highway and parking expansion towards safer public transport services – including improved vehicles, stations, walkways and bikeways – as well as prioritising transit-oriented development that provides convenient access to frequent and affordable services for low-income families and those with special needs.

- Since the start of the COVID-19 pandemic in 2020, its effects have continued to impact public transport ridership globally, with an estimated loss of 75 billion riders between 2019 and 2023. Recovery patterns have varied widely by region, as large Asian and European cities experienced higher gains in ridership than cities in North and South America.

- As a cultural shift due to the COVID-19 pandemic, the role of remote work has played out differently around the world.

- Although multiple factors have contributed to globally reduced ridership levels – including lifestyle changes from remote work, reduced commuting and rising living

KEY FINDINGS

costs – service quality remains the primary driver of public transport use. Investing in quality and abundant local passenger transport is critical to increasing this use.

- The development of public transport infrastructure has continued globally, with varying levels of expansion across different modes. Around 1,300 kilometres of new metro lines opened worldwide in 2024, contributing to a more than tripling of the total metro length since 2000. Light rail, tramway and streetcar networks added 120 kilometres, and bus rapid transit expanded nearly 170 kilometres.
- China led in metro system developments, representing two-thirds of 2024 openings and 45% of 2023 additions.
- As cities in emerging economies continue to develop, metro systems have experienced relatively consistent growth in network length between 2011 and 2023. Between 2010 and 2023, 73 new urban agglomerations worldwide launched their first metro systems, with China accounting for nearly half of these openings.
- After two decades of rapid growth, implementation of bus rapid transit (BRT) and bus corridors has slowed in recent years. As of February 2025, BRT networks served 191 cities globally, carrying around 32 million passengers daily. Latin America led globally with the most daily passengers (19 million), the highest number of cities served (64) and the most extensive total corridor length (more than 2,000 kilometres).
- Some cities, especially in Latin America, have experienced challenges in the service quality of BRT as demand outpaces investments in capacity. These challenges reflect institutional and financial constraints rather than technical limitations of the bus systems themselves. With proper investment and management, BRT and bus systems, hold substantial potential – and eventual necessity – for sustainable urban mobility.
- Electric buses continued to grow in popularity, with 50,000 electric buses sold globally in 2023 and 70,000 in 2024 (30% annual growth). Electric bus sales represented around 6% of total bus sales in 2024 and expanded the worldwide e-bus fleet to around 730,000 units. China remained the global leader, but other Asian countries have taken a growing share of the market, and even Sub-Saharan Africa is experiencing new developments in electric bus deployment.
- China has remained the world leader in electric bus deployment, although its share of global sales fell from around 99% in 2017 to less than 70% in 2024, due to lower domestic demand and expanding sales elsewhere. The Chinese e-bus market has achieved maturation, with around 65% of its stock deployed before 2019, and at the end of 2022 the country withdrew subsidies for purchases of battery electric and plug-in hybrid electric buses. Chinese manufacturers including BYD and Yutong continue to dominate exports.
- Growing interest in electric buses has been driven by a decrease in their total cost of ownership – making them more competitive with conventional alternatives – although high upfront capital costs and supply chain constraints have affected adoption rates. Since 2022, electric bus manufacturers have faced multiple challenges related to market share and industry dynamics.

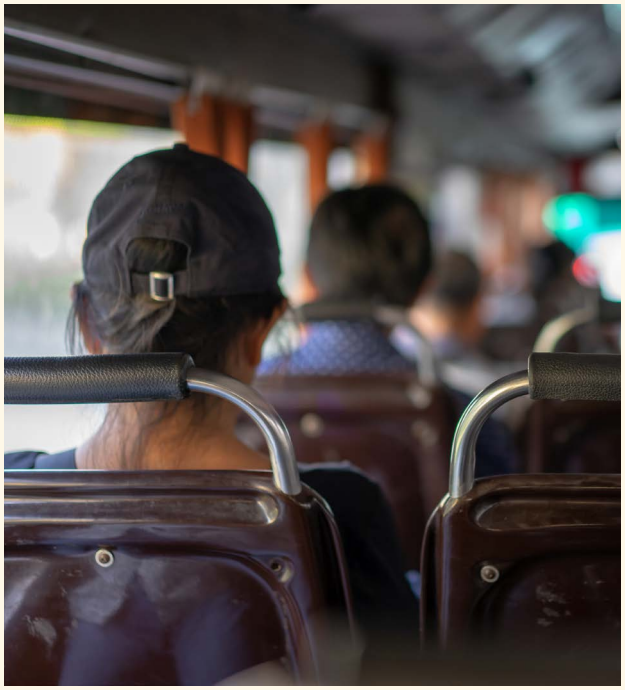
KEY FINDINGS

Sustainability and climate trends

- Public transport is widely recognised as a cost-effective strategy for decarbonising transport. Buses and rail contribute lower emissions than other passenger transport modes (such as cars and planes) on both a life cycle assessment (LCA) and a well-to-wheel (WTW) basis. Buses show median emission values of 43 grams of CO_2 per passenger-kilometre on a WTW basis and 48 grams of CO_2 per passenger-kilometre for LCA, whereas rail exhibits median emissions of around 29 grams for WTW and 33 grams for LCA.

- Battery electric buses emit 3-4 times fewer greenhouse gases than internal combustion engine buses, according to a 2024 study in Latin America. Electric and zero-emission buses also offer quieter, smoother rides and reduce local air pollution, providing benefits in marginalised communities historically impacted by vehicle emissions. The most substantial emission reductions can be achieved when electric buses are powered by renewable energy sources rather than fossil fuels.

- Privately owned vehicles are projected to dominate urban passenger transport globally by 2050. Improvements in vehicle efficiency and technological advances, as well as shifts towards low-carbon modes and improved land use planning, are expected to contribute to a 23% decrease in urban passenger transport emissions by 2050. An additional 8% reduction could be achieved by combining public transport systems with shared mobility options (such as cycling, walking and ridesharing), while simultaneously improving and integrating informal transport networks.



- One study estimates that achieving climate goals will require rapid transit systems in the world's 50 highest-emitting cities to expand and double in infrastructure between 2020 and 2030. More ambitious policy measures and investments will be needed.

- Public transport systems play an important role in improving air quality by reducing private vehicle dependency and its associated emissions, particularly through fleet renovation and the adaptation of new powertrain technologies.

- Public transport fleets can present environmental challenges depending on the fuel type, vehicle age and technology. Although heavy-duty vehicles such as buses and freight trucks represented less than 5% of vehicles on roads in 2019, they generated as much as two-thirds of urban air pollutants, including NO_x, black carbon, $PM_{2.5}$ and sulphur dioxide (SO_2), by mass. As such, public transport needs to be closely linked to transport planning, low/zero-emission zones and related activities.

- Farebox recovery ratios, defined as the share of operating costs covered by fare revenues, vary widely across public transport agencies globally. Asian agencies typically exhibit higher ratios than their North American and European counterparts. In 2022, nearly 90% of US public transport agencies recovered less than one-fifth of their operating costs through fare revenue, highlighting heavy dependence on local and federal government subsidies.

- Since the COVID-19 pandemic, operating costs for many public transport agencies have risen due to inflation, energy price rises, and wage growth, whereas fare revenues have tended to remain below pre-pandemic levels. European metropolitan areas illustrate these financial pressures.

- In addition to reducing greenhouse gas emissions, efforts towards climate adaptation and resilience have become equally vital in the public transport sector. Public transport is exposed to risks linked to biological, societal and meteorological/hydrological hazards.

KEY FINDINGS

Policy and investment trends

- Safe, convenient, reliable and affordable public transport is key to successful and thriving cities and communities. Public transport has strong links to the positive achievement of 14 of the 17 United Nations Sustainable Development Goals.
- During 2022-2024, several important policy shifts across public transport systems had notable effects at the national and international levels. Governments have applied a wide range of policy strategies, from outright bans on fossil fuels to generous tax incentives, with mixed but noticeable progress.
- Public transport in many countries is often cushioned by fuel tax exemptions and/or direct subsidies, but these supports become harder to sustain during price and political fluctuations, especially in countries already experiencing financial stress.
- A 2025 study of urban rail projects worldwide – including metros, subways and light rail systems – estimated the global weighted average cost at around USD 238 million per kilometre, based on 696 lines across 189 cities; however, construction costs vary dramatically across countries.
- Public transport agencies that have maintained revenue stability have adopted diversified funding models including real estate development, advertising and regional transport taxes. The COVID-19 pandemic prompted agencies worldwide to reconsider their revenue sources and fare policies, with some offering fare-free services.
- While fare-free transit has gained political attention and been extensively implemented in countries such as Brazil, an emerging consensus suggests that targeted policies – such as subsidies for specific populations (e.g., students, elderly, etc.) – may be more sustainable than blanket fare-free systems, since transport infrastructure requires funding regardless of fare structure. Ultimately, effective fare policies must balance access, sustainability and financial viability within broader integrated transport strategies.
- As of 1 August 2025, a total of 29 countries had submitted their third-generation Nationally Determined Contributions (NDCs) to the UN Framework Convention on Climate Change (UNFCCC); of these, 25 NDCs included content related to transport, but only 15 featured content (either as targets or actions) on public transport.
- Public transport actions in the third-generation NDCs were aimed at improving and expanding services and increasing access. However, the low number of NDCs submitted as of 1 August 2025 made it difficult to identify detailed trends and to compare actions to previous generations of NDCs.
- In the second generation of NDCs (submitted to the UNFCCC between 2020 and 2023), 67% of countries prioritised action with public transport. Identified gaps included a lack of ambitious targets, clear timelines for activities, and specifying ministries and budgets.
- Efforts to decarbonise public transport must be paired with strategies to adapt to and withstand potential climate-related hazards. Strengthening the synergy between mitigation and adaptation is essential to ensure that investments in low-carbon public transport remain effective amid intensifying climate stress and more frequent extreme weather events.

Context, challenges and opportunities

Public transport presents one of the most powerful and cost-effective solutions available to tackle our pressing climate crisis and development challenges. The environmental benefits are substantial: buses and trains can slash greenhouse gas emissions by around two-thirds per passenger-kilometre when compared with private vehicle use.[1] This has led the United Nations' (UN) recent climate action assessment to designate increased public transport ridership as not merely beneficial, but "essential" for meaningfully curbing climate change.[2]

Beyond environmental impact, public transport serves as a vital catalyst for economic opportunity and social equity. Public transport can generate economic returns that are about five times greater than the initial investment made in it, making it one of the most cost-effective ways to improve urban accessibility and economic productivity, and reduce traffic and parking congestion problems.[3] **When properly implemented, these systems provide affordable access to essential activities and services such as employment, education, health care and urban amenities for diverse populations.**

The safety and accessibility advantages are also compelling. Transit-oriented communities have much lower per capita traffic fatality rates than automobile-dependent areas, while public transport systems remain far safer and more affordable than personal car travel.[4] Safe and reliable public transport plays an important role for women, whose trip patterns are more complex than men's given the role that women play in the mobility of care.

Globally, public transport use varies based on differences in urban development approaches, infrastructure availability, pricing policies and cultural attitudes towards shared mobility. Even before the COVID-19 pandemic, North American cities demonstrated extreme car dependency with 92% of journeys by private vehicle and only 4.6% by public transport.[5] Car use in northern and southern European cities was 50-75%, while western Europe recorded 35-63% of trips by car with high rates of active transport (walking and cycling) (25-50%).[6] East Asian cities maintain balance with 46% public transport use and 19% by car.[7] Latin American cities tended to be split roughly equal between active mobility, public transport and cars.[8]

The window for capitalising on post-pandemic mobility transitions is narrowing, particularly in North America, which has one of the higher rates of remote work adoption.[9] In many regions, COVID-19 experiences led to a shift away from public transport towards walking and cycling and private vehicles.[10]

Successful public transport uptake requires unified urban visions that integrate public transport with land-use planning, governance that discourages car dependency,

sustained funding and bold political leadership. Transport agencies must quickly adapt service patterns to reflect changing community needs, focusing on improving service frequency, reliability and safety to attract riders.

Demand, use and access

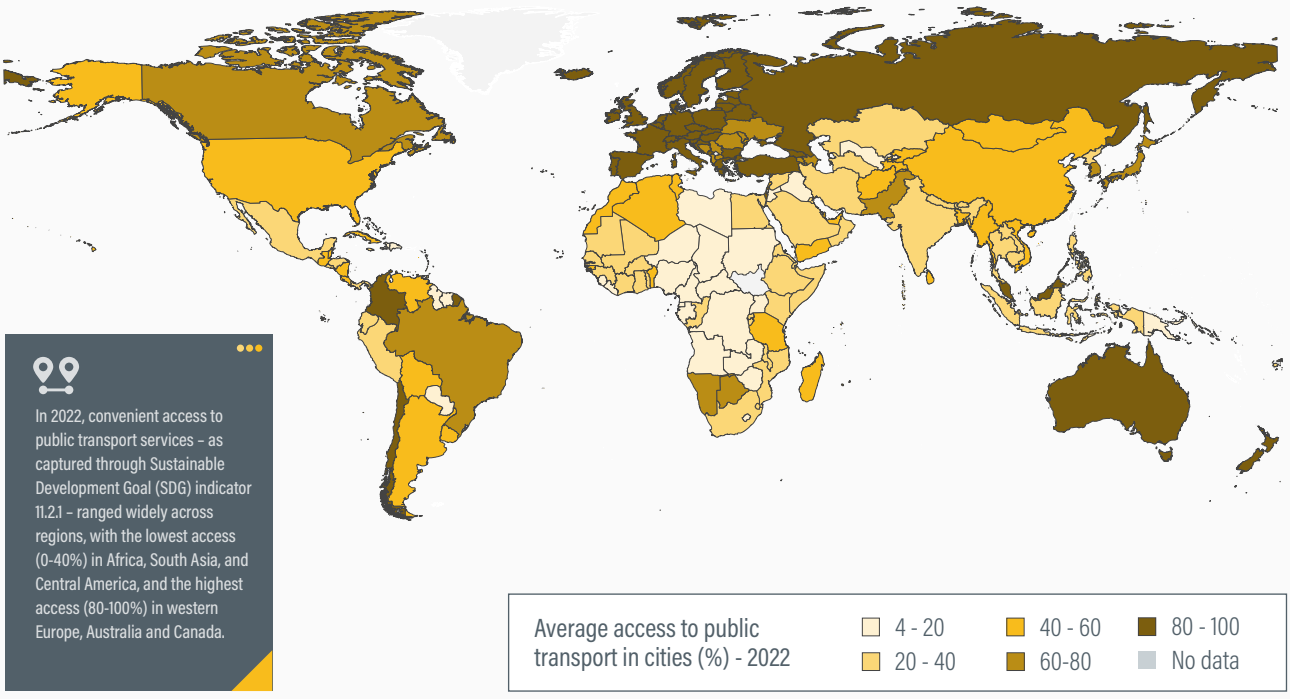
Public transport serves as the connective tissue to help people realise their capabilities, getting them to where they need to be and directly contributing to more liveable, healthy and economically viable communities. At its core, "access" is a matter of transport justice, distributive in nature and wrestling with the question of how fairly transport systems serve different population segments and areas.[11] Access is conceptually defined as "the potential for interaction" and has become a key indicator in urban and transport planning, as it captures the relationships among transport, land use and people.

In 2022, convenient access to public transport services – as captured through Sustainable Development Goal (SDG) indicator 11.2.1 – ranged widely across regions, with the lowest access (0-40%) in Africa, South Asia, and Central America, and the highest access (80-100%) in western Europe, Australia and Canada (Figure 1).[12]

Average access to public transport can be misleading even for urban areas when socio-economic and individual factors – such as income, gender, disability status, race and ethnicity – create systematic barriers to public transport use. Public transport affordability is commonly measured by examining the cost of a monthly pass relative to household income (Figure 2).[13] In lower- to middle-income groups, economic barriers may effectively render even nearby public transport services inaccessible.

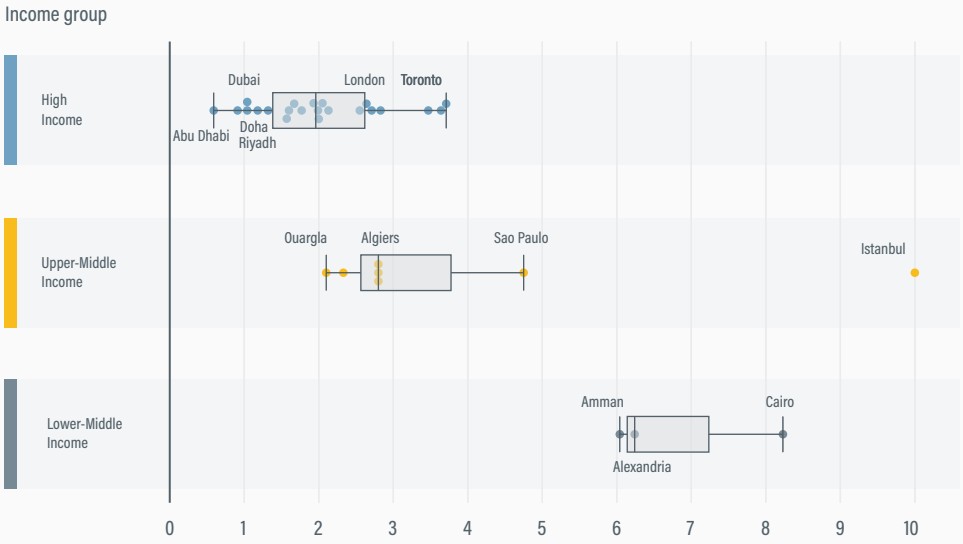
Safety concerns result in curtailed access, especially for vulnerable travellers such as women, children and people with disabilities who make trips during off-peak hours or in isolated areas. These challenges are compounded by distinct patterns of "trip chaining": women generally make shorter but more complex journeys as they balance employment, caregiving responsibilities and household duties.[14] **Traditional transit network services often poorly accommodate such linking of multiple destinations in**

FIGURE 1. Share of urban population with convenient access to public transport (population-weighted average), by country, 2022



Source: See endnote 12 for this section.

FIGURE 2. Ratio of monthly pass cost to average monthly income (%) in selected cities, 2025



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Source: See endnote 13 for this section.

a single trip. Recent research highlights gender-based disparities in safety perceptions and mobility patterns associated with public transport worldwide. Factors such as inadequate lighting, desolate environments and intoxicated individuals greatly increase perceived risk. Lack of proper facilities such as safe passenger waiting areas contributes to security risks for women.[15]

- A 2022 study on public transport safety perceptions in 18 cities globally found high rates of sexual harassment victimisation, ranging from 70% in São Paulo (Brazil) and Lagos (Nigeria) to around 30% in Guangzhou (China) and Tokyo (Japan); female students consistently reported feeling less safe than male counterparts.[16]
- A study in Peshawar (Pakistan) in 2024 revealed that 66% of female users of bus rapid transit aged 18-30, and 52% of those aged 31-45, reported experiencing harassment at transport stations, with visual harassment being most prevalent.[17] Young women were particularly vulnerable: 54% of users under 18 and 56% of users aged 18-30 reported harassment on buses.[18]

Improving travellers' comfort, safety and security is a key way to increase mobility and economic productivity, and reduce traffic problems. This includes redirecting funding from urban highway and parking expansion towards safer public transport services – including improved vehicles, stations, walkways and bikeways – as well as prioritising transit-oriented development that provides convenient access to frequent and affordable services for low-income families and those with special needs.

Since the start of the COVID-19 pandemic in 2020, its effects have continued to impact public transport ridership globally, with an estimated loss of 75 billion riders between 2019 and 2023.[19] Recovery patterns have varied widely by region, as large Asian and European cities experienced higher gains in ridership than cities in North and South America.[20] Many smaller cities worldwide continue to struggle with reduced ridership and operating costs.

- In the United States, public transport ridership rebounded to 85% of pre-pandemic (2019) levels in the first quarter of 2025.[21] In 2024, US ridership grew by 491 million passenger trips (7%) to reach a total of 7.7 billion passenger trips.[22]
- Public transport ridership in Canada grew 8.8% in 2024 to around 1.6 billion passenger trips, or roughly 84% of the pre-pandemic (2019) volume.[23] Despite annual increases since 2021, operating revenue remained at USD 2.71 billion (CAD 3.9 billion) in 2024 – around 94% of 2019 levels – due to ridership shortfalls.[24]
- In Brazil, bus ridership had been in decline even before the pandemic-related disruption. Between 2013 and 2023, monthly passenger numbers fell by 176 million passengers (45%) to reach a total of 214 million passengers.[25]
- European public transport agencies recorded 10% growth in ridership in 2023, although most urban transport systems remained below 2019 levels.[26] In Valencia (Spain), ridership in 2023 was up 17% over 2019 levels, attributed in part to discounted fares.[27]
- China's urban rail systems have experienced strong recovery, reflecting rising post-pandemic demand as

well as network expansion. Annual passenger volumes nationwide surged 52% in 2023 (from 19.4 billion trips to 29.4 billion trips) and were up 9.5% in 2024 (to 32.2 billion trips).[28] In Shenzhen, passenger volumes grew 72.5% in 2023, rising from 1.6 billion trips to 2.7 billion trips.[29]

- Ridership on Singapore's public transport system rose from a pandemic low of 5.0 million passengers daily in 2020, to 7.2 million passengers in 2023 and 7.5 million passengers in 2024 (although still 3% below the 2019 peak of 7.7 million).[30] Urban rail services showed an especially strong recovery, with 2024 ridership of 3.41 million daily trips surpassing the 3.38 million recorded in 2019. [31]

As a cultural shift due to the COVID-19 pandemic, the role of remote work has played out differently around the world. In US cities, the ongoing debate over "return to office" has severely affected public transport systems, whereas elsewhere the recovery of public transport has been stronger despite remote work.

- The Bay Area Rapid Transit (BART) system in San Francisco (United States) carried only 46% of its pre-pandemic ridership as of October 2024.[32]
- Helsinki (Finland) has one of the highest work-from-home rates in Europe, yet it achieved 90% recovery of public transport ridership by summer 2024.[33]

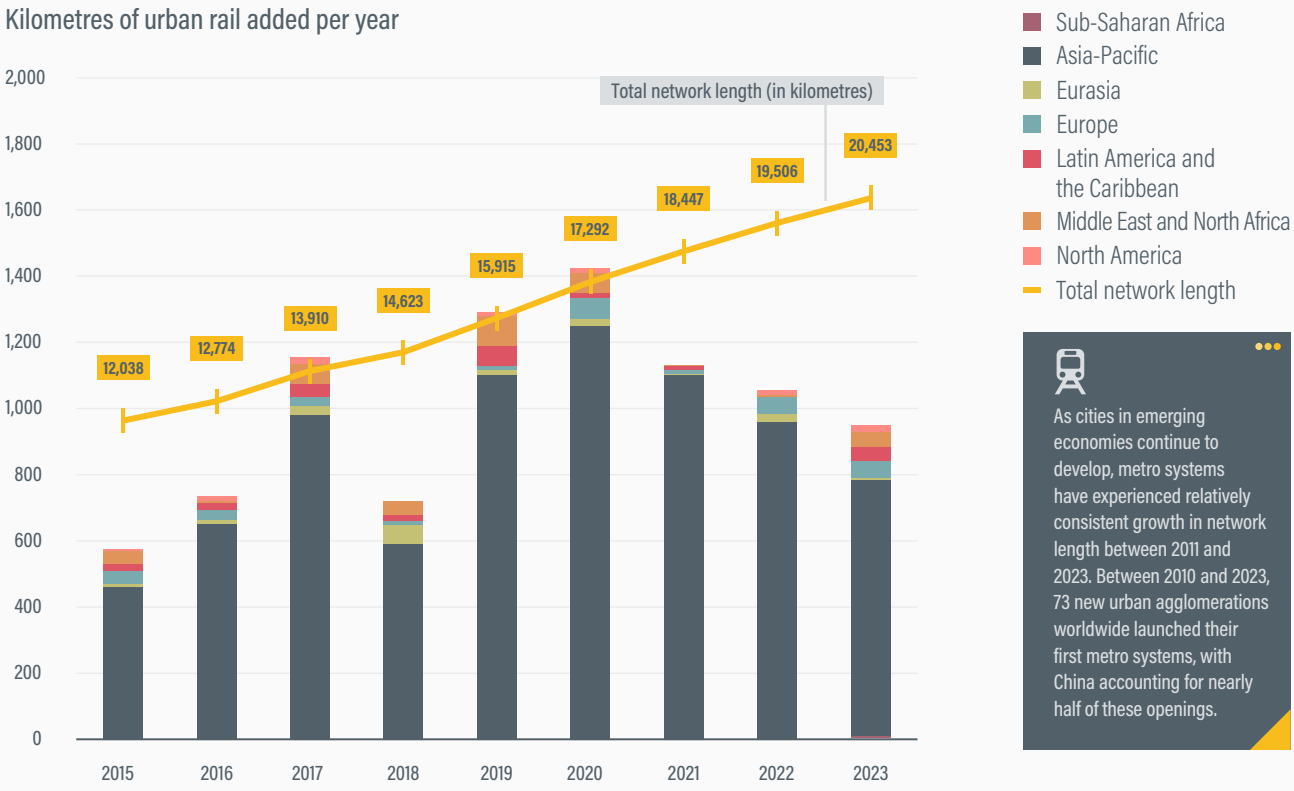
Although multiple factors have contributed to globally reduced ridership levels – including lifestyle changes from remote work, reduced commuting and rising living costs – service quality remains the primary driver of public transport use. Investing in quality and abundant local passenger transport is critical to increasing this use. Frequent, reliable service directly correlates with higher user satisfaction and increased ridership.[34]

The development of public transport infrastructure has continued globally, with varying levels of expansion across different modes. Around 1,300 kilometres of new metro lines opened worldwide in 2024, contributing to a more than tripling of the total metro length since 2000.[35] Light rail, tramway and streetcar networks added 120 kilometres, and bus rapid transit expanded nearly 170 kilometres.[36]

- Metro systems consistently dominate new developments: of the 1,760 kilometres of urban public transport added in 2023, metros accounted for 64% of the total route distance – well above the shares for commuter/regional rail (16%), light rail (10%) and bus rapid transit (6%).[37]
- **China led in metro system developments, representing two-thirds of 2024 openings and 45% of 2023 additions.**[38] This expansion has occurred mainly in major cities, including new loop lines in Guangzhou and Xi'an in 2024.[39]

As cities in emerging economies continue to develop, metro systems have experienced relatively consistent growth in network length between 2011 and 2023 (Figure 3).[40] **Between**

FIGURE 3. Metro network length by region, 2015-2023



Source: See endnote 40 for this section

2010 and 2023, 73 new urban agglomerations worldwide launched their first metro systems, with China accounting for nearly half of these openings.[41]

- A metro line was opened in at least one urban area in China every year between 2010 and 2022.[42]
- The Pearl River Delta region, a mega urban agglomeration that includes Guangzhou, Hong Kong, Shenzhen, and surrounding areas, had the most extensive metro service in the world in 2024, at 1,667 kilometres.[43]
- As of 2025, India's metro system spanned more than 1,000 kilometres across 23 cities, making it the world's third largest after China and the United States.[44] Delhi's ongoing metro expansion is expected to surpass New York's system in the coming years.[45]
- Viet Nam's first metro line began operations in Ho Chi Minh City in December 2024, 12 years after construction began in 2012.[46]
- In Quito (Ecuador), metro operations began in December 2023 with a 22-kilometre inaugural line and 15 stations; this fully electric transport system is projected to reduce carbon dioxide (CO_2) emissions by 67,000 to 84,000 tonnes annually.[47]
- Ahead of the 2024 Olympic Games, and to boost network capacity and connectivity, Paris (France) expanded Metro Line 14 by around 16 kilometres (adding eight new stations) and extended RER Line E by 8 kilometres (adding three new stations), alongside tramway upgrades.[48]
- After 38 years of planning, excavation, and delays, the driverless metro system in Greece's second largest city, Thessaloniki, opened in November 2024, featuring more than 300,000 archaeological artefacts discovered during construction and displayed throughout its 13 stations.[49]
- In the United States, three long-awaited rail projects finally opened in 2022 after decades of planning: Boston's Green Line extension, Los Angeles' Crenshaw Line, and Washington, D.C.'s Silver Line extension to Dulles Airport.[50]

After two decades of rapid growth, implementation of bus rapid transit (BRT) and bus corridors has slowed in recent years.[51] **As of February 2025, BRT networks served 191 cities globally, carrying around 32 million passengers daily.**[52] **Latin America led globally with the most daily passengers (19 million), the highest number of cities served (64) and the most extensive total corridor length (more than 2,000 kilometres).**[53] BRT systems offer dedicated lanes,

faster journey times and higher capacities than conventional bus-based transit. During their early expansion, BRT systems typically garnered strong community enthusiasm.[54]

- After ten years of development, TransBrasil in Rio de Janeiro (Brazil) opened in February 2024 as the city's fourth BRT corridor, featuring 20 stations along the Avenida Brasil; the system expects to serve up to 250,000 people daily by 2030 and to reduce peak-hour travel times up to 50%.[55]
- As of 2024, the extensive Karachi Breeze network in Pakistan included two operational lines (Green and Orange), two under construction (Red and Yellow), and two planned (Blue and Brown), totalling 112.9 kilometres with around 90 stations.[56] The Green Line became partially operational in late 2021 but remained incomplete as of mid-2025, while the Orange Line became fully operational in 2022.[57]
- Although metro expansion remains limited in the United States, BRT improvements in 2024 included the launch of Metro Rapid Route A in Madison (Wisconsin) – featuring articulated battery-powered buses and centre-running bus lanes – and the entry into service of the IndyGo Purple Line in Indiana, connecting downtown Indianapolis and Lawrence via 31 stations along a 24.5 kilometre corridor. [58]
- In Dar es Salaam (Tanzania), the BRT Phase 2 infrastructure has been completed, but operations were pending the arrival of clean natural gas buses by mid-2025.[59]

Some cities, especially in Latin America, have experienced challenges in the service quality of BRT as demand outpaces investments in capacity.[60] These challenges reflect institutional and financial constraints rather than technical limitations of the bus systems themselves. With proper investment and management, BRT and bus systems, hold substantial potential – and eventual necessity – for sustainable urban mobility.

Electric buses continued to grow in popularity, with 50,000 electric buses sold globally in 2023 and 70,000 in 2024 (30% annual growth).[61] Electric bus sales represented around 6% of total bus sales in 2024 and expanded the worldwide e-bus fleet to around 730,000 units.[62] China remained the global leader, but other Asian countries have taken a growing share of the market, and even Sub-Saharan Africa is experiencing new developments in electric bus deployment.

- In 2024, India and the Republic of Korea overtook the United States to become the second and third largest national electric bus markets by sales volume (after China), with more than 3,200 and 2,800 sales, respectively.[63]
- In India, electric bus registrations grew around 81% in 2024 (from 1,919 units to 3,616 units), although electric buses still represented only 4% of annual bus registrations.[64] Delhi, Gujarat, Karnataka and Maharashtra together accounted for more than three-quarters of the country's total electric bus registrations in 2023.[65]
- Electric bus sales in Europe, the world's second largest market, grew nearly 15% in 2024, bringing the region's sales share to more than 13%.[66]
- Battery electric bus registrations in Europe increased 53% in 2023 to reach 6,354 units across the European Union (EU-27) plus Iceland, Norway and Switzerland.[67] In 2024, zero-emission (battery electric and hydrogen) buses comprised nearly half (49%) of new city bus registrations in the region, up from 15% in 2020.[68]
- Madrid (Spain) established Europe's largest electric bus charging facility in 2024, with capacity to charge 118 buses simultaneously.[69]
- In Latin America and the Caribbean, electric bus sales rose from around 600 in 2020 to more than 2,000 in 2024.[70]
- Latin America's electric bus fleet grew 13% in 2024 to reach 6,055 vehicles, following average annual growth of 33.5% since 2017 (driven by battery electric bus adoption initially in Chile and Colombia, and later in Brazil and Mexico).[71]
- In late 2023, Mérida (Mexico) launched IE-Tram, the country's first all-electric BRT system, projected to serve more than 25,000 daily passengers.[72]
- Dakar (Senegal) launched Africa's first fully electric BRT system in December 2023.[73]
- In Kenya, private sector innovation has driven electric bus adoption through companies such as BasiGo, which had sold 35 buses to 11 co-operatives in Nairobi as of late 2024 and established the country's first dedicated electric bus assembly in partnership with Kenya Vehicle Manufacturers.[74] Working directly with co-operatives and *matatu* (minibus) owners, transit electrification presents an opportunity to catalyse broader reform in Kenya's informal transport sector. (See 4.6 Informal Transport.)

China has remained the world leader in electric bus deployment, although its share of global sales fell from around 99% in 2017 to less than 70% in 2024, due to lower domestic demand and expanding sales elsewhere.[75] The Chinese e-bus market has achieved maturation, with around 65% of its stock deployed before 2019, and at the end of 2022 the country withdrew subsidies for purchases of battery electric and plug-in hybrid electric buses.[76] Chinese manufacturers including BYD and Yutong continue to dominate exports: between 2017 and 2023, they supplied more than 85% of electric city buses in Latin America and expanded their share in the EU from 10% to 30% of total bus sales.[77]

Growing interest in electric buses has been driven by a decrease in their total cost of ownership – making

them more competitive with conventional alternatives – although high upfront capital costs and supply chain constraints have affected adoption rates.[78] **Since 2022, electric bus manufacturers have faced multiple challenges related to market share and industry dynamics**, including higher raw material costs following the Russian Federation's invasion of Ukraine, intensified price competition and industry consolidation pressures.[79] These pressures contributed to industry restructuring: for example, major US manufacturer Proterra filed for bankruptcy in August 2023.[80]

Box 1. Artificial intelligence, big data and public transport

Public transport authorities have long employed big data analytics for real-time predictions, schedule optimisation, maintenance forecasting and passenger flow analysis. Curation of transit data in the format of General Transit Feed Specification (GTFS) by organisations such as MobilityData and DigitalTransportforAfrica enables trip planning and accessibility analyses, among other applications. Many of these data-driven approaches now integrate with newer artificial intelligence (AI) capabilities, especially generative AI deploying Large Language Models, to create more responsive and interactive transit solutions globally.

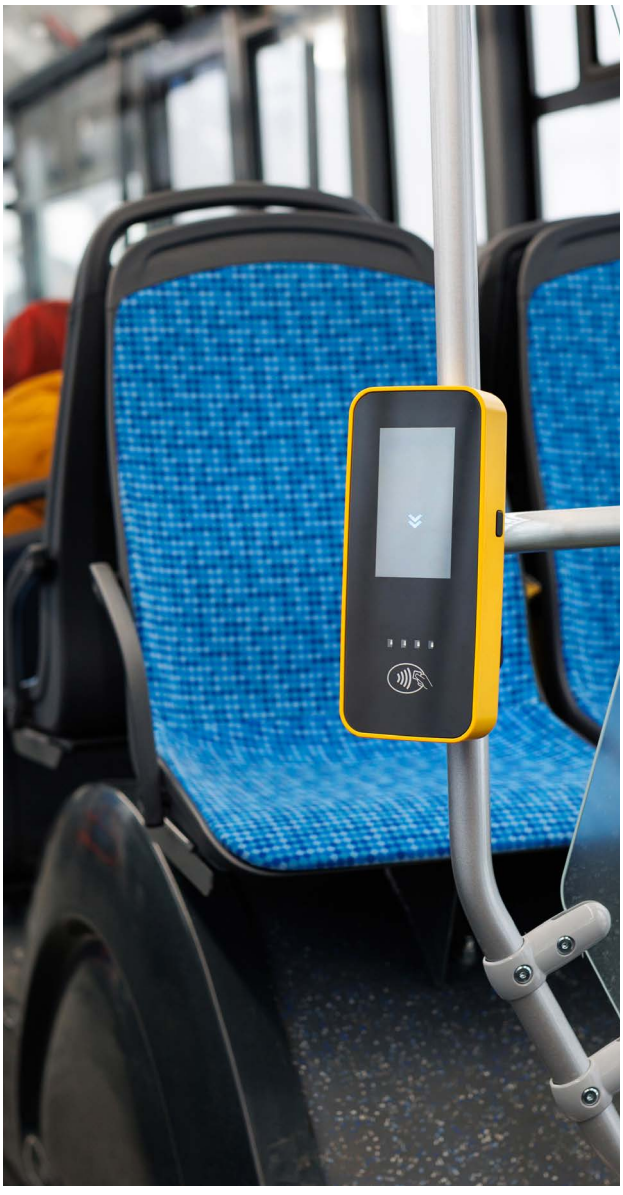
Modern AI systems help urban planners process multi-modal data sources; ingest structured data alongside videos, text, audio and visual inputs to enhance prediction accuracy; and improve customer interfaces.

- In 2025, Japan's JR East began deploying a generative AI system for signalling equipment failures across rail lines in the Shinkansen and Tokyo areas – the first of its kind in the country. The system automatically generates incident reports from radio communications, simplifies data input, and provides estimated causes and repair timelines, targeting up to 50% faster service restoration.
- Barcelona Metro (Spain) has deployed an AI ventilation control system that optimises air quality and thermal comfort in real-time. The system was initially implemented in 2020 to help limit the spread of COVID-19, and since 2022 it has balanced meteorological conditions, energy costs, and fan performance, achieving a 1.3 degrees Celsius temperature reduction, 25% energy savings, 21% improved fan efficiency and 11% increase in passenger satisfaction.
- Using Google's AI technology, the Chicago Transit Authority (United States) launched the chatbot "Chat with CTA" in 2024; it provides multilingual customer support in five languages, handling real-time updates, incident reporting and customer feedback on non-emergency topics such as cleanliness, maintenance and service disruptions.

Despite these potential advantages, serious challenges remain around the need for human oversight in safety-critical public transport operations. Privacy concerns have intensified as data collection on passenger tracking becomes more sophisticated. The lack of transparency behind AI's complex decision-making processes can create accountability challenges when the automated systems affect thousands or millions of daily passengers.

Additionally, the substantial energy requirements of AI systems present a sustainability paradox for public transport's decarbonisation goals. In 2022, data centres supporting AI consumed around 460 terawatts globally, with AI training clusters requiring seven to eight times more energy than typical computing workloads. For transit agencies promoting low-carbon mobility, these energy requirements must be carefully considered within sustainability frameworks.

Source: See endnote 81 for this section.



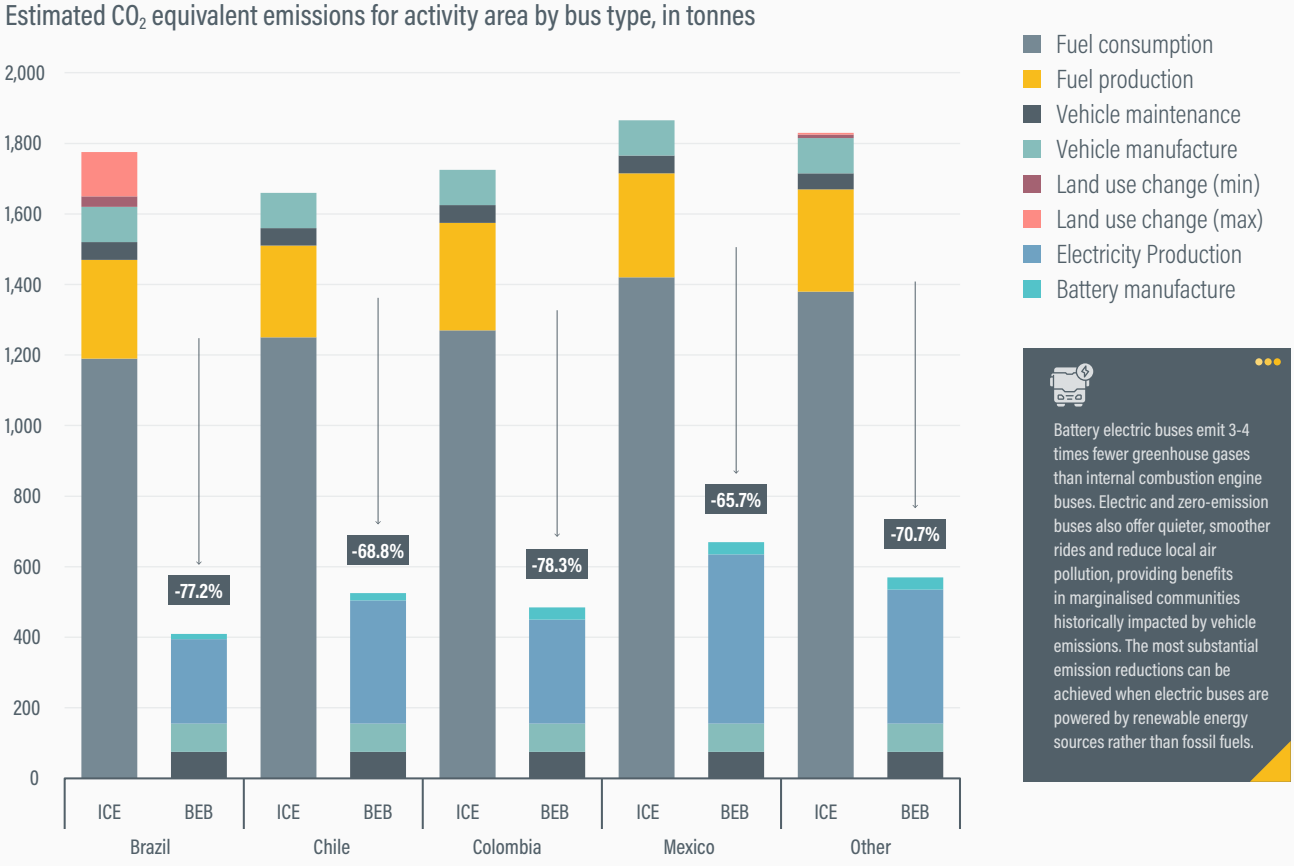
Sustainability and climate trends

Public transport is widely recognised as a cost-effective strategy for decarbonising transport. Buses and rail contribute lower emissions than other passenger transport modes (such as cars and planes) on both a life cycle assessment (LCA) and a well-to-wheel (WTW) basis. Buses show median emission values of 43 grams of CO_2 per passenger-kilometre on a WTW basis and 48 grams of CO_2 per passenger-kilometre for LCA, whereas rail exhibits median emissions of around 29 grams for WTW and 33 grams for LCA.[82] To reduce emissions, cities have introduced electric and zero-emission buses to their fleets.

Battery electric buses emit 3-4 times fewer greenhouse gases than internal combustion engine buses, according to a 2024 study in Latin America.[83] **Electric and zero-emission buses also offer quieter, smoother rides and reduce local air pollution, providing benefits in marginalised communities historically impacted by vehicle emissions.**[84] **The most substantial emission reductions can be achieved when electric buses are powered by renewable energy sources rather than fossil fuels.** For 12-15 metre buses in 2024, the life-cycle emissions for battery electric units compared to internal combustion engine units were 77.2% lower in Brazil and 78.3% lower in Colombia, but they were only 65.7% lower in Mexico, due to the different carbon intensities of the countries' respective electric grids (Figure 4).[85]

Privately owned vehicles are projected to dominate urban passenger transport globally by 2050.[86] **Improvements in vehicle efficiency and technological advances, as well as shifts towards low-carbon modes and improved land use planning, are expected to contribute to a 23% decrease in urban passenger transport emissions by 2050.**[87] **An additional 8% reduction could be achieved by combining public transport systems with shared mobility options (such as cycling, walking and ridesharing), while simultaneously improving and integrating informal transport networks.**[88]

FIGURE 4. Comparison of life-cycle emissions of 12-15 metre buses in Latin America, 2024



Battery electric buses emit 3-4 times fewer greenhouse gases than internal combustion engine buses. Electric and zero-emission buses also offer quieter, smoother rides and reduce local air pollution, providing benefits in marginalised communities historically impacted by vehicle emissions. The most substantial emission reductions can be achieved when electric buses are powered by renewable energy sources rather than fossil fuels.

Note: ICEB = internal combustion engine buses; BEB = battery electric buses

Source: See endnote 85 for this section.

(See 4.6 Informal Transport.) However, even these combined measures remain insufficient to meet the emission reduction goals of the Paris Agreement.[89]

One study estimates that achieving climate goals will require rapid transit systems in the world's 50 highest-emitting cities to expand and double in infrastructure between 2020 and 2030.[90] More ambitious policy measures and investments will be needed.

Public transport systems play an important role in improving air quality by reducing private vehicle dependency and its associated emissions, particularly through fleet renovation and the adaptation of new powertrain technologies.

- Since 2017, Stockholm (Sweden) has successfully transitioned its public transport system to 100% renewable energy.[91] In February 2024, the city became the world's first capital city with bus services that are 100% fossil free; nearly two-thirds (64%) of Stockholm's buses are fuelled by biodiesel, resulting in CO_2 emission reductions of up to 90% when compared to conventional fuels.[92]
- In June 2022, Germany temporarily introduced a USD 9.3 (EUR 9) monthly ticket for regional and public transport, effectively reducing fares up to 90%; during the month, pollution levels nationwide fell an estimated 8%.[93]
- A 2024 study demonstrated that the Cablebus Line 1 in Mexico City (Mexico), inaugurated in July 2021, reduced nitrogen dioxide (NO_2) levels in areas near the cable car system by around 13%, helping to improve air quality in a city where the high-altitude mountain plateau creates pollution-trapping effects.[94]
- A 2025 modelling study on the impacts of medium- and heavy-duty electric vehicle policies in New York City found that complete electrification of these vehicles could save USD 2.4 billion in health costs by 2040, primarily from NO_2 reduction, while also preventing 248 premature deaths and 173 childhood asthma emergency department visits.[95] The greatest health benefits would occur in communities with the highest percentages of historically marginalised populations.[96]

Public transport fleets can present environmental challenges depending on the fuel type, vehicle age and technology. Although heavy-duty vehicles such as buses and freight trucks represented less than 5% of vehicles on roads in 2019, they generated as much as two-thirds of urban air pollutants, including NO_x, black carbon, $PM_{2.5}$ and sulphur dioxide (SO_2), by mass.[97] As such, public transport needs to be closely linked to transport planning, low/zero-emission zones and related activities. (See 4.2 Integrated Transport Planning.)

Farebox recovery ratios, defined as the share of operating costs covered by fare revenues, vary widely across public transport agencies globally. Asian agencies typically exhibit higher ratios than their North American and European counterparts.[98] In 2022, nearly 90% of US public transport agencies recovered less than one-fifth of their operating costs through fare revenue, highlighting heavy dependence on local and federal government subsidies.[99] To improve farebox recovery ratios, public transport agencies must improve service efficiencies (for example, with dedicated bus lanes and transit priority at intersections), and increase ridership and load factors by improving service quality and providing travel demand management (TDM) incentives for travellers to use public transport for more urban trips. Overall, the financial sustainability of these systems depends on the balance between operational costs and revenue generation.

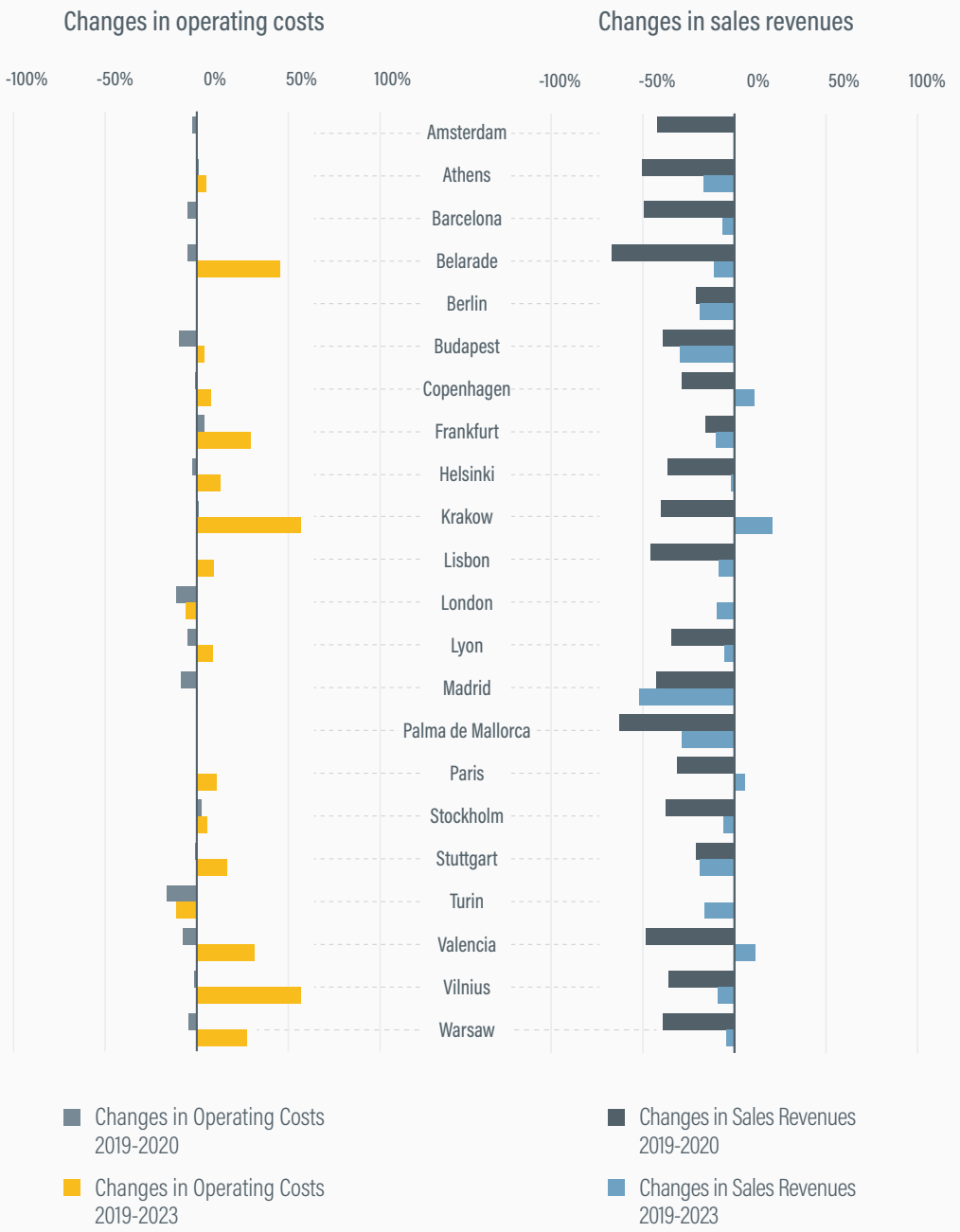
Since the COVID-19 pandemic, operating costs for many public transport agencies have risen due to inflation, energy price rises, and wage growth, whereas fare revenues have tended to remain below pre-pandemic levels. European metropolitan areas illustrate these financial pressures (Figure 5).[100]

- Cities in Europe that experienced modest changes in operating costs between 2019 and 2023 included Amsterdam (Netherlands; -2.4%), Athens (Greece; 5.1%) and Copenhagen (Denmark; 7.5%).[101]
- European cities that faced substantial increases in operating costs included Belgrade (Serbia; 45.5%), Frankfurt (Germany; 29.1%) and Krakow (Poland; 57.0%).[102]
- Between 2019 and 2023, revenue from transport sales grew in Rotterdam (Netherlands; 13.6%) but fell in Athens (Greece; -16.7%), Belgrade (Serbia; -11.0%) and Frankfurt (Germany; -18.1%).[103]

In addition to reducing greenhouse gas emissions, efforts towards climate adaptation and resilience have become equally vital in the public transport sector. Public transport is exposed to risks linked to biological, societal and meteorological/hydrological hazards. Service providers and users operate in environments increasingly strained by climate-related events, including heatwaves and flooding and their compounding and cascading effects. Adaptation is broadly defined as making adjustments to address and protect against expected or actual climate impacts, and is increasingly urgent as rising temperatures and extreme weather events pose growing threats to transport infrastructure.

- **Biological hazards:** The COVID-19 pandemic had profound consequences for the public transport sector, as countries grappled with physical distancing requirements that fundamentally conflict with the nature of mass transport operations. Studies have found that consistent

FIGURE 5. Transport operating costs and revenue recovery in European cities, 2019-2020 and 2019-2023



Since the COVID-19 pandemic, operating costs for many public transport agencies have risen due to inflation, energy price rises, and wage growth, whereas fare revenues have tended to remain below pre-pandemic levels. European metropolitan areas illustrate these financial pressures.

Source: See endnote 100 for this section.

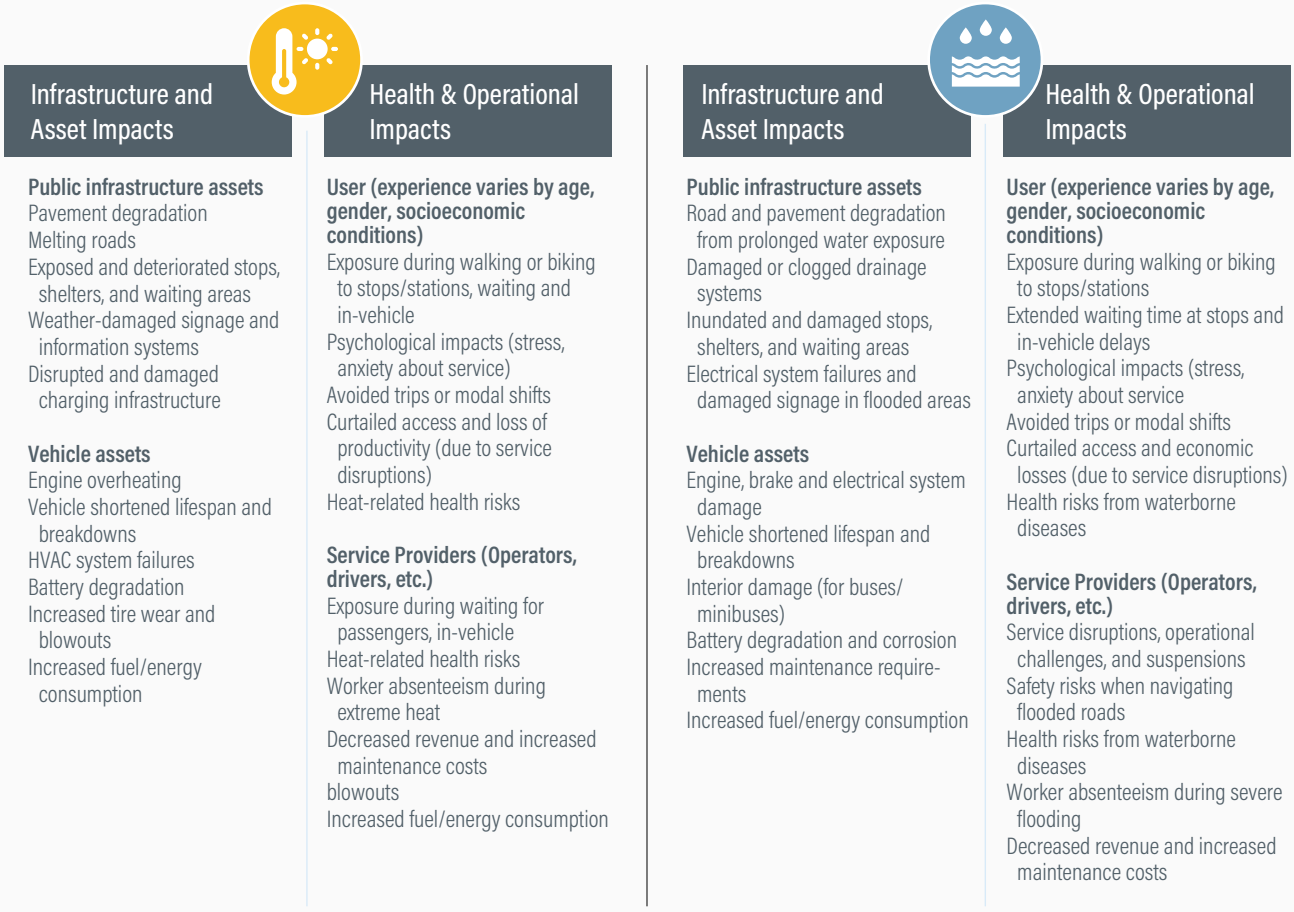
use of face masks in enclosed environments such as transport vehicles can greatly reduce transmission risks.[104] However, further research is required to determine how best to adapt to such hazards in the future. In addition to operational challenges and health concerns, the pandemic raised questions around public transport's underlying economic sustainability, equity access and long-term mobility goals.

- **Societal hazards:** The Russian Federation's invasion of Ukraine in 2022 illustrated how conflicts can disrupt public transport systems, not only in directly affected nations (in the Russian case due to sanctions) but also in surrounding regions. In Ukraine, Kyiv Metro suspended regular service early in the invasion, repurposing its tunnels as bomb shelters.[105] Across the EU, countries experienced changing mobility patterns in response to spiking fuel prices. A

study of 25 EU countries found that the 2022 energy crisis altered travel behaviours, with strong correlations between rising petrol and diesel prices and public transport use in Bulgaria, Denmark, Latvia, Poland and the Slovak Republic (with ridership in Bulgaria surpassing pre-pandemic levels).[106]

- **Meteorological and hydrological hazards:** Without major emission reductions, up to three-quarters of the global population could be exposed to lethal heat-humidity conditions by the end of the century, up from under one-third in 2000.[107] Urban flood risks are also expected to rise due to climate change and urbanisation, disrupting public transport operations.[108] In many cities, heat and flooding risks are compounded – sometimes occurring on the same day or triggering one another.[109] These hazards pose challenges for public transport authorities, operators, manufacturers and wider stakeholders, as they threaten infrastructure by damaging roads, tracks, and vehicles, often leading to service disruptions, delays and suspensions. The resulting impacts create ripple effects on mobility, access to essential services, public health, safety and economic productivity (particularly for users with limited transport alternatives) (Figure 6).[110]

FIGURE 6. Impacts of extreme heat (left) and flooding (right) on public transport users, service providers and physical assets



Source: See endnote 110 for this section.

Policy and investment trends

Safe, convenient, reliable and affordable public transport is key to successful and thriving cities and communities. Public transport has strong links to the positive achievement of 14 of the 17 United Nations Sustainable Development Goals.[111] They include:

- SDG 1 (No Poverty) – by providing access to education and economic opportunities;
- SDG 3 (Good Health and Well-being) – through better road safety, improved air quality, increased physical activity getting to and from fixed stations, and improved access to health centres;
- SDG 5 (Gender Equality) – by providing safe and independent mobility to empower women and girls to reach education and job opportunities;
- SDG 7 (Affordable and Clean Energy) – by creating demand for clean and sustainable electricity, through electrification efforts;
- SDG 8 (Decent Work and Economic Growth) – by creating jobs and connecting people to opportunities;
- SDG 9 (Industry, Innovation and Infrastructure) – by allowing optimisation of investments in resilient infrastructure; and
- SDG 11 (Sustainable Cities and Communities) – by expanding public transport, notably through target 11.2.[112]

During 2022-2024, several important policy shifts across public transport systems had notable effects at the national and international levels. Governments have applied a wide range of policy strategies, from outright bans on fossil fuels to generous tax incentives, with mixed but noticeable progress.

- In 2024, Ethiopia became the first country to completely ban imports of non-electric vehicles , aiming to reduce its annual petrol and diesel import bill of USD 7.6 billion.[113] The move builds on the country's 2022 imposition of a 200% customs duty on fossil fuel vehicles (versus just 15% on electric vehicles).[114]
- Egypt demonstrated its commitment to low-emission mobility by deploying 260 electric buses for the 2022 UN Climate Change Conference in Sharm El-Sheikh (COP 27).[115] Although a national strategy has been announced, a detailed five-year roadmap for petrol and electric bus adoption was still pending as of mid-2025.[116]
- In 2025, Morocco announced that it would invest USD 10.7 billion in public transport and high-speed rail to enhance connectivity and drive economic growth.[117]
- India concluded its nine-year FAME (Faster Adoption and Manufacturing of Hybrid and Electric Vehicles) policy in March 2024, after providing subsidies totalling USD 1.37 billion (INR 11,500 crore) to support 1.6 million electric vehicles, including more than 5,100 e-buses.[118] The successor scheme, PM Electric Drive Revolution in Innovative Vehicle Enhancement (PM e-DRIVE), was launched in September 2024 with an allocation of USD 1.29 billion (INR 10,900 crore) over two years.[119]
- Bus electrification in India is driven by the National Electric Bus Program, targeting 50,000 e-buses by 2027 in major cities, and by PM-eBus Sewa, a USD 6.9 billion (INR 57,613 crore) programme deploying 10,000 e-buses across 169 smaller cities.[120]
- In the United States, the 2021 Infrastructure Investment and Jobs Act authorised funding of up to USD 108 billion for public transport through 2026, including USD 5.6 billion for the Low or No Emission Vehicle Program.[121] As of 2024, the US Environmental Protection Agency's Clean School Bus Program had allocated nearly USD 2 billion to replace around 5,000 school buses with electric models.[122] The Inflation Reduction Act (IRA) of 2022 offers complementary tax credits for electric vehicle infrastructure, although both acts faced political headwinds in 2025. (See 3.5 North America Overview and 5.2 Road Vehicle Electrification.)
- The EU's Green Deal Industrial Plan, launched in 2023 as a response to the US IRA, addresses the growing global competition in clean technologies by backing net zero industries through subsidies and streamlined regulation, including simplified procedures and a more favourable investment environment.[123]
- The amended EU Regulation on Heavy-Duty Vehicle CO_2 Emissions, adopted in 2024, sets more ambitious binding targets for urban buses, calling for 90% of new city buses to be zero-emission by 2030, and 100% by 2035.[124]
- In Latin America, Uruguay created a Sustainable Mobility Trust Fund in November 2023 to incentivise electric bus adoption and replace diesel-focused subsidies.[125]
- In 2022, São Paulo (Brazil), with a bus fleet of more than 13,000 vehicles, banned new diesel bus procurement in line with its Climate Law.[126]
- Bogotá (Colombia) ended purchases of fossil-fuelled buses in early 2022.[127]

Public transport in many countries is often cushioned by fuel tax exemptions and/or direct subsidies, but these supports become harder to sustain during price and political fluctuations, especially in countries already experiencing financial stress. The impacts vary depending on countries' different policy priorities and responses when balancing mobility needs against broader fiscal constraints.

- Colombia began phasing out its Fuel Price Stabilization Fund (FEPC) in 2022 due to the fund's growing fiscal burden.[128] By early 2024, petrol subsidies had been mostly removed, and diesel subsidies were reduced by USD 0.18 (COP 800) per gallon.[129] The original plan called for reductions of COP 1,904 but was revised downward

after protests from freight truckers and public transport operators facing rising operational costs.[130]

- In Malaysia, diesel subsidy costs surged dramatically from USD 300 million (RM 1.4 billion) in 2019 to USD 3 billion (RM 14.3 billion) in 2023.[131] In June 2024, the government responded by raising diesel prices more than 50% and shifting from blanket subsidies to a targeted, tiered system.[132] For public transport, under the new fleet card programme Sistem Kawalan Diesel Subsidi (SKDS 1.0), operators pay a lower diesel rate of USD 0.42 (RM 1.88 per litre), while non-subsidised users pay the full USD 0.75 (RM 3.35) per litre.[133]
- The Philippines allocated USD 52.6 million (PHP 3 billion) for its 2024 transport fuel subsidy programme, of which USD 43 million (PHP 2.5 billion) was earmarked for direct fuel subsidies to public utility vehicle drivers, including those operating jeepneys, tricycles, ride-hailing services and delivery vehicles.[134] The subsidy programme aims to ease immediate fuel price pressures while supporting long-term development goals, especially in the context of the Public Utility Vehicle Modernization Program. However, ongoing transport strikes since 2023 have protested the programme, which mandates replacing the iconic traditional jeepneys with more expensive, eco-friendly models.[135]
- In May 2023, Nigeria's removal of fuel subsidies caused petrol prices in Abuja to triple, reaching USD 0.45 (NGN 700) per litre; transport fares doubled nationwide, and intra-city bus fares rose around 98%.[136] The abrupt policy shift led inflation to hit a 27-year high by December 2023, making basic goods unaffordable for many people.[137] In response to the economic strain and public backlash, the government partially reinstated fuel subsidies in early 2024, along with additional relief measures such as halving public transport fees and offering free train rides during the holiday season.[138]

A 2025 study of urban rail projects worldwide – including metros, subways and light rail systems – estimated the global weighted average cost at around USD 238 million per kilometre, based on 696 lines across 189 cities; however, construction costs vary dramatically across countries.[139]

- US urban rail projects exhibit exceptionally high costs, with the Second Avenue Subway Phase I in New York City reaching around USD 1.7 billion per kilometre (adjusted in 2023 dollars); this was driven by factors such as complex underground conditions, extensive consultant costs and stringent regulatory requirements (such as maintaining four traffic lanes during construction).[140]
- In Hong Kong, the Tung Chung Line Extension cost around USD 3.1 billion (HKD 24.2 billion) for just 2.5 kilometres, or roughly USD 1.2 billion per kilometre; this reflected the challenge of building in one of the world's most densely populated areas, requiring extensive community facility relocations and complex engineering in limited space.[141]
- Metro construction in Italy demonstrates cost effectiveness, averaging 57% below global benchmarks at around USD 120 million per kilometre; this results from procurement reforms implemented since the 1990s that prioritised transparency and competition, strong in-house public sector capacity for planning and design, and standardised designs that reduce engineering complexity.[142]

Public transport agencies that have maintained revenue stability have adopted diversified funding models including real estate development, advertising and regional transport taxes.[143] **The COVID-19 pandemic prompted agencies worldwide to reconsider their revenue sources and fare policies, with some offering fare-free services** (Table 1).[144] Advocates of fare-free transit argue that eliminating fares repositions public transport from a market commodity to a public good (thereby addressing social exclusion and inequality), whereas critics raise concerns about potential service quality deterioration due to funding shortages for operations and maintenance.[145] In the United States, many public transport systems that relied on COVID-19 relief funds later faced funding gaps as the temporary funding expired.

- New York City (United States) and Bangkok (Thailand) use congestion charging to fund public transport improvements, while London (United Kingdom) uses its ultra-low emission zone as a funding stream.[146]
- Queensland (Australia) trialled reducing its public transport fares to USD 0.31 cents (AUD 0.50) in August 2024 and then made the programme permanent in February 2025.[147] The number of public transport users was 18.3% higher than during the same six-month period (August to February) a year prior and 5% higher than pre-pandemic levels of 2019, and users had saved around USD 112 million (AUD 181 million) through the first six months of the programme.[148]
- Kansas City, the first major US city to implement fare-free public transport in 2020, had a projected USD 26 million funding gap as of 2025 and was considering transitioning to a USD 2 base fare while maintaining free access for seniors and people with disabilities.[149]

While fare-free transit has gained political attention and been extensively implemented in countries such as Brazil, an emerging consensus suggests that targeted policies – such as subsidies for specific populations (e.g., students, elderly, etc.) – may be more sustainable than blanket fare-free systems, since transport infrastructure requires funding regardless of fare structure. Ultimately, effective fare policies must balance access, sustainability and financial viability within broader integrated transport strategies.

TABLE 1. Selected fare-free transit systems and their funding mechanisms, as of January 2025

Transit agency and/or location	Date implemented (status if available)	Funding mechanism	Additional notes
Belgrade (Serbia)	January 2025	Not available	With a population of 1.7 million, Belgrade became the largest European city to implement fare-free public transport for all residents. Covers buses, trams and trolleybuses.
Brazil	Various	Not available	Number of cities with free public transport grew from 42 in 2020 to 136 as of September 2024. A 2024 study found that the fare-free policy resulted in a 4.3% emission reduction and a 3.8% increase in jobs, with the benefits outweighing the costs.
Chapel Hill Transit, Chapel Hill (United States)	2002 (active)	University partnership, municipal* funding, federal/ state subsidies	Celebrated 50th transit anniversary in 2024. Ridership grew from 3 million (2002) to 7 million (2019). Longest-running major fare-free system in the United States.
Corvallis Transit System, Corvallis (United States)	February 2011 (active)	Transit Operations Fee on utility bills (USD 3.89 per single-family household, as of February 2025)	Ridership increased 37.9% in first year of fare-free service. Utility fee provides stable funding that grows with costs. Experienced service reductions in 2022-2023 due to driver shortages.
Colorado Zero Fare Transit Program, Colorado (United States)	Summer 2023-2025 (active – ongoing seasonal)	State funding through Senate Bill 24-032	Statewide programme offering fare-free transit during July-August to reduce ground-level ozone. Includes multiple transit agencies across Colorado.
DASH, Alexandria, (United States)	September 2021 (active)	City subsidy (USD 1.7 million), VA Transit Ridership Incentive Program (TRIP) grant (USD 7.1 million through 2025)	Record ridership of 4.5 million boardings in FY2023. 54% of riders started using DASH after fare elimination. 62% of new riders cited free fares as reason for riding.[150]
Estonian County Buses, Estonia (rural areas)	2018 (partially active as of January 2024)	National and regional government funding	Free transit in rural counties was largely abolished in January 2024 but remains available for people under 19 and over 63.
Indian states of Delhi, Karnataka, Kerala, Punjab, Tamil Nadu and Telangana	2021	Not available	Free public transport for women. Women's use of public transport increased 60-99% in the six cities.
Intercity Transit, Olympia (United States)	January 2020 (active through at least 2028)	Sales tax increase approved by voters in November 2018	Initially a five-year "Zero-Fare" demonstration project. Extended its pilot due to the COVID-19 pandemic. Ridership increased 40% in the first two months before the pandemic.
Kharkiv (Ukraine)	2022	Not available	Introduced fare-free public transport to support residents during the ongoing conflict.
Luxembourg Public Transport, Luxembourg (nationwide)	February 29, 2020 (active)	National government funding	First country to make all public transit free nationwide, although first-class train service still requires payment. Limited modal shift impact but improves social equity.
Malta Public Transport, Malta (nationwide)	October 2022 (active)	National government funding	Second country (after Luxembourg) to implement nationwide fare-free transit. Available for residents only on most routes through personalised Tallinja Card system; excludes some express and on-demand services.
Spain	2022	Free passes, government subsidies; discounts were extended through June 2025, with plans to introduce a new subsidy model starting in July	Free commuter train passes (Cercanías and Rodalies) in metropolitan areas. Subsidised urban transport systems. The policy was introduced to combat inflation and rising living costs exacerbated by the economic effects of the Russian Federation's invasion of Ukraine.
Stavanger (Norway)	Not available	Not available	First Norwegian city to offer free public transport to its residents. Aim was to reduce the number of car trips by 70%.
TaM, Montpellier (France)	December 2023 (active)	Local taxes, using a redistributive policy to restore purchasing power while supporting environmental transition; mobility payments from companies with 11-plus employees	Largest French metropolis with fare-free transport. Eligible for 510,000 inhabitants across 31 municipalities; residents only. 33% ridership increase in first year.

Note: This table showcases various funding mechanisms in the public transport sector, using fare-free systems as a standardised comparison point. Affordable fares should be combined with service quality improvements to attract and retain users, creating a positive feedback loop that benefits the entire system.

* The term "municipal" may represent different governmental structures in different countries. In the United States, municipal typically refers to city or town government, whereas in other countries municipal authorities may have different powers, responsibilities and funding mechanisms.

Source: See endnote 144 for this section.

As of 1 August 2025, a total of 29 countries had submitted their third-generation Nationally Determined Contributions (NDCs) to the UN Framework Convention on Climate Change (UNFCCC); of these, 25 NDCs included content related to transport, but only 15 featured content (either as targets or actions) on public transport (Andorra, Botswana, Brazil, Canada, Kenya, Lesotho, Maldives, Moldova, Monaco, Nepal, Somalia, Singapore, the United Kingdom, the United States and Uruguay).[151] Belize, Botswana, Canada, Lesotho, Moldova, Monaco and Nepal outlined specific targets related to public transport, covering expansions, modal shifts as well funding targets.

- Botswana's new NDC commits to increasing the share of public transport in total transport use to 30% by 2030.[152]
- Canada aims to contribute USD 2.1 billion (CAD 3 billion) per year for public transport through the Canada Public Transit Fund from 2026 onwards.[153]
- Lesotho's NDC has a target to increase the share of public transport from around 10% in 2022 to 30% by 2030.[154]
- Moldova's NDC features a transition to hybrid vehicles for public transport by 2030, followed by 50% fleet electrification by 2040 and complete electrification by 2050.[155]
- Monaco's NDC commits to replace all public buses with electric vehicles by 2030.[156]
- The new NDC of Nepal targets effective public transport systems in all cities by 2035; an integrated electric bus, trolley and light-rail system of at least 50 kilometres by 2030 and 100 kilometres by 2035; and at least 50 cable-based transport services by 2030 and 150 by 2035.[157]

Public transport actions in the third-generation NDCs were aimed at improving and expanding services and increasing access. However, the low number of NDCs submitted as of 1 August 2025 made it difficult to identify detailed trends and to compare actions to previous generations of NDCs.

- Andorra highlights in its 2025 NDC that all public transport has been free since 2022.[158]
- Brazil aims in its NDC to reduce dependence on private transport by improving public transport.[159]
- Canada's NDC mentions ambitions in Vancouver to reduce vehicle emissions by promoting a shift to public transport; British Columbia plans to electrify public transport.[160]
- Kenya's NDC emphasises a comprehensive approach of promoting low-carbon, climate-resilient and efficient transport systems that are gender responsive and accessible to all, through electrification, modal shifts, urban mass rapid transport systems and overall greening of transport.[161]
- Singapore's NDC highlights the "Walk-Cycle-Ride" approach, including expanding its rail network from around 270 kilometres as of 2025 to 360 kilometres in the early 2030s, putting 8 in 10 households within a 10-minute walk from a train station.[162]
- The United Kingdom's NDC highlights a complete overhaul of public transport services and integrating transport networks to make the sustainable choice the most convenient choice.[163]
- The US NDC emphasises the need to invest in affordable, accessible, reliable public transport and rail to reduce emissions and to promote benefits for communities with environmental justice concerns.[164]
- Uruguay's NDC features the optimisation of public transport services through improved accessibility and affordability.[165]

In the second generation of NDCs (submitted to the UNFCCC between 2020 and 2023), 67% of countries prioritised action with public transport.[166] Identified gaps included a lack of ambitious targets, clear timelines for activities, and specifying ministries and budgets. High-income countries focused on clean vehicle technologies, whereas low- and middle-income countries focused on infrastructure and system improvements. However, in many cases the public transport-related policies or measures outlined in second-generation NDCs were vague in both terminology and intended on-the-ground impact.

Efforts to decarbonise public transport must be paired with strategies to adapt to and withstand potential climate-related hazards. Strengthening the synergy between mitigation and adaptation is essential to ensure that investments in low-carbon public transport remain effective amid intensifying climate stress and more frequent extreme weather events. Although the shift to electric buses can lower emissions, it introduces new vulnerabilities to power supply disruptions. Without adequate adaptation and the integration of transport and climate resilience, disruptions may erode public confidence and push users back towards more emission-intensive, privately owned vehicles, jeopardising climate goals.

- During China's 2022 heatwave and drought, hydropower outputs in Sichuan Province were halved, causing blackouts and temporary shutdowns of electric vehicle charging stations.[167]
- Ahmedabad (India) has advanced its Heat Action Plan by piloting cooling interventions such as high-pressure misting systems and shaded structures at bus stops to reduce heat exposure for commuters.[168]
- In Phoenix (United States), the Cool Corridors Program, launched in 2022, aims to create shaded routes by planting up to 200 trees per mile to provide safer, cooler walking environments for residents, including those accessing transit stops and services.[169]
- In Poland, the cities of Poznań, Siemiatycze and Warsaw

have installed "green bus stops" – nature-based solutions that have green roofs and vegetated retention-infiltration systems – which are designed to retain stormwater, reduce local flooding and mitigate urban heat.[170]

Partnerships in action

- Between 2021 and 2025, the **TUMI E-Bus Mission** spearheaded an ambitious initiative to build strong coalitions at the global and local levels, collaborating with 20 Deep Dive Cities and inspiring action in 100 additional cities.[171] Through roadmaps, technical support, and knowledge exchange, the Mission enabled cities to design e-bus fleets tailored to their contexts. By bringing together public and private sector partners, it created a lasting foundation for a global community committed to advancing cleaner, greener and more sustainable urban transport.[172]
- The World Resources Institute's (WRI) **Reimagining Public Transport** project helps cities in Brazil, China, India and Mexico improve public transport's mode share, quality, efficiency and prosperity. It also supports WRI's Mobility and Accessibility Program, the TUMI E-Bus Mission and global efforts such as the World Bank's Sustainable Mobility for All.[173]
- **Transforming Transportation**, organised by the World Bank and WRI's Ross Center for Sustainable Cities, is an annual gathering of high-level decision makers and cutting-edge thinkers focused on sustainable, equitable transport solutions for low- and middle-income countries.[174] The March 2026 event will feature a week-long programme, side events and partner meetings delivered in a dynamic hybrid format combining in-person networking, high-level sessions and virtual participation to engage its global community.[175]
- The **Access to Climate Finance for Transport** initiative, supported by the High Volume Transport programme of the UK Foreign, Commonwealth and Development Office, aims to assist low- and middle-income countries in obtaining climate finance for low-carbon transport solutions.[176] Between January and June 2024, WRI and partners engaged a broad range of stakeholders through five multi-stakeholder convenings, workshops and roundtables.[177]
- In 2024, the International Association of Public Transport (UITP) developed the **Public Transport National Determined Contributions Template**, a guidance document on how to integrate public transport targets in the new third-generation NDCs. Countries can use the template to explore options that reflect national priorities and address key implementation and financing needs. It consists of 4 key elements (and 14 key policies and actions): 1) Articulate a vision for the desired state of the future that puts public transport at the heart of urban transport climate action; 2) Accelerate transformations with ambitious targets in order to bring about change and accelerate ambition; 3) Detail the actions to reach the vision, targets and objectives that will help to bring about higher ambition and better urban mobility built on a backbone of public transport; 4) Elaborate indicators linked to the SDGs to monitor and verify progress against the actions so it accelerates change and delivers multiple sustainability benefits.
- The research project on **Inclusiveness, Accessibility, and Equity in Public Transport** was launched in March 2025 by UITP's Asia-Pacific Centre for Transport Excellence. The project aims to address the growing need for public transport systems that are inclusive, accessible and socially equitable, particularly for underserved and marginalised groups in growing Asia-Pacific cities.[178]
- Funded by Horizon Europe, the three-year **GOLIA** initiative (Governing, Optimising and Leveraging Innovations proActively) brings together 21 partners, including **UITP**, to rethink how mobility is planned, governed and delivered.[179] It focuses on three key areas – climate resilience, social inclusion and governance – to help cities build mobility systems that can withstand environmental, political and structural disruptions.[180]
- UITP's **Public Transport Benefits Toolbox** offers brochures, posters, visuals and other resources to help communicate the value of public transport to the public, policy makers and other stakeholders.[181]
- In April 2025, the International Union of Railways (UIC) and Southwest Jiaotong University hosted the **UIC World Congress on Railway Training** in Chengdu (China), gathering training directors, executives, human resource professionals and rail education institutions to promote best practices, showcase innovative research, address new training challenges and share knowledge across the industry.[182]
- UIC, through its Africa Programme, launched the **UIC Taskforce 'Women in Rail in Africa'** to develop recommendations, conclusions, and initiatives that enhance women's contribution to the rail sector in Africa – both as part of the workforce and as passengers.[183]

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Informal Transport

THIS CHAPTER IS SUPPORTED BY
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KEY FINDINGS

- Informal transport – also known as popular transport or paratransit – refers to a broad range of privately organised and operated transport services, mainly in the Global South. It can include motorcycle taxis, auto-rickshaws, minibus taxis, private automobiles and even boats. The level of informality of these services depends on the operational context, regulation, working conditions and level of involvement of public authorities in their planning and delivery.
- Because of the informal character of this sector, updated and consistent data are lacking on fundamental aspects such as the size and characteristics of vehicle fleets, the scale of operations and the number of workers. Such data are essential to better inform policies and investment that improve the service based on the local context.
- In recent years, interest, advocacy and knowledge sharing on informal transport have grown, and international organisations have increasingly funded and supported research, planning and policy in this area. In most cases, efforts have focused on large cities. However, there is an understanding that informal transport also plays a crucial role in peri-urban and rural areas, where other transport services may be unavailable or unreliable.
- Traditional modes of informal transport have steadily evolved towards motorised, digitalised and electric alternatives. In some settings, governments have integrated informal transport services into broader strategies for modern and sustainable urban mobility. In areas where political will or capacity may be limited, the private sector has helped drive modernisation.
- Recent policy initiatives have focused on fleet modernisation, regulation, data collection and sustainable transport planning. Yet challenges persist in data availability, financial sustainability, and regulatory co-ordination, limiting the informal transport sector's potential contributions to equitable and low-carbon urban transport solutions.
- Although informal transport could be a potential low-carbon solution with high passenger capacity, the sector's widespread inefficiencies and challenges related to quality, security and reliability must be addressed to prevent users from transitioning to more carbon-intensive private vehicle travel and to ensure truly inclusive and sustainable transport solutions.

Demand, use and access

- Global data on the size, operations and ridership of informal transport fleets remain sparse, inhibiting the ability to generate insights for better policy and planning.
- Data on informal transport for different cities in the Global South show that trips using these modes still represent a large share of passenger transport services, ranging from 11% to 95% of trips in different cities, with an average of 48% of trips.
- Informal transport using two- and three-wheelers is extremely common in cities across the Global South, particularly in Asia, and is often also the backbone of rural mobility. Auto-rickshaws, *tuk-tuks*, motorcycle taxis and bicycle taxis have become essential in providing connectivity and access to transport both in congested city centres and in areas outside or in the periphery of urban centres that may have limited public transport options.
- Globally, two- and three-wheelers remained the most electrified road transport segment in 2024, with more than 9% of the total fleet being electric. Although overall sales of two-wheelers fell in 2023, the electric two- and three-wheeler segment surged, thanks to innovative business models and policies such as India's FAME II scheme. Electric versions of informal transport such as *boda bodas*, auto-rickshaws, *ojeks*, *tuk-tuks* and others have appeared in many Global South cities.
- The transition to electric two- and three-wheelers is the most advanced in Asia, thanks to public incentives. In 2023, Asia held 53% of the global electric three-wheeler market and 52% of the electric two-wheeler market, with China alone holding 35% and 12%, respectively.
- A surge in the popularity of ride-hailing apps has sustained the demand for two- and three-wheelers (including electrified versions), with many informal transport operators incorporating these technologies into their daily operations.

KEY FINDINGS

- Minibus taxis play a prominent role in urban transit in different cities in Africa, underscoring their central place in urban mobility. In Gaborone (Botswana) and Maseru (Lesotho), they accounted for more than 70% of all trips as of 2021.
- Fewer data are available on other forms of informal transport, such as private (clandestine) taxis, pick-up trucks, and maritime and human-powered transport services. Pick-up trucks are frequently used as informal transport in rural areas, sometimes with seats or other adaptations in the back. Traditional boat ferries are common in many geographies, but their role in mobility has been less explored.
- In South-East Asia, traditional informal transport modes have evolved towards motorised and digitally integrated alternatives, due in part to interest from younger users. To actively promote modern and sustainable urban transport systems, some governments have explicitly banned traditional informal modes.
- Across Africa, informal transport continues to work in tandem with public transport to meet the region's growing urbanisation and mobility needs. Data and research on informal transport in Latin America are limited in comparison to Asia and Africa.
- Surveys reveal that in some of Latin America's biggest cities, informal transport may be more difficult to access than formalised public transport options, particularly in cities with well-developed mass transit networks or where regulations restrict informal operations. Although informal transport may not be as present in the city cores of large metropolitan areas, it plays a key role in connecting peri-urban areas and residents in informal settlements. In many contexts, informal buses still provide better access to transport services than other mass transport options such as trains or formal buses.
- A small but growing field of research has focused on informal transport in sub-regions such as Central America and the Caribbean, providing data on the roles of smaller vehicles and informal boat services in coastal secondary cities and rural areas.
- Although informal transport is usually explored in the context of the Global South, many high-income countries host small-scale, unregulated services. These services cater mainly to tourism but also operate in areas underserved by public transport, or disrupt the market by offering a cheaper transport option.

KEY FINDINGS

Sustainability and climate trends

- Informal transport is frequently valued as a catalyst for economic activity and local development, offering access factors such as door-to-door service, speed, cost and maneuverability in small or narrow streets found in the Global South.
- The informal transport sector intersects with many dimensions of sustainability and has the potential to generate numerous social, economic, and environmental benefits, contributing to at least 7 of the 17 United Nations Sustainable Development Goals (SDGs).
- Road safety remains a key challenge facing informal transport, with the lack of regulation and oversight contributing to a high risk of injuries and fatalities among users. On average, 22.5% of road traffic deaths globally in 2016 involved riders or passengers of two- and three-wheelers.
- Women are among the main users of informal transport but are the least represented in the sector's workforce, as they face challenges related to recruitment, retention and sexual harassment. Overall, there is an urgent need to improve working conditions in the informal transport sector.
- Smaller vehicles that make it possible to transport more people at the same time – such as auto-rickshaws and minibuses – are considered the most energy-efficient and least carbon-intensive modes of informal transport. A study in Cape Town (South Africa) found that motorcycle and minibus taxi services are still less energy intensive than petrol or hybrid-equivalent vehicles, which are more common than electric cars in cities in the Global South.
- Studies in different cities around the world indicate that, on average, the contribution of informal transport to overall transport emissions is 20%, although it can reach 40% in some cities. This contribution depends on characteristics such as the types and ages of vehicles, which can affect a vehicle's operational efficiency.
- Many of the vehicles used in informal transport are older, second-hand vehicles imported from other countries, raising significant safety, environmental and public health concerns. As of 2019, more than 80% of Africa's road vehicles failed to meet Euro 4 emission standards and often lacked valid roadworthiness. Older vehicles emit far more pollutants than newer models, especially when poorly maintained or fitted with low-quality components.
- In many African cities, where second-hand motorcycles dominate the informal transport fleet, emissions depend on the vehicle age and mileage, and drivers and users are among the most vulnerable to road crashes and injuries. In Kampala (Uganda) and Nairobi (Kenya), initiatives such as Lubyanza collect quarterly data on *boda bodas* that includes topics such as vehicle characteristics, road worthiness compliance, helmet use, reflective jacket use, and worker profiles and needs. Such insights can inform sustainability and climate action projects and help address challenges such as improving working conditions and compliance with road safety requirements.
- The electrification of informal transport has contributed to climate action, air quality and noise pollution goals while also improving services for users. Electric two- and three-wheelers accounted for around 60% of the avoided oil demand in the global road transport sector in 2023, driven by their rapid adoption and expansion in regions such as China, India and South-East Asia. However, many countries continue to face grid reliability issues that affect vehicle charging, and electricity is often sourced from highly polluting bagasse, coal and petroleum.

KEY FINDINGS

Policy and investment developments

- Recent policy developments in informal transport have focused on electrification, fleet modernisation, regulation and integrating the sector into data collection efforts and sustainable transport planning. Some governments have introduced digital registration and verification for drivers of informal transport vehicles; however, broader integration efforts are still evolving.
- As fleet electrification continues to expand, the push to electrify informal transport vehicles must be accompanied by strong planning and policy measures to ensure that systems are inclusive, sustainable and safe. Key challenges to electrification include data availability, access to affordable and appropriately scaled financing, the need for viable business models, and regulatory co-ordination, limiting the sector's potential contributions to equitable and low-carbon urban transport solutions.
- Despite the high prevalence of informal transport in the Global South, countries have only recently started to incorporate the sector into their Nationally Determined Contributions (NDCs) towards reducing emissions under the Paris Agreement. As of 2025, only Angola, Uganda and Somalia mentioned or included goals associated with informal transport in their NDCs.
- Vehicle scrappage and modernisation schemes have been implemented in various countries to replace ageing informal transport vehicles. Experiences in Africa, particularly in Dakar (Senegal), in the 2000s have generated insights and models for countries elsewhere to replicate.
- In addition to government action, a diversity of other stakeholders – including public-private partnerships and non-governmental organisations – have undertaken data collection and policy initiatives to improve and modernise informal transport services.
- Despite these advancements, significant gaps remain in formal recognition, integration and support for informal transport providers. To accelerate and support policy development in the field, international organisations have launched guiding documents and resources that provide recommendations and insights for policy makers to follow and integrate into their work.

Context, challenges and opportunities

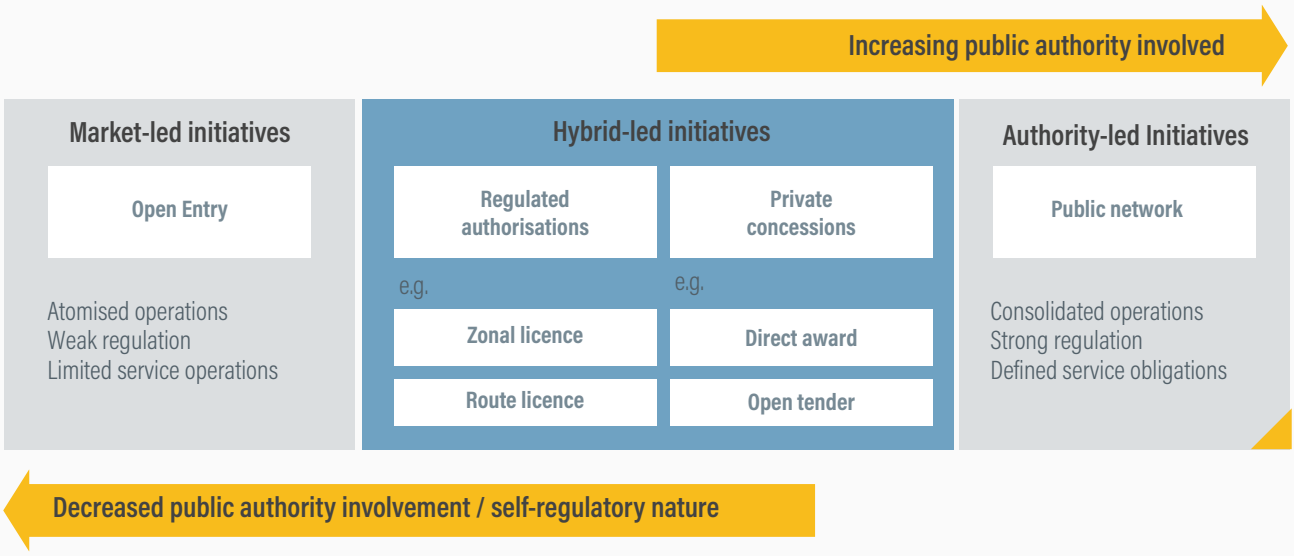
Informal transport – also known as popular transport or paratransit[i] – refers to a broad range of privately organised and operated transport services, mainly in the Global South. It can include motorcycle taxis, auto-rickshaws, minibus taxis, private automobiles and even boats. The level of informality of these services depends on the operational context, regulation, working conditions and level of involvement of public authorities in their planning and delivery (Figure 1).[1]

Because of the informal character of this sector, updated and consistent data are lacking on fundamental aspects such as the size and characteristics of vehicle fleets, the scale of operations and the number of workers. Such data are essential to better inform policies and investment that improve the service based on the local context. Data are also crucial for understanding the informal transport sector's contribution to greenhouse gas emissions and sustainability goals, both nationally and in pursuit of global ambitions such as the Paris Agreement and the Sustainable Development Goals (SDGs).

In recent years, interest, advocacy and knowledge sharing on informal transport have grown, and international organisations have increasingly funded and supported research, planning and policy in this area. In most cases, efforts have focused on large cities. However, there is an understanding that informal transport also plays a crucial role in peri-urban and rural areas, where other transport services may be unavailable or unreliable. The growing inclusion of the sector in the development of Sustainable Urban Development Plans and Sustainable Urban Mobility Plans has helped generate updated data on vehicle fleets and demand trends across different cities, while also enabling the interaction, investment and improvement of informal transport services.

Traditional modes of informal transport have steadily evolved towards motorised, digitalised and electric alternatives. In some settings, governments have integrated informal transport services into broader strategies for modern and sustainable urban mobility. In areas where political will or capacity may be limited, the private sector has helped drive modernisation – often in the form of super-apps, ride-hailing and e-mobility companies – covering gaps left by public policy. This increased private sector involvement has spurred innovations in business models, such as moving away from commission-based pricing[ii].[2]

FIGURE 1. Scale of informality of transport services according to their context



Source: See endnote 1 for this section

i Additional names for informal transport include: traditional, artisanal, provisional, illegal, unregulated, and clandestine transport, among others.
ii Commission-based pricing refers to the mechanism used by ride-hailing apps where a percentage is deducted from each fare to generate revenue.

Recent policy initiatives have focused on fleet modernisation, regulation, data collection and sustainable transport planning. Yet challenges persist in data availability, financial sustainability, and regulatory co-ordination, limiting the informal transport sector's potential contributions to equitable and low-carbon urban transport solutions. The sector also faces enormous challenges related to working conditions, police harassment, social security, and worker health and safety, in addition to discrimination and sexual harassment in the case of female workers.[3] Continued efforts are needed to incorporate informal transport into climate action through a just transition towards modern, sustainable, inclusive and integrated transport systems that ensure workers' wellbeing.

Although informal transport could be a potential low-carbon solution with high passenger capacity, the sector's widespread inefficiencies and challenges related to quality, security and reliability must be addressed to prevent users from transitioning to more carbon-intensive private vehicle travel and to ensure truly inclusive and sustainable transport solutions.

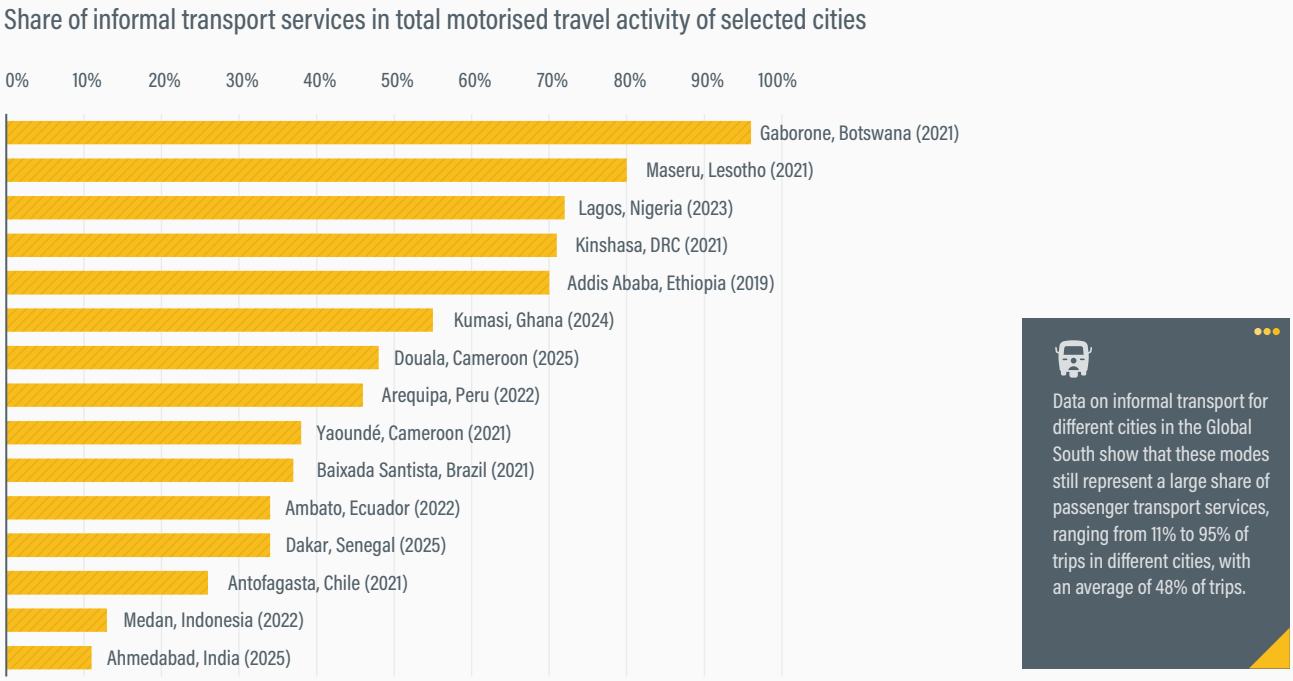
Demand, use and access

Global data on the size, operations and ridership of informal transport fleets remain sparse, inhibiting the ability to generate insights for better policy and planning. However, localised efforts in cities and countries – including the quarterly data insights from Lubyanza Research Group, the Atlas of Popular Transport, TUMI Data and the Partnership for Informal and Shared Mobility (PRISM) – have contributed to a more nuanced view of informal transport in different contexts.[4]

Data on informal transport for different cities in the Global South show that these modes still represent a large share of passenger transport services, ranging from 11% to 95% of trips in different cities, with an average of 48% of trips (Figure 2).[5] The share of informal transport has exceeded 70% in at least five African cities: Addis Ababa (Ethiopia), Gaborone (Botswana), Kinshasa (Democratic Republic of the Congo), Lagos (Nigeria) and Maseru (Lesotho).[6]

Given the loosely defined nature of informal transport, the methodology for calculating its share of trips can vary based on factors such as the type of vehicle or trip, the number of trips taken and the share of vehicle-kilometres travelled. Informal transport relies on many different vehicle types – often in response to the local context, markets, geography and climate – which may limit the standardisation of data collection.

FIGURE 2. Share of informal transport trips in selected cities and years



Data on informal transport for different cities in the Global South show that these modes still represent a large share of passenger transport services, ranging from 11% to 95% of trips in different cities, with an average of 48% of trips.

Source: See endnote 5 for this section.

MobiliseYourCity has prepared methodology guides and toolkits for integrating informal transport into calculations of greenhouse gas emissions.[7]

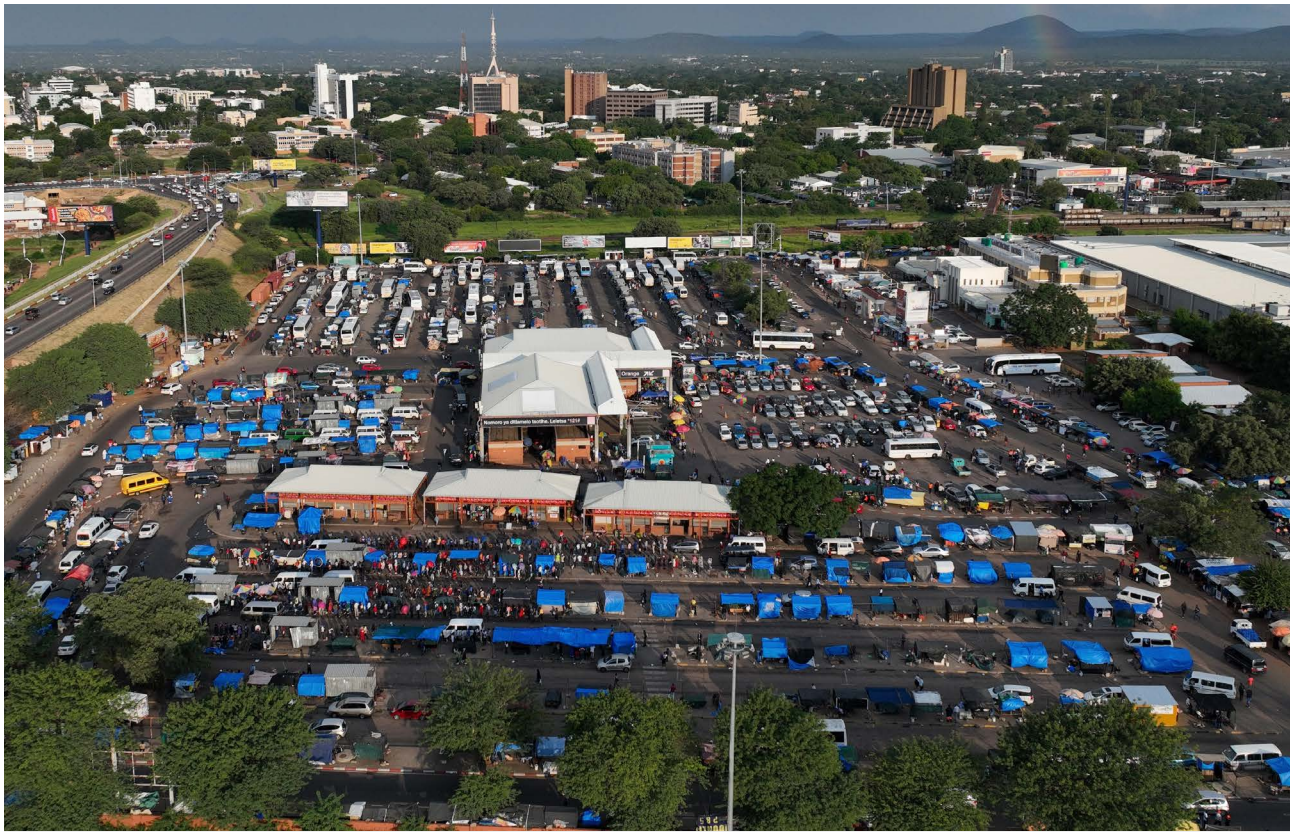
Informal transport using two- and three-wheelers is extremely common in cities across the Global South, particularly in Asia, and is often also the backbone of rural mobility.[8] Auto-rickshaws, *tuk-tuks*, motorcycle taxis and bicycle taxis have become essential in providing connectivity and access to transport both in congested city centres and in areas outside or in the periphery of urban centres that may have limited public transport options. Efforts have sought to improve the integration of two- and three-wheelers with mass transit, digitalise their operations, and improve personal and road safety.

- In China and India, two- and three-wheelers account for a large share of both general traffic and informal transport services.[9]
- In Thailand, motorcycle taxis and ride-hailing play an important role in connecting riders to mass public transport stations, and in India three-wheelers serve a similar demand.[10]
- In 2020, 28% of all trips in Amman (Jordan) were carried out on two- and three-wheelers.[11]

Globally, two- and three-wheelers remained the most electrified road transport segment in 2024, with more than 9% of the total fleet being electric.[12] Although overall sales of two-wheelers fell in 2023, the electric two- and three-wheeler segment surged, thanks to innovative business models and policies such as India's FAME II scheme.[13] Electric versions of informal transport such as *boda bodas*, auto-rickshaws, *ojeks*, *tuk-tuks* and others have appeared in many Global South cities.[14] However, precise data on the share of electric two- and three-wheelers used in informal transport are lacking.

- The social enterprise Greenwheels Africa, based in Nairobi (Kenya), manages a fleet of electric motorcycles (*bodas*) for on-demand passenger and cargo services, providing drivers with the vehicles, training and a fixed income.[15] Greenwheels carried more than 700,000 passengers in its first year of operation (2024), and in partnership with Uber it has expanded its fleet from 50 to over 500 bikes.[16]
- In Thailand, the electric *tuk-tuk* start-up MuvMi recorded more than 3 million trips between 2018 and 2023 and had plans to triple its fleet from 350 to 1,000 units in response to increased demand for rides.[17]

The transition to electric two- and three-wheelers is the most advanced in Asia, thanks to public incentives. In 2023,



Asia held 53% of the global electric three-wheeler market and 52% of the electric two-wheeler market, with China alone holding 35% and 12%, respectively.[18]

- As of 2021, India had surpassed China in the number of two- and three-wheelers with internal combustion engines (15.1 million units versus 15 million units), and a further 1.3 million electric two- and three-wheelers were sold in India and other parts of South Asia that year, helping to consolidate India's leadership in these vehicles by 2023.[19]
- Electric auto-rickshaws (e-autos) accounted for 6% of vehicle registrations in India in 2023, and the government has committed to 80% market penetration of electric three-wheelers by 2030, with various states setting their own targets and offering incentives to promote e-autos.[20]

A surge in the popularity of ride-hailing apps has sustained the demand for two- and three-wheelers (including electrified versions), with many informal transport operators incorporating these technologies into their daily operations.[21]

- The trend towards app integration has helped counter reports from 2018 indicating a possible slowdown of the motorcycle market across South-East Asia.[22]
- The Namma Yatri app, launched in India in 2022 by the Bengaluru Auto Rickshaw Drivers' Union, accumulated a total of 86 million trips, 621,000 drivers, and 11 million registered users as of 2025, generating more than USD 161 million.[23]
- Super-apps such as Gojek in Indonesia and Ola in India are establishing ambitious goals to electrify their two- and three-wheeler fleets, partnering with other private entities to manufacture electric two-wheelers, battery packs, and battery swap stations, and to offer them to drivers along with financing.[24]

Minibus taxis play a prominent role in urban transit in different cities in Africa, underscoring their central place in urban mobility.

- **In Gaborone (Botswana) and Maseru (Lesotho), minibus taxis accounted for more than 70% of all trips as of 2021.**[25]
- In South Africa, an estimated 80.2% of work trips in 2020 were taken using minibus taxis, far exceeding the shares by formal buses (16.6%) and trains (3.2%).[26]

Fewer data are available on other forms of informal transport, such as private (clandestine) taxis, pick-up trucks, and maritime and human-powered transport services. Pick-up trucks are frequently used as informal transport in rural areas, sometimes with seats or other adaptations in the back. Traditional boat ferries are common in many geographies, but their role in mobility has been less explored.

- In Thailand, *songthaews* (modified pick-up trucks with two rows of seats along the back) are convenient for both locals and tourists due to their affordability.[27]
- Pick-up truck services are common in both peri-urban and rural areas of Latin America, and similar services (known as *my loves*) are used in areas of Maputo (Mozambique) in Africa.[28]
- Across Central America, informal small boats known as *lanchas* or *pangas* provide key maritime transport options, with semi-regulated operators serving important routes across the Gulf of Fonseca (bordered by El Salvador, Honduras and Nicaragua) and the Caribbean coasts of Belize, Guatemala and Mexico.[29]

In South-East Asia, traditional informal transport modes have evolved towards motorised and digitally integrated alternatives, due in part to interest from younger users. To actively promote modern and sustainable urban transport systems, some governments have explicitly banned traditional informal modes. Bangkok (Thailand), Ho Chi Minh City (Viet Nam) and Jakarta (Indonesia) have all prohibited the operation of non-motorised bicycle rickshaws (*cyclo*, *becak*) and horse-drawn carriages (*delman*) in urban areas.[30]

Across Africa, informal transport continues to work in tandem with public transport to meet the region's growing urbanisation and mobility needs.

- Greater Cairo (Egypt) has a diverse multi-modal transport network, complementing its large metro and municipal bus system with informal transport systems that fulfilled 8.1 million trips per day in 2021.[31]
- In Nairobi (Kenya), some 20,000 *matatu* minibuses handled around 40% of daily trips as of 2020.[32]
- In greater Lagos (Nigeria), the estimated 75,000 minibuses on the road in 2021 captured 72% of all trips, more than 14 times the combined share of bus rapid transit and regulated bus services (5%).[33]
- Minibus taxis accounted for an estimated 80.2% of work trips in South Africa in 2020 (up from 67.2% in 2013 and 63% in 2003), whereas buses accounted for just 16.6% of work trips (down from 19.5% in 2013 and 22% in 2003).[34] A 2024 survey, using different methods and classifications, found that minibus taxis, sedan taxis and *bakkie* taxis accounted for 27.7% of work trips.[35]
- In 2025, clandestine taxis held 11.5% of the modal share in Dakar (Senegal), with fleet estimates ranging between 4,000 and more than 5,000.[36]
- A 2020 study of cities in mainland Africa with at least 100,000 residents found that the share of cities with motorcycle taxis was around 25% in Southern Africa but rose to 46% in East Africa, 69% in West Africa and 74% in Central Africa.[37]

Data and research on informal transport in Latin America are limited in comparison to Asia and Africa. Most information has focused on larger cities such as Bogotá (Colombia) and Mexico City (Mexico), where the development of mass transit systems has incentivised the collection of information on informal transport services. Such efforts reveal the importance of informal transport modes as crucial connectors, providing "last-mile" services as well as essential services to reach parts of the city that formal transit does not, forming a hybrid ecosystem that supplies mobility for millions.[38]

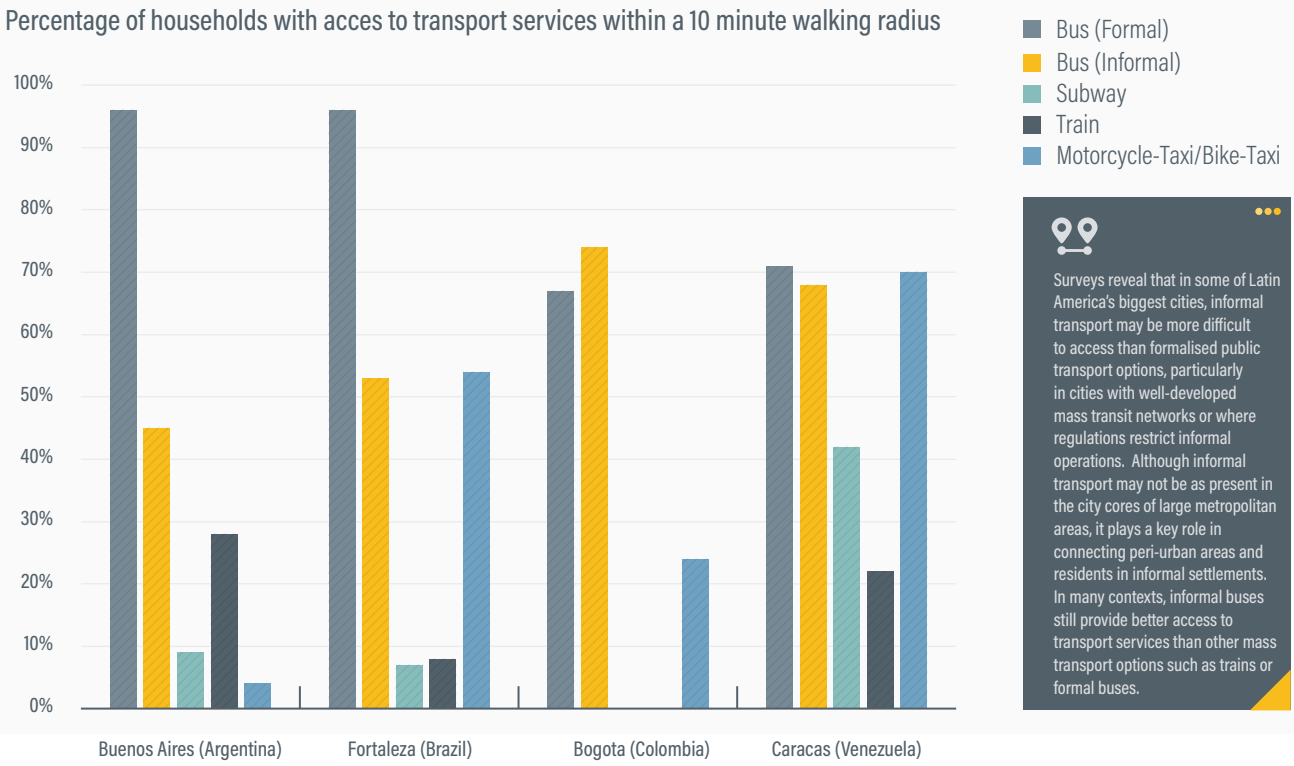
Surveys reveal that in some of Latin America's biggest cities, informal transport may be more difficult to access than formalised public transport options (Figure 3), **particularly in cities with well-developed mass transit networks or where regulations restrict informal operations.**[39] **Although informal transport may not be as present in the city cores of large metropolitan areas, it plays a key role in connecting peri-urban areas and residents in informal settlements.**[40] **In many contexts, informal buses still provide better access to transport services than other mass transport options such as trains or formal buses.**

- Nearly two-thirds (65%) of Mexico City's more than 21 million inhabitants were served by small buses (*peseros*) as of 2020.[41] In 2024, an estimated 1,000 human-powered tricycles (*bicitaxis*) were operating in the city and its periphery, with 256 units registered to the downtown area.[42]
- A 2019 study found that, when informal modes were included, "absolute access" using public transport (measured as the number of people who can be reached within 30 minutes as a proxy for opportunities) increased 54% in the Mexico City Metropolitan Area and 35% in Bogotá (Colombia) (Figure 4).[43]

A small but growing field of research has focused on informal transport in sub-regions such as Central America and the Caribbean, providing data on the roles of smaller vehicles and informal boat services in coastal secondary cities and rural areas.

- A 2024 study found that three-wheelers had become the third most used mode of transport (after cars and bicycles) in the rural area of Puerto Viejo (Costa Rica).[44]
- As of 2024, a reported 30-50 *lanchas* (boats), each with an estimated capacity of 8-12 passengers, were operating daily in Puerto Los Coquitos on the mainland of El Salvador, connecting populations along the Gulf of Fonseca.[45] In 2022, more than 400 *lancha* passengers arrived daily to Puerto Los Coquitos from nearby islands and from Honduras and Nicaragua.[46]

FIGURE 3. Share of households able to access transport modes within a 10-minute walk, in four Latin American cities, 2017



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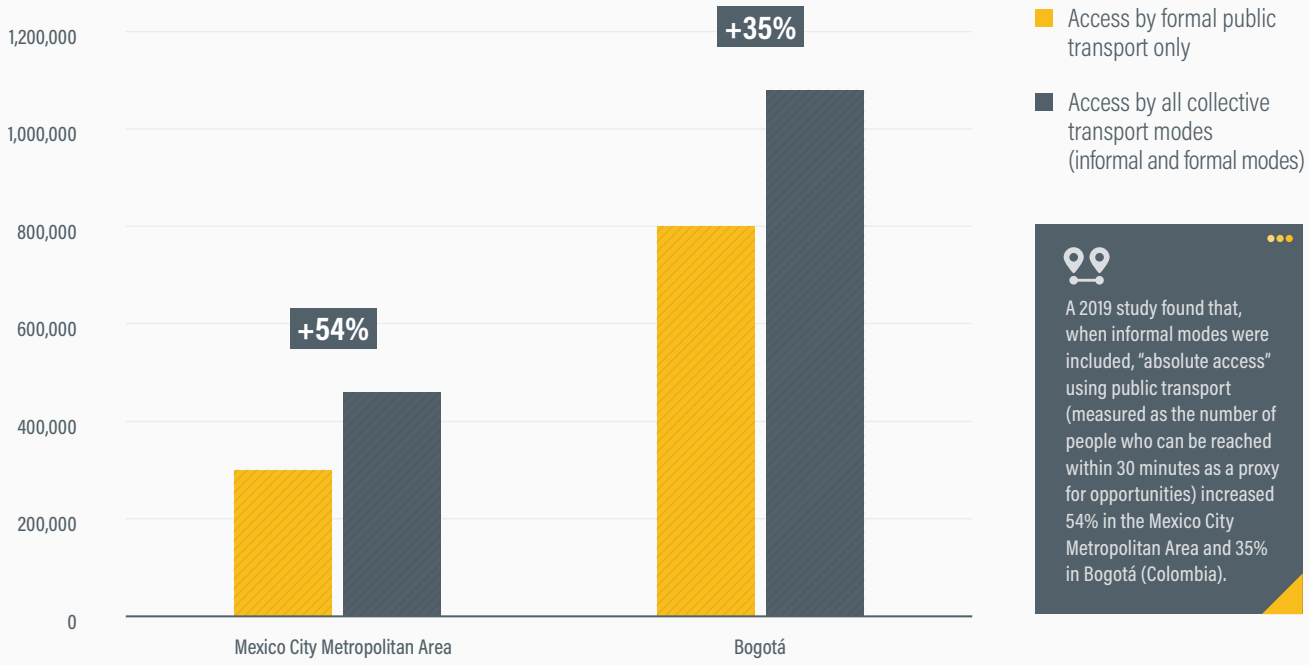
Source: See endnote 39 for this section.

FIGURE 4. Absolute access using public transport and informal modes in Mexico City and Bogotá, 2019



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Source: See endnote 43 for this section.

- **Although informal transport is usually explored in the context of the Global South, many high-income countries host small-scale, unregulated services. These services cater mainly to tourism but also operate in areas underserved by public transport, or disrupt the market by offering a cheaper transport option.**
- London (United Kingdom) had an estimated 200 to 900 (during peak season) pedicabs, or bicycle rickshaws, operating around the city in 2023, mainly serving tourists.[47] The city has had some voluntary codes of practice for pedicab drivers, and since March 2024 new regulations have given the transport authority oversight over pedicabs, considered the city's last form of unregulated transport.[48]
- In New York City (United States), dollar vans – often unregulated and unregistered – fill gaps and serve minority communities that may be neglected by subways and buses.[49] Private initiatives such as the start-up Dollaride offer operators technology integrations, electrification solutions and financing.[50]

Sustainability and climate trends

Informal transport is frequently valued as a catalyst for economic activity and local development, offering access factors such as door-to-door service, speed, cost and maneuverability in small or narrow streets found in the Global South. Research continues to focus on the role of informal transport in addressing inequality and poverty issues by granting access to employment, educational opportunities and health care to people in marginalised communities.[51] However, literature on motorcycle taxis suggests that their social contributions are contested by issues related to road safety, insufficient operator training, lack of proper understanding of road rules, road conditions and sparse use of safety equipment.[52]

The informal transport sector intersects with many dimensions of sustainability and has the potential to generate numerous social, economic, and environmental benefits, contributing to at least 7 of the 17 United Nations Sustainable Development Goals (SDGs) (Box 1).[53]

Box 1. How climate action on informal transport can contribute to the Sustainable Development Goals

The Global NDC Template for Popular Transport suggests that effective climate action in the informal transport sector would contribute to the following seven SDGs:

SDG 3 (Good Health and Well-being) – by reducing pollution, improving air quality, road safety and health in cities.

SDG 5 (Gender Equality) – by making services and working environments more inclusive and safer for women.

SDG 7 (Affordable and Clean Energy) – by promoting the use of renewable energy and energy-efficient vehicles.

SDG 8 (Decent Work and Economic Growth) – by improving working conditions and supporting the formalisation and strengthening of small and medium-sized enterprises.

SDG 10 (Reduced Inequalities) – by improving access to transport services, reducing transport inequalities and improving livelihoods.

SDG 11 (Sustainable Cities and Communities) – by improving transport accessibility and the quality of existing services.

SDG 13 (Climate Action) – by decarbonising the most used motorised transport service in the world and avoiding private car use.

Source: See endnote 53 for this section.

Road safety remains a key challenge facing informal transport, with the lack of regulation and oversight contributing to a high risk of injuries and fatalities among users. On average, 22.5% of road traffic deaths globally in 2016 involved riders or passengers of two- and three-wheelers.[54] Head and neck injuries remain the leading causes of death and severe disability among motorcycle riders and passengers.[55]

- Helmet use remains low in many regions, despite its benefits in reducing the risk of fatal head injuries by up to 42% and the risk of head injuries by 69%.[56]
- A 2020 survey across 48 countries found that up to 47% of drivers and 71% of passengers did not wear protective helmets while riding two-wheelers.[57]

Women are among the main users of informal transport but are the least represented in the sector's workforce, as they face challenges related to recruitment, retention and sexual harassment. In high-traffic areas, two-wheelers can reduce women's travel time by navigating congestion and busy roads in a more agile way.[58] A key concern for many women that work (or attempt to work) in the informal transport sector is sexual harassment from vehicle owners, other transport workers, and passengers, as female workers express feeling forced to "put up with it" to keep their jobs.[59]

- In Cali (Colombia) and Quito (Ecuador), low-income women often resort to informal transport services because public transport routes and schedules do not adequately meet their needs.[60]
- In Sub-Saharan Africa, two-wheelers enhance women's mobility, contributing to greater time availability for

education, economic activities and leisure – ultimately fostering economic development and community welfare.[61]

- In the minibus sector of Nairobi (Kenya), women make up only 7% of the workforce and face challenges related to recruitment, retention and promotion; 58% of female workers in the sector report being victims of sexual harassment every day.[62]
- Women are heavily underrepresented in the transport workforce in Uganda, where *boda boda* riders, a group with an estimated 1.1 million workers, are more than 99% male.[63]

Overall, there is an urgent need to improve working conditions in the informal transport sector. According to the International Transport Workers Federation's 2025 Labour Impact Assessments, several pressing concerns must be addressed to improve working conditions in the sector.[64] These include:

- identifying and implementing alternatives to the target system (where workers must reach a daily income target to pay off their vehicle rental before receiving their earnings);
- establishing efforts to end gender discrimination, violence against women, and sexual harassment, both for users and workers of the informal transport sector;
- providing vocational training for workers in the sector, not just driver training for new bus services such as bus rapid transit or electric vehicles;
- co-ordinating policy and regulation between police, security services and transport authorities, to handle extortion and police harassment of informal transport workers and operators;
- improving sanitation, shelter, drainage, rest and catering areas, and other facilities to improve working conditions;
- providing mechanisms and incentives to enable access to affordable capital for electrification and recapitalisation of vehicles; and

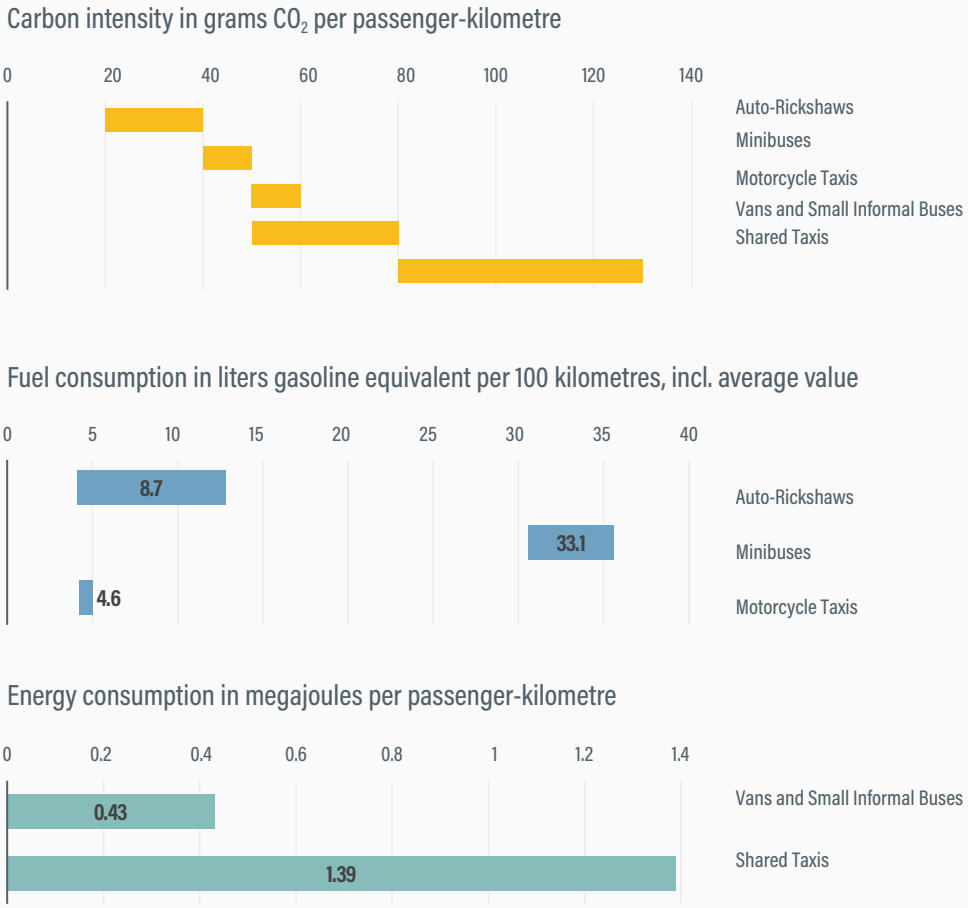
- developing state-supported social protection programmes or supporting workers' organisations to extend and improve provision of social protection services.

Smaller vehicles that make it possible to transport more passengers during a single trip – such as auto-rickshaws and minibuses – are considered the most energy-efficient and least carbon-intensive modes of informal transport (Figure 5).[65] **A study in Cape Town (South Africa) found that motorcycle and minibus taxi services are less energy intensive than petrol or hybrid-equivalent vehicles, which are more common than electric cars in cities in the Global South.**[66] However, data on greenhouse gas emissions from informal transport are limited, and few countries collect disaggregated data for the sector. Research, policy and investments in several areas are helping to decarbonise informal transport or at least better understand its decarbonisation potential.[67]

Studies in different cities around the world indicate that, on average, the contribution of informal transport to overall transport emissions is 20%, although it can reach 40% in some cities (Figure 6).[68] **This contribution depends on characteristics such as the types and ages of vehicles, which can affect a vehicle's operational efficiency.**

- In Ambato (Ecuador) and Dakar (Senegal), informal transport accounts for a similar share (34%) of total transport trips; however, the sector contributed only 10% of total transport emissions in Ambato (in 2022) but 28% in Dakar (in 2025).[69]
- In Ambato, informal transport consists mainly of minibuses and buses, with a total fleet size of 4,237 units and combined annual tank-to-wheel greenhouse gas emissions of 60.2 kilotonnes in 2022.[70]

FIGURE 5. Typical carbon dioxide emission factors and energy efficiency for different informal transport modes



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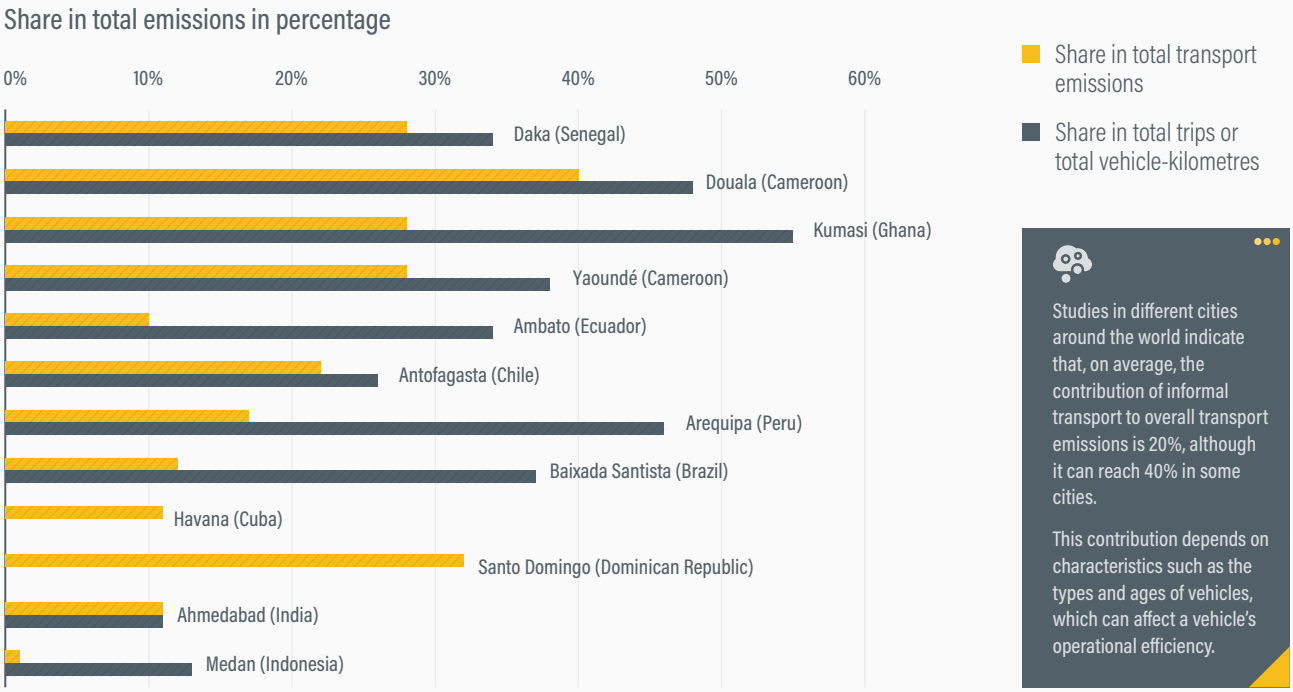
Source: See endnote 65 for this section.

FIGURE 6. Informal transport's share of emissions in selected cities globally



Source: See endnote 68 for this section.

- In Dakar, *clandos* (clandestine or unregistered taxis) – generally older vehicles that can carry 4-6 passengers – are prominent, but they have among the highest emissions per vehicle per passenger.[71]
- In 2025, Dakar's *clandos* emitted 5.31 tonnes of CO_2 per vehicle per passenger, compared with 4.62 tonnes for *cars rapides* (minibuses) and 2.88 tonnes for *ndiaga ndiaye* (minibuses).[72]

Many of the vehicles used in informal transport are older, second-hand vehicles imported from other countries, raising significant safety, environmental and public health concerns. As of 2019, more than 80% of Africa's road vehicles failed to meet Euro 4 emission standards and often lacked valid roadworthiness.[73] Older vehicles emit far more pollutants than newer models, especially when poorly maintained or fitted with low-quality components. In some cases, exporters remove exhaust after-treatment systems to bypass emission controls or salvage valuable parts, further increasing emissions. In Kampala (Uganda), road transport contributed 60% of nitrogen dioxide and up to 24% of particulate matter ($PM_{2.5}$) in 2021.[74] Inspections of vehicles bound for Africa have also revealed severe safety risks, including prior accident damage, faulty brakes, non-operational lights, missing airbags and heavily worn tyres. (See Spotlight on Second-hand Vehicles.)

In many African cities, where second-hand motorcycles dominate the informal transport fleet, emissions depend on the vehicle age and mileage, and drivers and users are among the most vulnerable to road crashes and injuries. In Kampala (Uganda) and Nairobi (Kenya), initiatives such as Lubyanza collect quarterly data on *boda bodas* that includes topics such as vehicle characteristics, road worthiness compliance, helmet use, reflective jacket use, and worker profiles and needs (Figure 7)**.[75] Such insights can inform sustainability and climate action projects and help address challenges such as improving working conditions and compliance with road safety requirements.[76]**

The electrification of informal transport has contributed to climate action, air quality and noise pollution goals while also improving services for users. Electric two- and three-wheelers accounted for around 60% of the avoided oil demand in the global road transport sector in 2023, driven by their rapid adoption and expansion in regions such as China, India and South-East Asia.[77] However, many countries continue to face grid reliability issues that affect vehicle charging, and electricity is often sourced from highly polluting bagasse, coal and petroleum.[78]

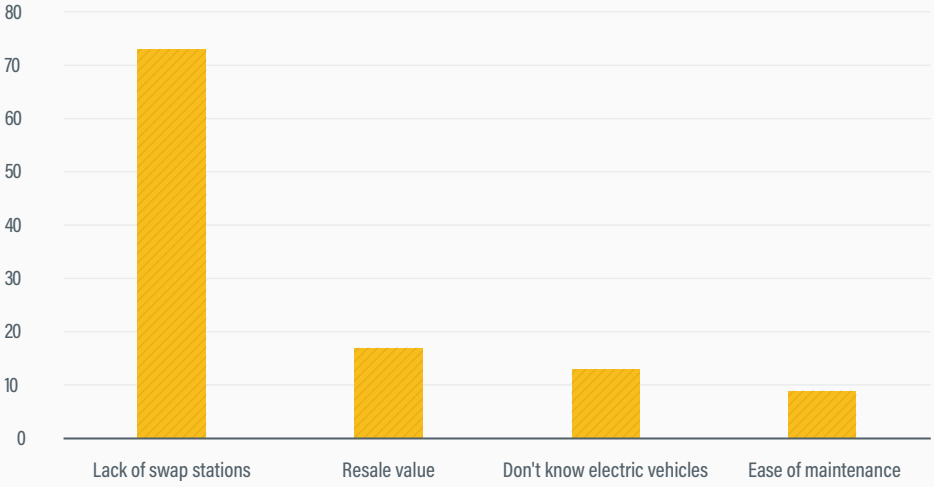
FIGURE 7. Insights on boda boda operations collected by Lubyanza Research Group during 2024

4% share their bike at least once a week

72% have never had a drivers license

40% of riders wearing reflector jackets

58% of bikes on the road are second-hand



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Source: See endnote 75 for this section.

Since it was launched in 2022, the BasiGo project in East Africa has expanded its electric bus fleet to 100 units in Kenya and Rwanda, avoiding an estimated 250 tonnes of CO_2 emissions each month.[79]

- Research found that, if electrified, only around 15% of Kenya's *matatus* (informal buses) would be able to complete their routes on a single charge; these vehicles, which cover an average of 150 kilometres per day, would require roughly five charging events daily.[80]

Although informal transport could be a potential low-carbon solution with high passenger capacity, these services have widespread inefficiencies and face challenges related to quality, security and reliability.[81] Efforts to improve the integration, safety and efficiency of informal transport vehicles (even those fuelled by petrol) are essential to ensure truly inclusive and sustainable transport solutions and to prevent users from transitioning to more carbon-intensive private vehicle travel, which can result in increased emissions, pollution, congestion and energy consumption.[82]

Policy and investment developments

Recent policy developments in informal transport have focused on electrification, fleet modernisation, regulation and integrating the sector into data collection efforts and sustainable transport planning. Some governments have introduced digital registration and verification for drivers of informal transport vehicles; however, broader integration efforts are still evolving. For example, regulation has emerged in different African cities.

- In 2024, the Philippines introduced digital registration and verification for informal transport drivers in its Bill 10424 (Motorcycles-for-Hire Act).[83]
- South Africa's National Land Transport Act, amended in 2023, requires the registration of taxi associations and outlines conditions for issuing fixed-route operating licences, while only recently permitting the electronic hailing of public transport.[84]

As fleet electrification continues to expand, the push to electrify informal transport vehicles must be accompanied by strong planning and policy measures to ensure that systems are inclusive, sustainable and safe. Key challenges to electrification include data availability, access to affordable and appropriately scaled financing, the need for viable business models, and regulatory co-ordination, limiting the sector's potential contributions to equitable and low-carbon urban transport solutions.

- Chulalongkorn University in Bangkok (Thailand) has developed research on the challenges and needs for electrifying motorcycle taxis based on differences in ownership and business models.[85]
- In Rwanda, to tackle rising electricity demand due to electrification, WRI China has explored ways that Chinese companies and other foreign investors can partner with battery swap station operators and moto drivers to create and expand access to solar-powered swap stations.[86]
- Kenya's BasiGo project has successfully implemented pay-as-you-go leasing models to support the financing and electrification of *matatus*, and it continues to expand to other African countries.[87]

Despite the high prevalence of informal transport in the Global South, countries have only recently started to incorporate the sector into their Nationally Determined Contributions (NDCs) towards reducing emissions under the Paris Agreement. As of 2025, only Angola, Uganda and Somalia mentioned or included goals associated with informal transport in their NDCs.[88]

- In its 2022 NDC, Angola recognises the contribution of *candongueiros* (minibus taxis) to local emissions but does not suggest actions to address this.[89]
- In its third-generation NDC, Somalia includes a goal to promote electric and energy-efficient vehicles, specifically *tuk-tuks*.[90]
- Uganda, in its 2022 NDC, proposes the electrification of *boda bodas* as an emission mitigation measure.[91]

Overall, informal transport is increasingly recognised as an essential service that is meeting people's mobility demands and improving access to transport services. There is also growing understanding that, with adequate support, the sector can address other environmental and social concerns. For example, the sector has been considered in discussions around the UN Decade of Sustainable Transport and in efforts to increase the attention to informal transport goals in the third generation of NDCs.

Vehicle scrappage and modernisation schemes have been implemented in various countries to replace ageing informal transport vehicles. Experiences in Africa, particularly in Dakar (Senegal), in the 2000s have generated insights and models for countries elsewhere to replicate.[92]

- Santo Domingo (Dominican Republic) has scrapped *concho* taxis and minibuses, substituting them with newer vehicles, in an effort to reform and modernise its vehicle fleet.[93]
- Mexico City (Mexico) has committed to scrap around 6,000 units between 2020 and 2023.[94] These efforts have been part of a larger reform to professionalise and modernise the city's informal transport sector.
- In 2023, Mexico City's transport agency SEMOVI launched the second iteration of its bus scrappage programme for vehicles older than 10 years operating in the Xochimilco corridor. The programme envisions replacing 236 ageing *combis* (minibuses), covering 16 million kilometres per year, with 142 higher-capacity diesel buses covering 7.8 million kilometres per year, with the aim of reducing CO_2 emissions by 2,898 tonnes (around 31%) annually.[95]
- As of mid-2024, Mexico City had replaced 97 diesel microbuses in the Aztecas transport corridor with 28 electric trolleybuses, resulting in an estimated 74% reduction in CO_2 emissions.[96]
- By 2025, South Africa's Taxi Recapitalization programme – responsible for scrapping ageing and unroadworthy minibus taxis – had met 63% of its goal, with 135,894 vehicles scrapped.[97] Although the scrapping component ended in 2018, the programme continues to introduce modern vehicles with added safety features such as seatbelts, speed governors and driver-operated doors.[98]

In addition to government action, a diversity of other stakeholders – including public-private partnerships and non-governmental organisations – have undertaken data collection and policy initiatives to improve and modernise informal transport services (Table 1).

TABLE 1. Examples of data collection and policy initiatives contributing to cleaner, more sustainable and just informal transport services

Area	Measures / Strategies	Examples
Data and information	• Collect and organise comprehensive transport policy, data and documentation. • Identify key data needed to measure or estimate the status of the informal transport sector. • Build a database with digitised and catalogued indicators of sustainable passenger transport. • Map indicators of inclusive and sustainable passenger transport options.	• In March 2021, the Asian Development Bank launched the **Asian Transport Observatory (ATO)** as an open data resource to strengthen transport knowledge in the region. The ATO has collected and analysed data, policy information, and documentation, including on informal transport modes, for different countries in the region.[99] • The Massachusetts Institute of Technology (MIT), through its **Atlas of Popular Transport**, has gathered and corrected data on informal transport for 16 cities around the world.[100] • MobiliseYourCity has supported nine cities, with more in process, in developing **Sustainable Urban Mobility Plans** that collect data and integrate informal transport into a city's wider mobility planning.[101]
Regulatory recognition and integration	• Recognise the function and value of informal transport systems. • Introduce regulations for informal transport modes based on safety and quality of service standards. • Establish registration processes for informal transport drivers. • Define authorities responsible for regulating the sector. • Establish regulatory oversight for fares, surcharges and other fees. • Introduce liability for digital platforms and operators for any deaths, injuries or damage.	• In July 2024, the Philippine legislature approved **House Bill 10424**, which introduced regulations for motorcycles-for-hire, mandated vehicle registration and speed limits, and limited the number and operations of motorcycles.[102] • The **City of Douala (Cameroon)** began digital registration of moto-taxi drivers in July 2024, creating a database of verified drivers with the aim of enhancing order.[103] • In **Mexico City**, after negotiations with bike taxi associations, a new vehicle standard was approved; all associations that comply with the standard receive licences and recognition under the city's integrated transport system.[104]
Business development	• Respond to feedback and concerns of different rider demographics. • Empower drivers to make decisions on pricing and fares. • Align union interests with operators. • Empower drivers and reduce prices by limiting commissions. • Monitor rider demand for modes and services. • Build out informal transport networks based on ridership demands. • Build operators' capacities to become formal businesses that can be recognised or hired by governments.	• In Bengaluru (India), to address the concerns of female riders (in many locations its main users), Uber introduced **UberMoto Women: Women-only rides**, an on-demand two-wheeler ride service with female-only drivers.[105] • Uber shifted its **business model for auto-rickshaws in India** from a per-trip commission to a daily fee, and drivers were empowered to set their own driving rates per ride, as opposed to previously pre-set fares.[106] • **Mexico City** has introduced training for minibus operators to become transport companies and to be able to access funding for new vehicle fleets. • The **Namma Yatri app**, launched in 2022 by India's rickshaw drivers' union, directly connects riders to drivers and removes commissions by avoiding digital intermediaries.[107]
Fleet improvement and electrification	• Lay out goals for manufacturing and adoption of electric informal modes. • Diversify manufacturing across various modes. • Prioritise affordability and access.	• **India's FAME II policy** aims to provide backing for 500,000 electric three-wheelers. Under this policy, the RAAHI Project (2022) in Amritsar works to transition the city's three-wheeler informal transport system to electric vehicles.[108] • In **Mexico City**, minibus operators received bonuses to transition their vehicles to electric models, and some have begun operating new less-polluting buses that have cameras, GPS and integrated payment.[109]
Operations	• Offer safe driver training and improve labour conditions. • Consolidate driver recruitment and management. • Formalise existing rural informal transport and provide training to drivers. • Provide open public transport data. • Support mapping and digitalisation of transport routes and improved data on operations. • Bridge multiple data sources within a single app.	• The municipal government of **Peten (Guatemala)** trained 39 drivers and operators of *tuk-tuk* services in Paxcamán, San Miguel and the central area of Santa Elena.[110] • General Santos City (Philippines) modernised its public transit using the **SafeTravelPH app**, aimed at engaging the government, transport industry providers and passengers in information sharing.[111] • The **Namma Yatri app**, which offers direct-to-driver ride-hailing In Indian cities such as Bengaluru, Chennai, and Delhi, provides open data access to live and historical data points such as ride totals and driver earnings.[112]

Despite these advancements, significant gaps remain in formal recognition, integration and support for informal transport providers. To accelerate and support policy development in the field, international organisations have launched guiding documents and resources that provide recommendations and insights for policy makers to follow and integrate into their work (Table 2)**.**[113]

TABLE 2. Guiding documents and resources to accelerate progress towards development, climate, safety and equity goals in the informal transport sector

Area	Document	Description
Informal transport and the climate and sustainability agendas	Connecting Informal Transport to the Climate Agenda (World Resources Institute – WRI; Volvo Research and Educational Foundations – VREF)	Offers recommendations and case studies on how to quantify emissions from informal transport, improve services to reduce or prevent private vehicle trips, and electrify minibuses and two- and three-wheelers.
	Missing Mobilities: The Popular Transport Gap in Climate Adaptation (WRI; PRISM)	Analyses existing knowledge and research on informal transport and climate adaptation, noting that the sector remains a missing element in climate resilience, adaptation, and action plans, generating a barrier to enhancing the transport sector's climate resilience in a holistic and equitable way. Provides recommendations and insights on how to improve resilience and adaptation planning through the inclusion of informal transport.
	Popular Transport of Goods in Africa (Global Network for Popular Transportation – GNPT)	Represents a first step towards recognising the role of small and medium-sized operators not just in transporting passengers, but also in distributing goods in Africa. Offers recommendations on how to improve infrastructure, data, and livelihoods, and to reduce emissions in the informal transport sector.
	Global NDC Template for Popular Transport (GNPT; Transport for Cairo; with support from the Transformative Urban Mobility Initiative – TUMI)	Provides guidance and recommendations for including informal transport in NDCs. Insights from the NDC template are also included in the International Transport Forum's (ITF) *Guide to Integrating Transport into Nationally Determined Contributions*.
	Life-Cycle Assessment of Passenger Transport: An Indian Case Study (ITF)	Demonstrates the use of life-cycle assessment for a holistic evaluation of electrification policy and the nuances of infrastructure in India, showing how electrification of three-wheelers would lead to lower emissions even in high-carbon electricity grid cases like India. Given the prevalence of high-carbon grids in the Global South, this framework could be used to present more robust emission estimations by considering upstream energy and emission impacts.
	2&3W Explainers on: Economics; Equity & Inclusion; Road Safety; Electrification (GNPT; Uber)	A series that explores the role of two- and three-wheelers in the mobility of Global South cities, providing policy recommendations on topics such as personal and road safety, economics, electrification, and equity and inclusion.

Understanding and integrated planning of informal transport	Paratransit Toolkit (MobiliseYourCity)	Includes guidelines, tools, training materials and case studies on how to better understand, assess, contract and decarbonise the informal transport sector.
	Description, Roles, and Functions of Paratransit A Business Model Toolkit for the Paratransit Sector The Value of Data for the Paratransit Sector (International Association of Public Transport – UITP)	A series of policy briefs that covers various aspects of informal transport, providing examples and case studies from different cities, descriptions of business models, and discussion on the importance of data collection in the sector.
	Incorporating Informal Transport in Mobility Planning (ITF)	Provides recommendations for including the sector in mobility planning processes, engaging with service providers, investing in institutional capacity building, and identifying comprehensive measures, beyond regulation, to address informal transport's negative externalities.
	A Tactical Planning Framework to Integrate Paratransit with Formal Public Transport Systems (Indian Institute of Technology)	Presents an integration strategy using a two-step optimisation process that co-ordinates network assignment and service frequencies. Applied to Visakhapatnam, India, the framework shows that joint planning and frequency optimisation of both modes can reduce total travel time and emissions 50-60% compared to conventional, separate planning approaches.
	Informal Transport Transformation Toolkit (MobiliseYourCity)	An outcome of the 2nd Africa Sustainable Urban Mobility Course in 2020, the toolkit was developed as a strategic long-term reform approach, with expert reviews and recommendations for its adoption.
Informal transport labour market and capacity building	Labour Impact Assessments as Tools to Improve Workers' Conditions (ITF; VREF)	Includes recommendations on: participatory research methods; defining what an informal transport worker is; building partnerships with local academic institutions; how to carry out dialogue and negotiation between trade unions and transport authorities; and building participation by trade unions and workers' associations representing informal transport workers.
	Building Capacity on Informal Public Transport in African Cities: Government Officials' Experiences (VREF; CODATU)	Shares how capacity building initiatives can help government officials and institutions more effectively address informal public transport challenges. Drawing on interviews with 10 officials, the study highlights gaps and opportunities in capacity building, including the need for training, better data procedures, and cross-sector collaboration to improve policy making in informal transport.

Source: See endnote 113 for this section.

Partnerships in action

- The **United Nations Environment Programme** has supported the electrification of two- and three-wheelers in nine African countries (Burundi, Ethiopia, Kenya, Madagascar, Rwanda, Sierra Leone, Tanzania, Togo and Uganda), with programmes for other modes of informal transport in more countries.[114]
- **SolutionsPlus** has co-developed innovative and integrated electric mobility solutions for urban passengers – including for informal transport vehicles – in Dar es Salaam (Tanzania), Kathmandu and Lalitpur (Nepal) and Pasig (Philippines).[115] The project seeks to diversify the sector's workforce to make it more inclusive and resilient.
- A collaborative team – involving ACDC Dynamics, GoMetro, HSW, MiX by Powerfleet and Stellenbosch University – launched **South Africa's first electric minibus taxi pilot project** in 2022 to accelerate the adoption of sustainable transport amid rising fuel costs and environmental concerns.[116] The project is testing various electric minibus models under local conditions and engaging taxi operators and policy makers to identify practical uses and infrastructure needs. By providing critical data and promoting regulatory discussions, the initiative aims to facilitate a broader transition to green mobility solutions in the minibus taxi industry.
- The **Partnership for Research in Informal and Shared Mobility,** initiated and funded by VREF, is collecting data and insights on informal and shared mobility around the world, documenting it, and taking it to international policy spaces to support data and science-based decision making on sustainable transport. The project – led by Columbia University in partnership with WRI and GNPT – has living labs in eight cities: Accra (Ghana), Bangkok (Thailand), Beijing (China), Bogotá (Colombia), Cape Town (South Africa), Kumasi (Ghana), Mumbai (India) and San José (Costa Rica).[117]
- **Paratransit/Popular Transport Day** is a one-day event dedicated to exchanging the latest knowledge, research and practice emerging from the informal transport sector.[118] The event is co-organised by the Africa Transport Policy Program (SSATP), the Center for Sustainable Urban Development, Climate Champions, Digital Transport for Africa, the International Transport Workers' Federation (ITF), PRISM, the Shared-Use Mobility Center (SUMC), Transport for Cairo, VREF, the World Bank and WRI's Ross Center for Sustainable Cities.[119]
- The **Leapfrogging Partnership**, part of the global Drive Electric Campaign, aims to accelerate the transition to electric vehicles in emerging economies, including vehicles used in informal transport.[120]
- The event **Emergent + Empowered: Mobilizing Global Popular Transportation Networks for Equity, Health, and Climate**, held in the Rockefeller Foundation's Bellagio Leadership Center in 2024, aimed to develop a common vision for the informal transport sector and commitments for implementation and engagement with other stakeholders to achieve the shared vision. It gathered 20 attendees – including transport workers and labor organisers, representatives from multilateral development banks, climate funders, global transport and climate organisations, and research institutions – to develop four Strategic Pathways to empower and transform informal transport, including: Climate Action, Sustainability, and Just Transition; Finance and Investment; Policy and Advocacy; and Research, Data, and Evidence. The event was co-ordinated by GNPT, SUMC, the Center for Sustainable Urban Development (Columbia Climate School), PRISM and VREF.

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Rail

KEY FINDINGS

Demand, use and access

- Global passenger rail demand showed signs of recovery following the disruption caused by the COVID-19 pandemic in 2020 and 2021. Demand reached an estimated 2,470 billion passenger-kilometres in 2022, up 15.8% from the total of 2,132 billion passenger-kilometres in 2021 but still well below the peak of around 4,120 billion passenger-kilometres in 2019. In 2022, rail accounted for around 11.6% of global passenger transport (in passenger-kilometres).

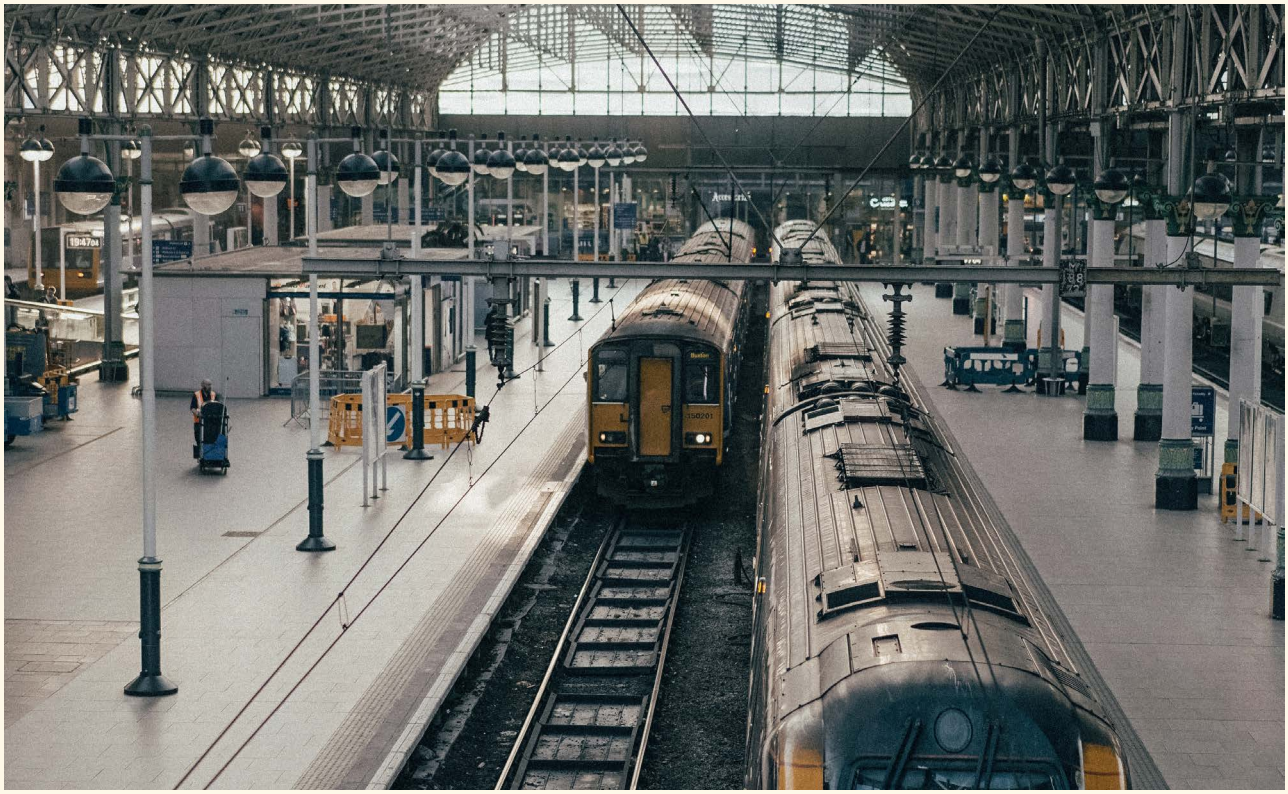
- Trends in passenger rail have been uneven across regions. In 2022, passenger rail activity experienced the slowest growth in Africa (7.6%) and in the Asia-Pacific region and Oceania (8.7%). Europe's passenger rail traffic grew more than 50% in 2022, nearing 2019 levels.

- Unlike passenger rail, the rail freight sector has proven largely resistant to global shocks, with rail freight activity rising 2.9% in 2022 to reach 11,892 billion tonne-kilometres. This growth was driven mainly by increases in the Asia-Pacific region (particularly in China, India, Kazakhstan and Australia), which together with Oceania accounted for 45% of all rail freight activity in 2022, followed by North and South America (27%). In 2025, rail represented 11% of global freight activity.

- High-speed rail infrastructure rose 14% between 2020 and 2023 to reach a total length of 64,698 kilometres globally. This expansion occurred particularly in middle-income countries, such as China and Türkiye. China's high-speed rail length far outstrips all other countries, with 45,390 kilometres in operation in 2023.

- As of 2023, more than 16,000 kilometres of high-speed rail was under construction globally, including major projects in Asia, the Middle East and North Africa, and North America.

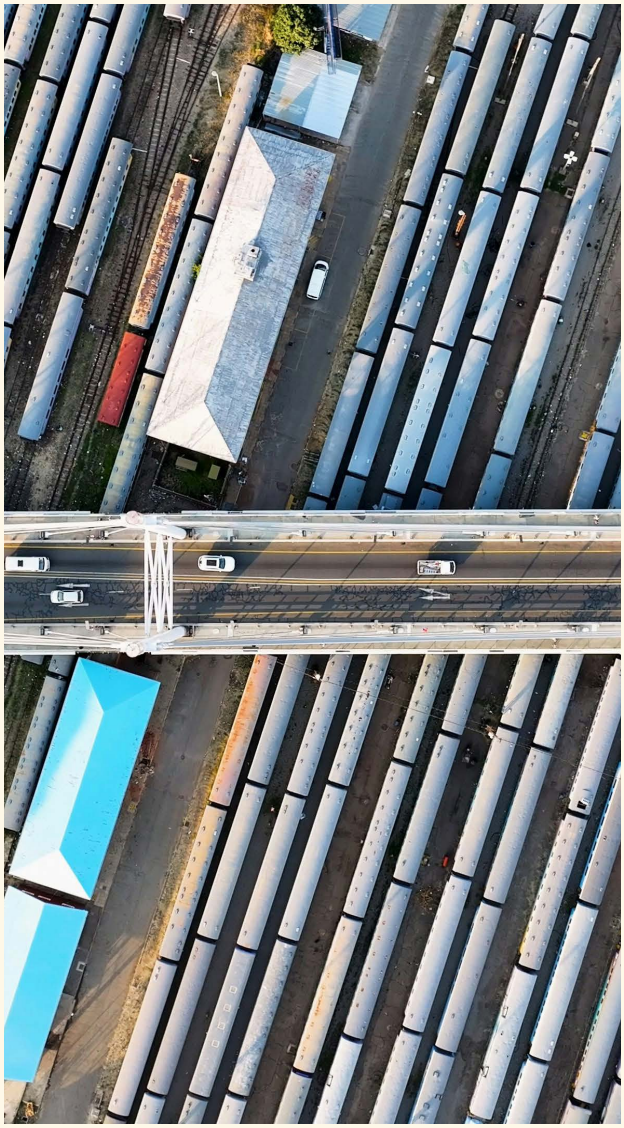
- Global high-speed rail activity totalled 678 billion passenger-kilometres in 2022, still well below the all-time high of 1,054 billion passenger-kilometres in 2019. Despite the continued growth in infrastructure, high-speed rail activity remained at 2015/16 levels as of 2022, as the COVID-19 pandemic had triggered a nearly 40% decline (in 2020).



KEY FINDINGS

Sustainability and climate trends

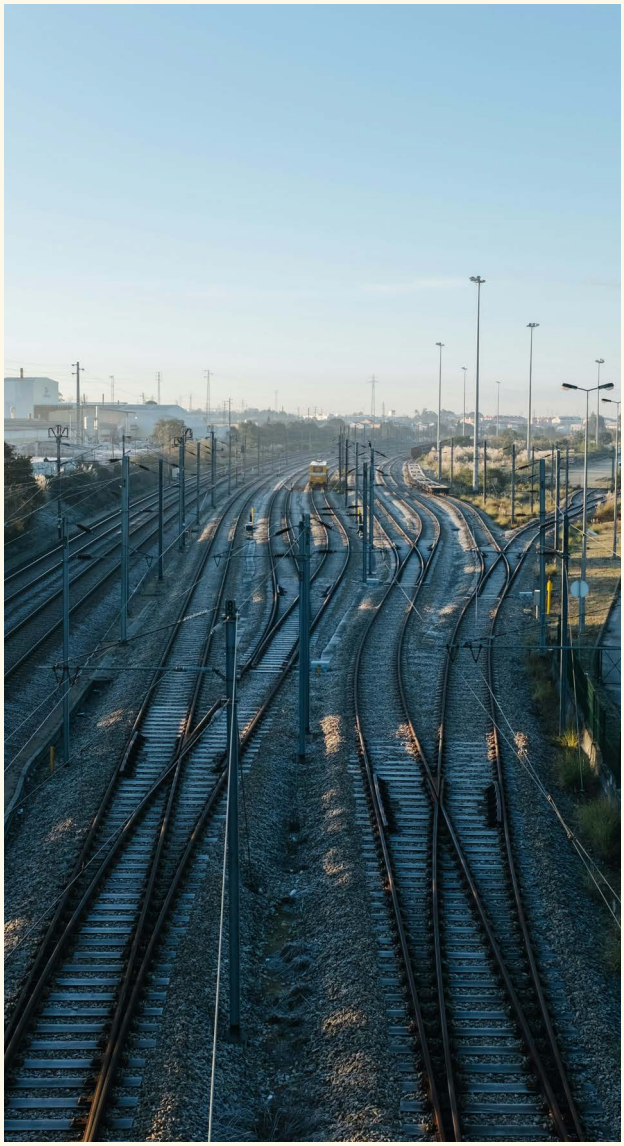
- Rail transport delivers significant socio-economic dividends, which are often overlooked in terms of the economic value that they generate. Rail's contribution to the national GDP ranges from 0.5% in the European Union in 2012, 0.7% in the United States in 2023, 0.8% in Australia in 2016 (even up to 1.6% in direct and indirect contributions) and 1.5% in India (even 3 to 4% through direct and indirect contributions).
- Rail can enhance social equity by providing accessible, affordable and sustainable mobility options – and therefore access to essential services, employment, and education, particularly for marginalised groups. Women are more likely than men to rely on public transport (especially rail and buses) due to differences in travel patterns and access to private vehicles. Rail transport contributes to improved air quality and reduced congestion, supporting better public health outcomes.
- Although rail transport can play a role in promoting gender equity in the transport workforce, women have remained under-represented in the rail workforce and in the wider transport sector.
- Rail transport remains the most energy-efficient mode of freight transport and collective passenger travel, thanks to its high energy efficiency and low greenhouse gas emissions per passenger- and tonne-kilometres.
- In 2023, rail passenger and freight transport accounted for 1.2% of global transport greenhouse gas emissions. Models estimate that freight contributed the major share (around 79%) of rail's greenhouse gas emissions in 2023.
- Passenger rail transport emitted 22.35 grams of CO_2 equivalent per passenger-kilometre (well-to-wheel) in 2023, reinforcing rail's role as the least carbon-intensive mode of motorised land transport.
- The carbon intensity of rail has continued to improve, declining 55.9% for passenger rail and 58.7% for freight rail between 2005 and 2023 (location-based). These gains place the sector ahead of its decarbonisation pathway for 2030, as rail operators reduce emissions through electrification, fuel switching and efficiency improvements.
- As of 2022, around one-third of all railways worldwide had been electrified, mainly in India, Japan and China. In 2023, 45% of global rail energy use came from electricity, with Europe nearing 60%.
- Rail consumed 2% of the total energy in the transport sector in 2022. It had the highest share of renewable energy use among motorised transport modes in 2022, at 16.1%, with rising integration of solar, wind and hydrogen systems into railway operations.
- Rail infrastructure is increasingly exposed to climate risks such as heatwaves, floods, storms and coastal erosion. Although vulnerabilities vary by region, the scale of the impacts has become more evident.



KEY FINDINGS

Policy and investment developments

- Governments have increasingly recognised rail's potential in decarbonisation strategies and national economic recovery plans. During 2023 and 2024, countries launched various plans to revive national economies through the upgrading and development of rail lines.
- Several African and Asian countries have implemented groundbreaking developments on rail since 2023 with the aim of connecting people and goods.
- Rail-related policy efforts have sought to promote inclusive and accessible services, improved customer experience, gender-responsive infrastructure, inclusive recruitment and safe working environments.
- As of 1 August 2025, only 8 (27%) of the 29 third-generation Nationally Determined Contributions (NDCs) submitted to the United Nations Framework Convention on Climate Change mentioned rail transport (Botswana, Brazil, Canada, Moldova, Nepal, the United Kingdom, the United States and Uruguay); only 3 NDCs (Botswana, Moldova and Nepal) had specific targets focused on rail transport.
- In 2022, rail represented about 26% of the total global investment in transport infrastructure from G20 countries.
- The share of public spending for road infrastructure remains much higher than for rail in most regions, risking the under-utilisation of rail's potential for climate mitigation.
- Significant investment and priority spending are needed in rail infrastructure for climate adaptation in the coming decades.
- Digitalisation and standardisation have emerged as critical enablers for emission reduction in the rail sector. Advanced train control, eco-driving systems and harmonised signalling help reduce energy consumption, increase network capacity and lower operating costs. Supported by real-time data and advisory systems, these techniques have delivered energy savings of 7-25% on various rail services across Europe and Asia, contributing to the sector's ongoing efforts to reduce operational emissions.
- To further progress in the rail sector, policies and regulations should incorporate an Avoid-Shift-Improve[i] prioritisation framework, with a focus on modal shift measures, an area where significant untapped potential remains.



i The Avoid-Shift-Improve framework has been central to sustainable, low carbon transport for more than a decade. It follows an implicit hierarchy, with appropriate and context-sensitive "Avoid" measures (which avoid and reduce the need for motorised travel) intended to be implemented first, followed by "Shift" measures (which shift to more sustainable modes) and finally by "Improve" measures (which improve transport modes). See https://slocat.net/asi and H. Dalkmann and C. Brannigan (2007), Transport and Climate Change, Module 5e: Sustainable Transport – A Sourcebook for Policy-Makers in Developing Cities, GIZ GmbH, https://changing-transport.org/wp-content/uploads/2007_dalkmann_brannigan_transportandclimatechange.pdf.

Context, challenges and opportunities

Rail transport is an important contributor to economic development, enabling the efficient movement of goods and people over long distances at scale. Rail facilitates domestic and international trade, reduces travel and freight costs, and improves access to markets for both rural and urban communities. By enhancing supply chain reliability and lowering logistics costs, rail systems increase business competitiveness and support regional economic integration.

Rail investments tend to have strong multiplier effects, especially in low- and middle-income countries where improved connectivity can unlock economic potential in underserved regions.[1] The passenger rail transport sector was strongly impacted by the COVID-19 pandemic in 2020 and 2021. As of 2022, rail passenger demand was still well below pre-COVID-19 levels.[2] Rail freight transport proved to be more resistant and increased between 2019 and 2022, particularly in Asia-Pacific.[3]

As greenhouse gas emissions continue to rise, rail offers a compelling solution for decarbonising the transport sector. Rail has one of the lowest carbon intensities among motorised inland transport modes and is well suited for medium- and long-distance passenger and freight movement.[4] In 2022, the global average well-to-wheel greenhouse gas intensity of rail was 22.3 grams of carbon dioxide (CO_2) equivalent per passenger.[5] As rail's overall emission performance continues to improve, the CO_2 intensity of rail freight fell 50.6% (market-based) and 58.7% (location-based) between 2005 and 2023, putting the sector well ahead of the expected trajectory for achieving net zero emissions by 2050.[6]

Electrification and energy efficiency remain the backbone of the strategy to decarbonise rail transport. The fastest growth in rail electrification has occurred in the Asia-Pacific region, with Indian Railways reaching more than 98% electrification on the broad gauge network in 2025.[7] Renewable electricity and alternative energy sources play a growing role in the rail sector's transition. With more than 16% of rail's energy sourced from renewables as of 2022 – the highest share among transport modes – the sector is increasingly integrating grid-supplied solar, wind and hydropower into its operations.[8] Hydrogen remains at a pilot scale on selected routes.

Investment in rail infrastructure has grown in several regions but remains a shrinking share of the total infrastructure spending for inland transport, particularly when compared to road transport. A key challenge to rail investment in low-income and lower-middle-income countries is securing sufficient and affordable financing. With limited tax revenues and high debt burdens, these countries are rarely able to fully self-finance rail projects, and private investment alone is often insufficient. International financial institutions and export credit agencies are crucial sources of development funding, yet most of their support has historically favoured road infrastructure.[9]

Despite challenges, rail remains a robust and weather-resilient transport mode, provided there is adequate investment in maintenance and that climate adaptation measures are in place.

Realising the full emission mitigation potential of rail transport requires integrated policy frameworks, targeted investment, and supportive behavioural and economic incentives to deliver a significant modal shift to rail. Rail companies continue to invest in strategies focused on improving energy efficiency, electrifying operations, integrating renewable and alternative energy sources, and deploying digital technologies.

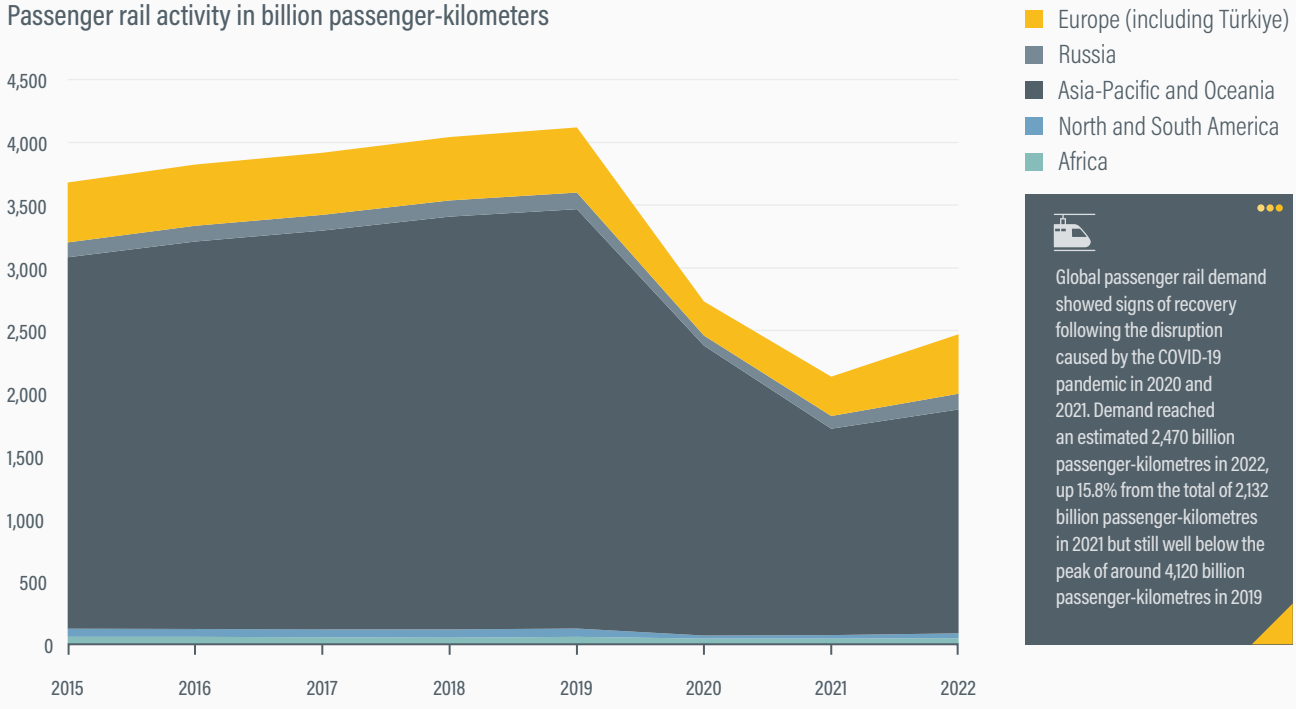
Demand, use and access

Global passenger rail demand showed signs of recovery following the disruption caused by the COVID-19 pandemic in 2020 and 2021. Demand reached an estimated 2,470 billion passenger-kilometres in 2022, up 15.8% from the total of 2,132 billion passenger-kilometres in 2021 but still well below the peak of around 4,120 billion passenger-kilometres in 2019 (Figure 1).[10] **In 2022, rail accounted for around 11.6% of global passenger transport (in passenger-kilometres).**[11] Estimates suggest that overall passenger transport activity – especially by road – recovered more quickly than rail transport from pandemic-related lows in 2020 and may have captured some of the demand from the rail sector.[12]

Trends in passenger rail have been uneven across regions. In 2022, passenger rail activity experienced the slowest growth in Africa (7.6%) and in the Asia-Pacific region and Oceania (8.7%).[13] **Europe's passenger rail traffic grew more than 50% in 2022, nearing 2019 levels.**[14]

- Brazil's subway, urban train, light rail and "people mover" systems carried 2.48 billion passengers in 2022, up 6% from the previous year.[15] Operating with 97.6% regularity and 98.6% reliability, these mostly electric urban rail systems provide clean transport and support sustainable city development, delivering an estimated USD 5.2 (BRL 32 billion) in social, economic and quality-of-life benefits.[16]
- Germany's rail passenger transport volume fell to 57.5 billion passenger-kilometres in 2021 but rebounded sharply in 2022 and 2023 to reach 101.4 billion passenger-kilometres (a 76.3% increase).[17]
- People in Japan undertake more rail travel than in any other country.[18] As of early 2024, passenger numbers were around 90% of pre-pandemic levels, with international tourism rebounding only gradually and domestic commuter traffic shifting in response to remote work trends.[19]

FIGURE 1. Passenger rail activity by region, 2015 to 2022



Source: See endnote 10 for this section.

- In Slovenia, rail passenger numbers increased more than 20% in 2022 to exceed pre-pandemic (2019) levels, and rose further in 2023.[20] National rail operator Slovenia Railways attributes this to new trains and attractive fares, among other factors.[21]
- In Spain, government subsidies led to a 33% increase in public transport ridership between 2022 and 2024.[22] Medium-distance rail services averaged 4.5 million trips per month in 2024, up 63.5% from 2019 and 82% from 2022.[23]

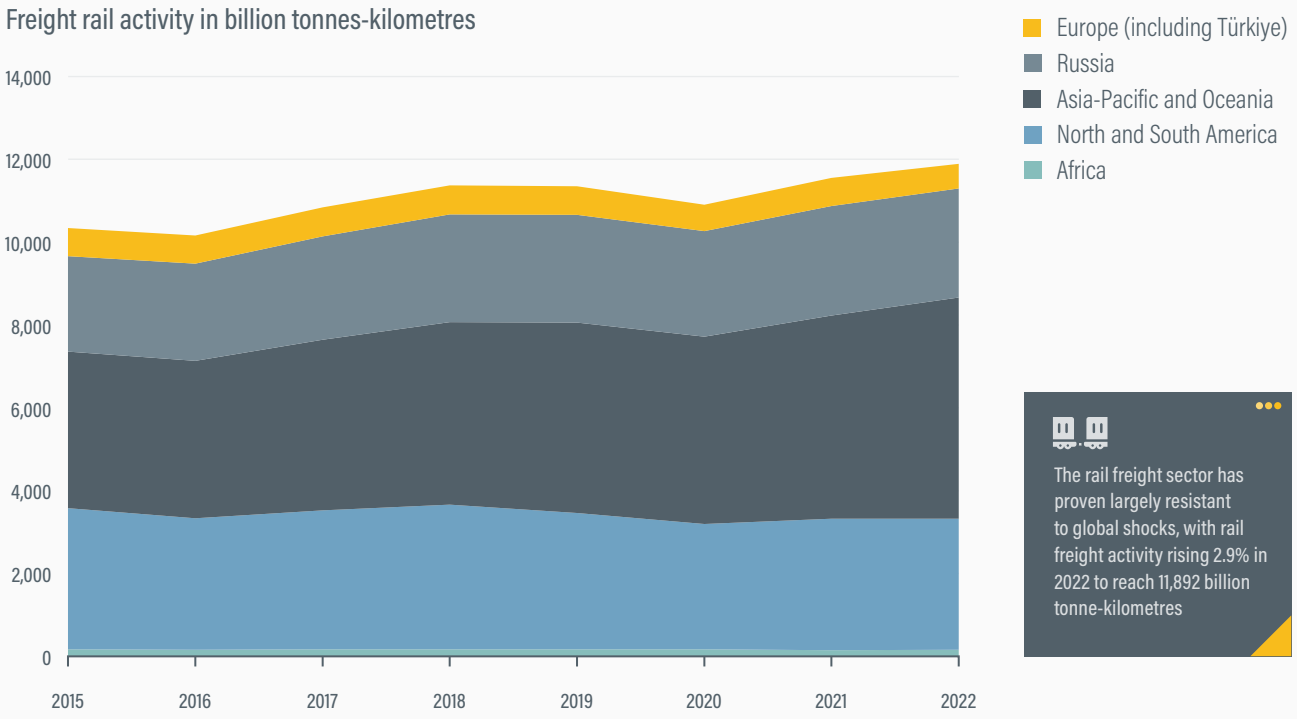
Unlike passenger rail, the rail freight sector has proven largely resistant to global shocks, with rail freight activity rising 2.9% in 2022 to reach 11,892 billion tonne-kilometres (Figure 2)**.**[24] **This growth was driven mainly by increases in the Asia-Pacific region (particularly in China, India, Kazakhstan and Australia), which together with Oceania accounted for 45% of all rail freight activity in 2022, followed by North and South America (27%).**[25] **According to 2025 estimates, rail represented 11% of global freight activity.**[26] The COVID-19 pandemic had only minor impacts on rail freight activities, with the sector's activity in 2021 (11,552 billion tonne-kilometres) already surpassing its 2019 level (11,346 billion tonne-kilometres).[27]

However, the growth in road freight transport outpaced rail freight.[28] **This is attributed to the faster growth of goods transport by road, particularly in China and India.**[29] **In 2023, rail freight experienced a slowdown (notably in Europe), although it continued to play an important role in many countries globally** (Figure 3)**.**[30]

- Rail freight volumes fell in North America in 2023 and 2024 due to economic headwinds, inventory adjustments in major sectors and service disruptions.[31] The Association of American Railroads reported a 3.1% year-to-year decline in US rail carloads in 2024.[32]
- In the European Union (EU-27), rail freight volumes fell 4.9% in 2023 to reach 378 billion tonne-kilometres, the lowest level since 2015 (excluding the pandemic year 2020).[33]
- The Middle Corridor has emerged as a key alternative for rail freight movement between Asia and Europe. Container volumes on the route rose 89% in 2023 and 70% in 2024, as Kazakhstan and other countries have boosted investments and capacity to shift traffic away from the Northern Corridor (via the Russian Federation).[34]

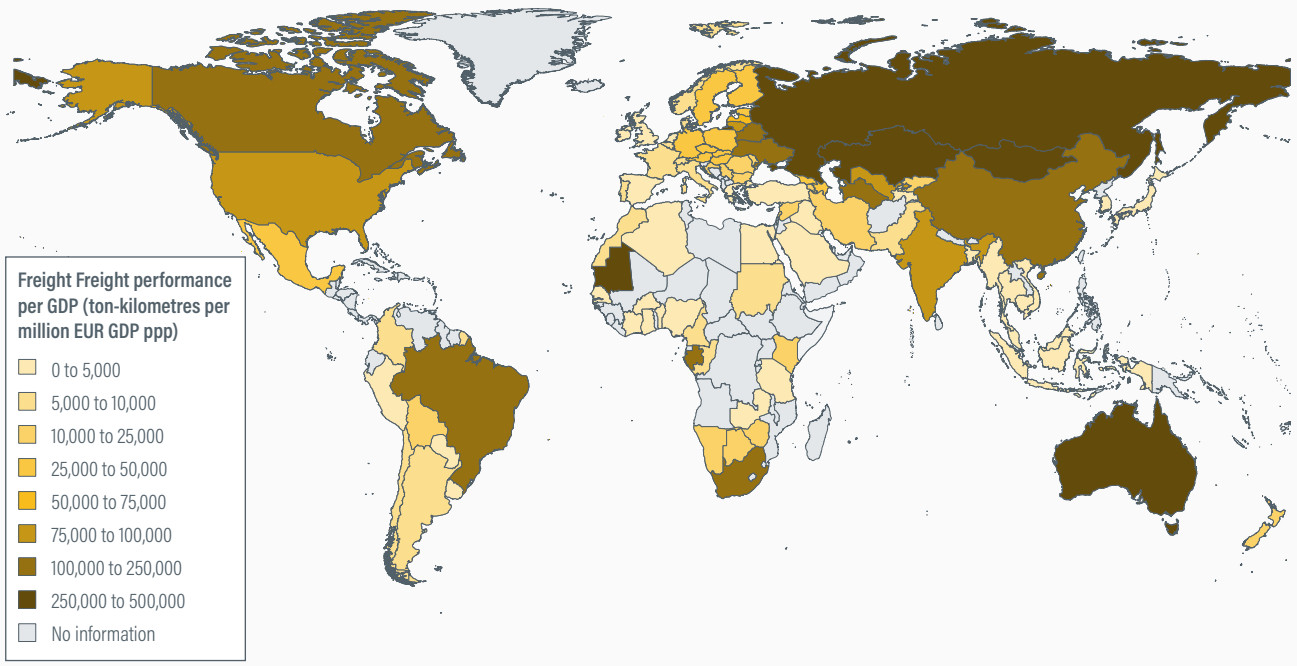
High-speed rail infrastructure rose 14% between 2020 and 2023 to reach a total length of 64,698 kilometres globally.[35] **This expansion occurred particularly in middle-income countries, such as China and Türkiye.**[36] **China's high-speed rail length far outstrips all other countries, with 45,390 kilometres in operation in 2023.**[37] **As of 2023,**

FIGURE 2. Freight rail activity by region, 2015-2022



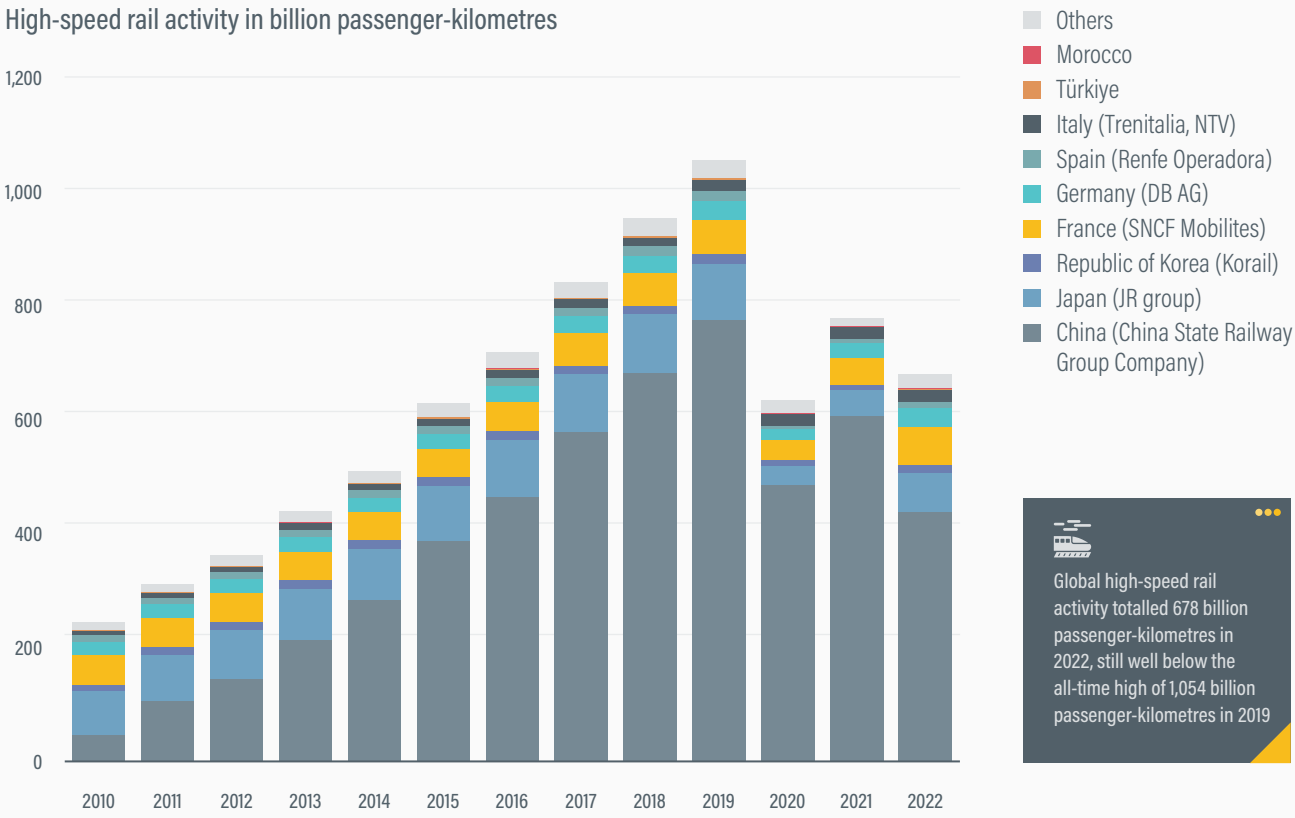
Source: See endnote 24 for this section.

FIGURE 3. Tonnes of rail freight carried per unit of gross domestic product, by country, 2023



Source: See endnote 30 for this section.

FIGURE 4. High-speed rail activity by country, 2010-2022



Source: See endnote 44 for this section.

more than 16,000 kilometres of high-speed rail was under construction globally, including major projects in Asia, the Middle East and North Africa, and North America.[38]

- Egypt's 2,000-kilometre high-speed rail network, initiated in 2018 and under active construction since 2021, aims to connect key cities along the Red Sea and Mediterranean Sea, reducing travel times and easing road congestion.[39] The project is expected to create more than 15,000 jobs and to reduce carbon emissions by shifting passengers from private vehicles to rail.[40]
- Indian Railways has launched and expanded Vande Bharat Express semi-high-speed trains between major cities, offering faster, energy-efficient alternatives to short-haul flights and road trips. The trains are produced in India and present significant updates and more comfort to users. The government announced plans to have 4,500 Vande Bharat trains running by 2047.[41]
- Indonesia's Jakarta-to-Bandung High-Speed Railway, opened in 2023, reduces the travel time between these cities from more than 3 hours to only 40 minutes, at 350 kilometres per hour.[42] With 31,000-plus daily seats and 5.8 million passengers served in its first year, the line has boosted the region's GDP by USD 5.62 billion (2019-2023) and saves USD 208 million in fuel costs annually. It alleviates congestion and spurs urban development along its 142-kilometre route.[43]

Global high-speed rail activity totalled 678 billion passenger-kilometres in 2022, still well below the all-time high of 1,054 billion passenger-kilometres in 2019 (Figure 4).[44] **Despite the continued growth in infrastructure, high-speed rail activity remained at 2015/16 levels as of 2022, as the COVID-19 pandemic had triggered a nearly 40% decline (in 2020).**[45] The low activity level in 2022 may reflect a lack of reporting by some high-speed rail companies.

Sustainability and climate trends

Rail transport delivers significant socio-economic dividends, which are often overlooked in terms of the economic value that they generate. Rail's contribution to the national GDP ranges from 0.5% in the European Union in 2012, 0.7% in the United States in 2023, 0.8% in Australia in 2016 (even up to 1.6% in direct and indirect contributions) to 1.5% in India (even 3 to 4% through direct and indirect contributions).[46]

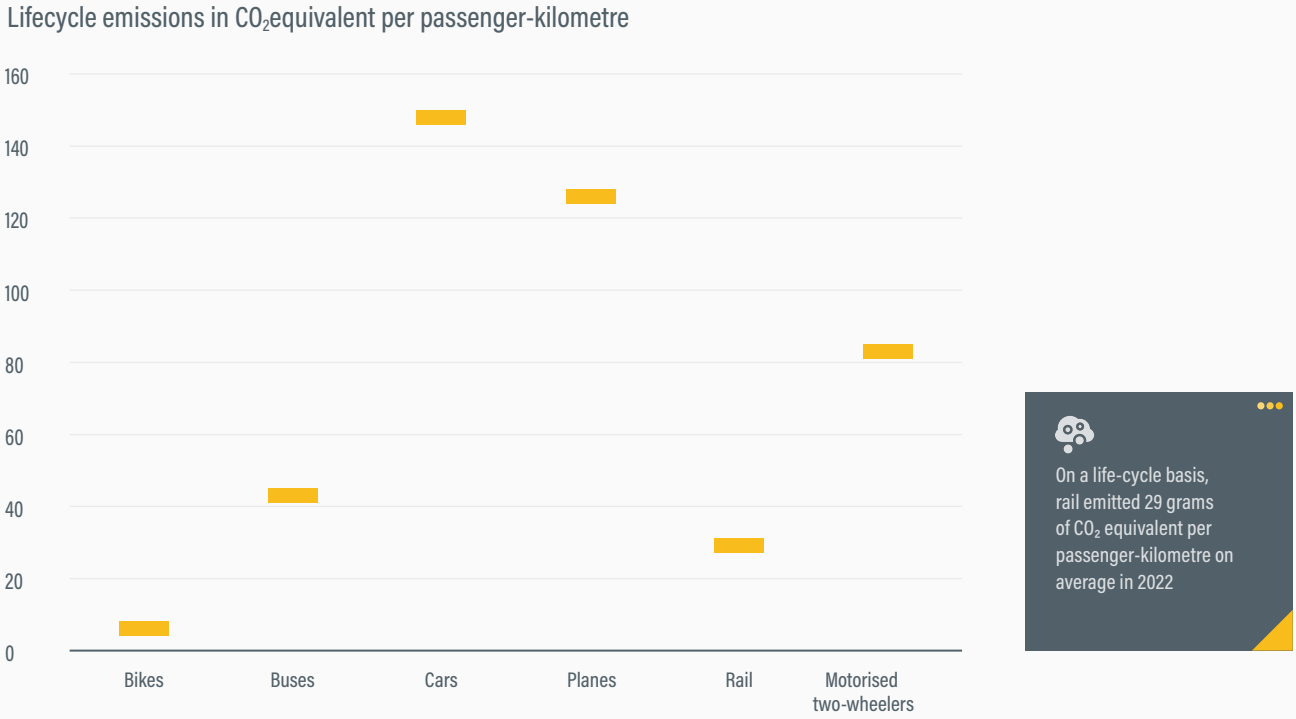
- Indian Railways contributed around 3-4% of the country's GDP in 2024 through direct and indirect contributions, such as trade and employment. The rail sector was also one of India's largest employers, with a direct workforce of 1.2 million people and more people working through contractors, vendors, logistics and suppliers.[47]
- In 2023, the US rail transport sector contributed around USD 50 billion to the country's GDP (roughly 0.7% of total GDP).[48]

Rail can enhance social equity by providing accessible, affordable and sustainable mobility options – and therefore access to essential services, employment, and education, particularly for marginalised groups. Women are more likely than men to rely on public transport (especially rail and buses) due to differences in travel patterns and access to private vehicles (See 1.2 Advancing the Right to Mobility for Sustainable and Inclusive Societies)**.**[49] **Rail transport contributes to improved air quality and reduced congestion, supporting better public health outcomes** (See 1.7 Driving Health and Wellbeing Forward: The Critical Link with Transport)**.**[50]

- As of 2023, the UK community rail movement engaged around 125,000 people annually in various activities, delivering USD 161.5 million (GBP 129 million) in social value from just over USD 9 million (GBP 7.2 million) in funding.[51] This represents a social return on investment of nearly USD 22.5 (GBP 18) for every USD 1.25 (GBP 1) spent.[52]
- The second phase of the Tanzania Intermodal and Rail Development Project, approved in 2024, relies on USD 200 million in financing to improve safety and efficiency along the Dar es Salaam-to-Isaka railway segment.[53] The project benefits nearly 900,000 people directly and an estimated 3.5 million indirectly, roughly 5% of Tanzania's population.[54] This includes railway users, residents along the line, businesses involved in trade, and communities along the Kinywasungwe catchment area.
- In Kenya, the Standard Gauge Railway (SGR) infrastructure project has enhanced trade between Nairobi and the coastal city of Mombasa, contributing to job creation (30,000 temporary construction jobs and 5,000 permanent jobs) and reducing transport costs for goods around 40-60% compared to roads.[55]

Although rail transport can play a role in promoting gender equity in the transport workforce, women have remained under-represented in the rail workforce and in the wider transport sector. In 2023, women made up 15.6% of the global transport and storage workforce.[56] In Europe, women represented an estimated 21% of the rail workforce in 2020.[57] Although comprehensive data for other regions are lacking, the available evidence suggests that shares are likely even lower. Because gender-disaggregated data remain a challenge in many regions, a global picture of women's participation in the rail workforce is not clear.

FIGURE 5. Life-cycle greenhouse gas emissions intensity of motorised passenger transport modes, 2022



Source: See endnote 62 for this section

Rail transport remains the most energy-efficient mode of freight transport and collective passenger travel, thanks to its high energy efficiency and low greenhouse gas emissions per passenger- and tonne-kilometres.[58] **In 2023, rail passenger and freight transport accounted for 1.2% of global transport greenhouse gas emissions.**[59] **Models estimate that freight contributed the major share (around 79%) of rail's greenhouse gas emissions in 2023.**[60]

Passenger rail transport emitted 22.35 grams of CO_2 equivalent per passenger-kilometre (well-to-wheel) in 2023, reinforcing rail's role as the least carbon-intensive mode of motorised land transport.[61] On a life-cycle basis, rail emitted 29 grams of CO_2 equivalent per passenger-kilometre on average in 2022 (Figure 5).[62] By comparison, small- and medium-sized cars emit around 148 grams of CO_2 equivalent per passenger-kilometre globally, while a regulated European truck emits an estimated 52.0 grams of CO_2 per tonne-kilometre.[63]

The carbon intensity of rail has continued to improve, declining 55.9% for passenger rail and 58.7% for freight rail between 2005 and 2023 (location-based).[64] **These gains place the sector ahead of its decarbonisation pathway for 2030, as rail operators reduce emissions through electrification, fuel switching and efficiency improvements.** Despite the demonstrated potential of a modal shift to rail in reducing emissions, rail's modal share has stagnated or even declined in many regions.

- In the EU, total CO_2-equivalent emissions from railway operations fell 57% (location-based) and 58% (market-based) between 2005 and 2023, far surpassing the region's target of a 30% reduction by 2030.[65]
- DP World's Modal Shift Programme increased the share of freight moved by rail from the UK's Port of Southampton from 21% to 30% between September 2023 and August 2024.[66] This shift removed 6,400 tonnes of CO_2 equivalent emissions in its first six months, helping to reduce road congestion and support the United Kingdom's 2050 targets for rail freight.[67]

As of 2022, around one-third of all railways worldwide had been electrified, mainly in India, Japan and China.[68] **In 2023, 45% of global rail energy use came from electricity, with Europe nearing 60%.**[69] These trends are reinforced by rolling stock upgrades, route electrification, and modal shift strategies that favour energy- and space-efficient rail operations.

- Among the member countries of the International Transport Forum, Armenia, Georgia, and Switzerland achieved 100% rail electrification in 2022, with Türkiye following in 2023.[70]
- As of 2022, 56.9% (202,100 kilometres of railway lines) of the EU rail network was electrified.[71]
- In 2023, Austria's national rail company ÖBB ordered up to 120 battery-electric units from Stadler, with an initial 16 trains set to replace their diesel units on partially electrified routes starting in 2028.[72] This shift is expected to save up to 1.7 million litres of diesel annually, avoiding around 4,250 tonnes of CO_2 emissions.[73]
- In India, which has rapidly advanced its rail electrification programme, 93.8% of the broad-gauge rail network was electrified as of March 2024, covering more than 60,000 kilometres. As of February 2025, 98% of the Indian Railways' (IR) Broad Gauge (BG) network has been electrified .[74] This progress supports Indian Railways' goal of becoming a net zero carbon emitter by 2030, with full electrification expected in the near future.[75]
- In 2024, Türkiye secured USD 660 million in financing from the World Bank to electrify a 660-kilometre section of the Eastern rail corridor from Divriği to Kars.[76] The project replaces diesel trains with electric traction and integrates the line into the low-carbon Middle Corridor. Full implementation of the project, expected by 2030, will result in the avoidance of an estimated 72,332 tonnes of carbon annually, with this figure rising to 245,835 tonnes by 2060.[77]

Rail consumed 2% of the total energy in the transport sector in 2022.[78] It had the highest share of renewable energy use among motorised transport modes in 2022, at 16.1%, with rising integration of solar, wind and hydrogen systems into railway operations.[79]

- In 2024, Etihad Rail in the United Arab Emirates (UAE) partnered with Emerge (a Masdar–EDF joint venture) to install a 600 kilowatt-peak solar photovoltaic system with 2.56 megawatt-hours of battery storage at its Ghuweifat freight terminal.[80]
- These efforts are aligned with the UAE's Net Zero by 2050 Strategy, whereby the railway network contributes to reducing CO_2 emissions in the country's road transport sector 21% annually by 2050.[81]

Rail infrastructure is increasingly exposed to climate risks such as heatwaves, floods, storms and coastal erosion. Although vulnerabilities vary by region, the scale of the impacts has become more evident. Climate-related events can affect critical rail components such as tracks, signalling, and power systems, leading to delays and service disruptions; impacting the quality of goods transported and the welfare of railway workers; and, in rare cases, posing safety risks such as derailments. Northern areas experience wetter winters and face high risks of landslides, track flooding and bridge collapse. Southern regions experience extreme heat and desertification, with wildfires disrupting operations, tracks buckling, and overhead wiring sagging. Coastal lines are impacted by storm surges and erosion.

- In Pakistan, devastating floods in 2022 caused widespread damage to the rail system – including the destruction of tracks, bridges and stations – contributing to estimated infrastructure losses of USD 2.5 billion across the transport sector alone, with rail being among the hardest hit sub-sectors.[82]
- In Viet Nam, national climate planning documents estimate that the disruption of railway lines due to climate hazards could lead to economic losses of USD 2.3-2.6 million per day, highlighting the critical role of resilience planning in rail infrastructure.[83]

Despite these challenges, rail systems are inherently more robust and less weather-sensitive than many other transport modes, in part because of their centrally controlled operations.

Policy and investment developments

Governments have increasingly recognised rail's potential in decarbonisation strategies and national economic recovery plans. During 2023 and 2024, countries launched various plans to revive national economies through the upgrading and development of rail lines.

- Chile's 30/30 Plan aims to connect towns within 30 kilometres or 30 minutes of regional capitals, with the purpose of expanding new urban areas that have better access to public transport.[84] The first rail service from Temuco to Pitrufquen (29.6 kilometres) under this project became accessible to the public in June 2023, benefitting around 330,000 people in 3 municipalities.[85]
- The EU's Trans-European Transport Network (TEN-T) policy has driven investment in rail electrification across priority corridors. The TEN-T Core Network targets full electrification and deployment of the European Rail Traffic Management System (ERTMS) by 2030, with the aim of reducing emissions, enhancing inter-operability, and shifting freight and passenger traffic from road to rail.[86] A focus on key cross-border sections – such as Spain/France, Germany/Austria and Italy/Slovenia – will help accelerate the decarbonisation and integration of the single European railway area.[87]
- South Africa has integrated rail rehabilitation and greening into its Climate Change Response Strategy and Just Energy Transition Investment Plan, aiming to shift freight from road to rail and to reduce the overall emission intensity of the transport sector.[88]
- In 2021, the United Kingdom included rail decarbonisation as a central pillar of its Transport Decarbonisation Plan, setting a target to remove all diesel-only trains from the network by 2040 and enabling emission reductions through improved network planning and fleet renewals.[89]

Several African and Asian countries have implemented groundbreaking developments on rail since 2023 with the aim of connecting people and goods.

- A newly initiated railway project will connect Guinea's four regions to the global trade network, helping the country export nearly 120 million tonnes of iron ore by the end of 2025.[90]
- In 2023, Indonesia inaugurated its first high-speed railway, a USD 7.3 billion project that is backed by China under its Belt and Road Initiative.[91]
- Iraq unveiled its ambition in 2023 for a USD 17 billion road and rail project to link Asia and Europe.[92]

Rail-related policy efforts have sought to promote inclusive and accessible services, improved customer experience, gender-responsive infrastructure, inclusive recruitment and safe working environments.

- The Women in Rail autonomous agreement – the first EU-level sectoral agreement on gender equality – is aimed at increasing women's participation in the rail workforce through measures such as recruitment targets, equal pay, career development and workplace protections. The agreement was signed in 2021 by the Community of European Railway and Infrastructure Companies (CER) and the European Transport Workers' Federation (ETF).[93]
- In Belgium, the SNCB Accessibility App was launched in 2023 to facilitate the booking of assistance for passengers with reduced mobility. Future improvements include integration with station staff tools for greater flexibility during incidents (such as traffic interruptions), adding accessibility details about rolling stock and infrastructure and doubling the number of accessible stations between 2022 and 2032.[94]
- In 2023, Italy's national rail company FS Group, in partnership with the organisation Right To Be, launched a campaign against sexual harassment in public places, providing tools on how to behave in the event of harassment. FS also rolled out a training programme for staff.[95]
- Nakuru County (Kenya) developed a Public Transport Code of Conduct with Flone Initiative to set minimum professional standards for transit operators, emphasising gender and disability inclusion, sexual harassment prevention and environmental sustainability [96]
- In 2022, Santiago (Chile) launched the "Stand Up" campaign against sexual harassment in transit, encouraging both victims and bystanders to report and safely intervene, creating a safer and more inclusive passenger environment.[97]
- In the Republic of Korea, KORAIL's Smart Air Quality System has been integrated into rail stations, seamlessly integrating cutting-edge fine dust monitors, high-tech air

purifiers and interactive display devices for measurement. Passengers receive real-time updates on fine dust levels, increasing their awareness and enabling them to trust the underground's air quality and to use the railway safely.[98]

As of 1 August 2025, only 8 (27%) of the 29 third-generation Nationally Determined Contributions (NDCs) submitted to the United Nations Framework Convention on Climate Change mentioned rail transport (Botswana, Brazil, Canada, Moldova, Nepal, the United Kingdom, the United States and Uruguay); only 3 NDCs (Botswana, Moldova and Nepal) had specific targets focused on rail transport.[99]

- Botswana's NDC features the target of a 30% shift to rail but does not clarify whether the focus is on passenger or freight transport.[100]
- Moldova's third-generation NDC commits to electrifying 30% of the rail network by 2040 and shifting freight from road to rail (30% by 2030 and 60% by 2050).[101]
- Nepal's NDC targets developing an electrified rail network of 200 kilometres by 2030 and 300 kilometres by 2035 for freight as well as passenger transport.[102] Nepal also aims to implement light rail systems for urban public transport.[103]

Very few of the second-generation NDCs submitted between 2019 and 2024 featured adaptation efforts for railways; however, two of the third-generation NDCs (Botswana and Brazil) mentioned railways as among the sectors to boost adaptation.

- Botswana's third-generation NDC highlights flood control efforts to prevent flooding of railways.[104]
- Brazil's NDC refers to the AdaptaBrasil platform to disseminate knowledge and decision making regarding climate adaptation for railways (as well as for port and road infrastructure).[105]

In 2022, rail represented about 26% of the total global investment in transport infrastructure from G20 countries.[106] Rail investments tend to have strong multiplier effects, especially in low- and middle-income countries where improved connectivity can unlock economic potential in underserved regions.[107]

- In North America, rail's share of investment in inland transport infrastructure fell from 12% in 2020 to 8% in 2022.[108]
- In the EU-27, rail infrastructure investment accounted for 44% of total transport infrastructure spending in 2022, up from 38% in 2008.[109]
- Brazil's Interurban Train North Axis (TIC) project, a public-private partnership that aims to connect São Paulo to Campinas, is expected to attract more than USD 2 billion (BRL 12.7 billion) in private investments, generating social

and economic benefits estimated at USD 0.5 billion (BRL 3.18 billion).[110] The service is projected to serve around 65,000 daily passengers on the São Paulo-Campinas express route by 2055, with local services anticipating around 650,000 daily users.[111]

The share of public spending for road infrastructure remained four times higher than for rail in most regions in 2022, risking the under-utilisation of rail's potential for climate mitigation.[112]

- Between 1995 and 2018, European countries have spent around USD 1.56 trillion (EUR 1.5 trillion) on road infrastructure and only USD 962.5 billion (EUR 930 billion) on rail.[113]
- Between 1995 and 2020, the total length of European railways fell 6.5% (losing 13,700 kilometres), whereas motorway lengths increased 60% (gaining more than 30,000 kilometres).[114]
- Denmark, France, Italy and Slovenia all increased their rail investments between 1995 and 2018 – rising more than 20 percentage points – although this was still far below the investment in road transport.[115]
- In the Asia-Pacific region, Australia, Japan and the Republic of Korea have all increased their rail investments, but the share of road investments still remains far higher than for rail.[116]

Significant investment and priority spending are needed in rail infrastructure for climate adaptation in the coming decades. With the necessary maintenance and climate adaptation measures – such as reinforcing infrastructure, emergency procedures, upgrading drainage and relocating vulnerable lines – rail can continue to reliably serve people and goods.

- In Buenos Aires (Argentina), the Belgrano Sur Passenger Railway Line, a USD 675 million World Bank-financed modernisation project, is focused on climate-resilient infrastructure, including structural and hydrological upgrades to bridges and viaducts, renovated drainage systems, new hydraulic and pumping systems with back-up generators, rainwater conduits and efficient lighting.[117]
- In the EU, an estimated USD 28.4 billion (EUR 27.4 billion) (in 2023 terms) in investment will be needed by 2040 under the TEN-T to adapt railway infrastructure to climate-exacerbated risks, based on projected mid-century warming conditions and related hazards such as heatwaves, floods, droughts and wildfires.[118]
- In the United States, nature-based solutions have been employed to address shoreline erosion and flooding threats at Lamberts Point Marine Terminal in Norfolk, Virginia.[119] Norfolk Southern railway partnered with the Elizabeth River Project to construct a living shoreline using 2,300 cubic yards of sand, 24,000 marsh plantings, 2,000 cubic yards of stone, and 90 cubic yards of oysters, providing climate-resilient protection for rail infrastructure while enhancing local biodiversity.[120]

Digitalisation and standardisation have emerged as critical enablers for emission reduction in the rail sector. Advanced train control, eco-driving systems and harmonised signalling help reduce energy consumption, increase network capacity and lower operating costs. Supported by real-time data and advisory systems, these techniques have delivered energy savings of 7-25% on various rail services across Europe and Asia, contributing to the sector's ongoing efforts to reduce operational emissions.[121] Standardised systems such as the European Train Control System (ETCS) and digital twins for asset management further support sustainable operations. Eco-driving – training and guiding rail drivers to optimise acceleration, cruising and braking for energy efficiency – has become a well-established practice.

- In Switzerland, adaptive control (ADL), also called the "green wave", provides train engine drivers with driving recommendations, enabling them to avoid unplanned stops in a more resource-saving manner. Trains run more smoothly, consume less energy and are highly energy efficient. Thanks to ADL, the Swiss national rail operator SBB saved 72 gigawatt-hours of power per year as of 2025, equal to the annual household energy use in the city of Fribourg, with around 38,000 inhabitants.[122]
- In the Netherlands, ProRail and NS (the Dutch infrastructure manager and main rail operator) have implemented the Smart communications for Efficient Rail Activities (SFERA) standard, bringing immediate benefits in punctuality and communication between operators. When trains are exactly on schedule, drivers save more energy by not having to catch up to the timetable.[123]

To further progress in the rail sector, policies and regulations should incorporate an Avoid-Shift-Improve[i] prioritisation framework, with a focus on modal shift measures, an area where significant untapped potential remains.

i The Avoid-Shift-Improve framework has been central to sustainable, low carbon transport for more than a decade. It follows an implicit hierarchy, with appropriate and context-sensitive "Avoid" measures (which avoid and reduce the need for motorised travel) intended to be implemented first, followed by "Shift" measures (which shift to more sustainable modes) and finally by "Improve" measures (which improve transport modes). See https://slocat.net/asi and H. Dalkmann and C. Brannigan (2007), Transport and Climate Change, Module 5e: Sustainable Transport – A Sourcebook for Policy-Makers in Developing Cities, GIZ GmbH, https://changing-transport.org/wp-content/uploads/2007_dalkmann_brannigan_transportandclimatechange.pdf.

Partnerships in action

The **International Union of Railways' (UIC) Rail Sustainability Index** collects information on the contributions that railways make to the United Nations Sustainable Development Goals, providing benchmarking and publishing results annually.[124] UIC members have also established common framework methodologies that focus on climate impact analysis, vulnerability, risk, and criticality assessment for two areas: Heavy Rains and High Temperature.[125] The UIC Multimodal Working Group launched its 30 January webinar with 60 participants, presenting its three Passenger Services Group, (PSG)-managed workstreams—Air+Rail, Door-to-Door, and NGRS—continuing projects since 2019.[126]

The **International Council on Clean Transportation's (ICCT) Off-road and Freight Decarbonization Symposium** in 2025 attracted national and city government authorities from China, the United States and Europe.[127] The ICCT published a technical brief in 2024 on *Zero-emission locomotive technologies: pathways for U.S. rail decarbonization* and a policy brief in 2025 titled *Introduction to the low-carbon freight aspects of China's opinions on accelerating the construction of an open and unified transportation market*.[128]

In 2025, Alstom continued to advance smart and sustainable mobility worldwide, delivering the first stainless-steel train for São Paulo's Line 6-Orange, modernising Romania's Bucharest-Giurgiu railway with electrification and ERTMS Level 2 signalling, and upgrading Lyon Metro Line D with 26 new automatic rubber-tyred trains and system renovations, enhancing capacity, reliability and passenger experience across these key projects.[129]

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This section covers trends in motorised individual road transport and topics of road vehicle activity, vehicle sales, autonomous road vehicles, congestion and road safety. Road-based public transport is covered in *4.5 Public Transport*, and informal collective transport services are covered in *4.6 Informal Transport*.

Road Transport

KEY FINDINGS

- Road transport is a crucial part of transport and mobility systems globally, yet persistent challenges remain in terms of sustainability, resilience, access and safety. Increasing resilience and access to roads is critical to development, connectivity, equity and economic growth.
- Road transport is the largest contributor to greenhouse gas emissions of all transport sub-sectors – contributing nearly three-quarters (74%) of total transport emissions in 2023. Thus, policies aimed at reducing these emissions are essential to achieve decarbonisation goals and meet climate targets.
- Automobiles and motorised two- and three-wheelers are often the largest source of air and noise pollution in cities, with significant impacts on people's health and well-being as well as on the environment. An estimated 99% of the global population is exposed to particulate matter ($PM_{2.5}$) levels above the safe guidelines of the World Health Organization (WHO), with low- and middle-income countries experiencing the worst exposure.
- High demand for motorised road transport can lead to declining road safety, with a greater likelihood of road crashes and fatalities. In 2021, an estimated 1.2 million people died in road traffic crashes globally, and 50 million people were left injured, with most fatalities occurring among vulnerable road users such as pedestrians, cyclists and motorcyclists.
- Low- and middle-income countries bear the brunt of these impacts, accounting for 93% of road deaths, with Africa seeing the highest rate of 18.8 fatalities per 100,000 people, above the global average of 15 fatalities per 100,000 people.
- With 85% of the world's lower-income population living in rural areas, governments have increasingly recognised the importance of improving rural transport and creating rural-urban connections to narrow the development gap.
- Fossil fuels continued to account for around 95.4% of the energy used in road transport in 2023 – a share that has barely changed *in the past five decades* – and vehicle-centric models persist. A fundamental shift is necessary to transform this long-engrained approach to road transport.
- Alongside policies to advance zero-emission vehicle use, fuel efficiency standards, and renewable energy, governments at all levels need to prioritise policy and behaviour change measures that encourage shifts towards rail and inland waterways for freight transport and towards walking, cycling, informal (shared) and public transport for passenger transport – while reducing the need for total vehicle travel.

KEY FINDINGS

Demand, use and access

- emand for both passenger and freight road transport has increased in recent years, characterised by shifts in mode share to more road vehicles, changes in patterns of vehicle-kilometres travelled, mainstreaming of electric vehicles (EVs), and increasing interest in artificial intelligence (AI) and autonomous vehicles.
- Global demand for passenger transport grew 10% between 2019 and 2025 (modelled values), reaching 68.3 trillion passenger-kilometres in 2025. Road transport alone accounted for an estimated two-thirds (67%) of passenger mobility globally in 2025, although this share varies highly by location and to some degree urban density.
- In 2022, the absolute number of cars grew to a global average of 219 four-wheeled vehicles per 1,000 people, with much higher averages in North America (805), Europe (588) and Oceania (587). In many low- and middle-income countries, most of the vehicle growth has been in two- and three-wheelers, which tend to outnumber cars in these locations.
- Despite advances in road infrastructure and connections, more than 1 billion people globally did not have access to all-weather roads as of 2019, particularly in low- and middle-income countries and in rural places. Only 38% of the global rural population had access to all-weather roads as of 2019.
- Global freight activity grew an estimated 8% between 2020 and 2025 (modelled values), surpassing 171 trillion tonne-kilometres in 2025. Around 10% of total freight activity in 2025 was transported by road, below the shares for maritime transport (74%) and rail (11%). However, one estimate found that road transport accounted for 22% of total freight activity in 2019.
- Emerging countries, particularly in Asia, continued to see increases in freight activity, although most of Asia's freight transport growth was in maritime shipping.
- Road vehicles regained their popularity as production and sales soared to pre-pandemic levels. Sales of all vehicles approached 93 million in 2023 – surpassing 2019 levels (92 million) – after falling sharply to 80 million in 2020 and growing only slightly to 82-83 million during 2021-2022.
- Electric car sales (including plug-in hybrid electric vehicles) reached a sales share of 22% in 2024, totalling a record 17.5 million units. However, growth was slower than in previous years due to stagnating sales in Europe, as government support was reduced or eliminated in some markets and EU-level carbon dioxide (CO_2) targets were not strengthened.
- Larger vehicles such as sport-utility vehicles (SUVs) and pick-up trucks continued to rise in popularity (both conventional and electric models), due to their status appeal in many markets, potential comfort enhancements, and greater marketing efforts by manufacturers due to the larger profit margins.
- In 2023, SUVs surpassed a 50% market share in advanced economies for the first time and accounted for 48% of car sales globally, posing a growing challenge for public space, road safety and emissions. Global SUV revenues were projected to reach USD 1 trillion by 2025.
- Global demand for two- and three-wheelers has continued to increase. Models with internal combustion engines (ICE) remain dominant in most markets, although electric models have gained ground, especially in Asia. Asia has led in two-wheeler growth, with annual sales of ICE models projected to grow 1.6% in 2024 to reach 57 million and then fall to around 56 million by 2028.
- Despite the increase in electrification, global transport energy demand grew more than 21% between 2010 and 2023, with most of this growth being met by fossil fuels. Oil products supplied around 90% of the energy demand for transport in 2023. Road transport alone accounted for 75% of transport energy consumption and 48% of global oil demand that year.
- However, while global oil demand for transport continued to grow annually to 2023, growth in oil demand for road transport continued to decline (with no growth in 2024), due mainly to changes in the Chinese market.
- Integration of AI in passenger cars continued to advance, with the global market reaching USD 41 billion in 2024 and projected to grow nearly three-fold to USD 114.5 billion by 2029.

KEY FINDINGS

Sustainability and climate trends

- As access to convenient public transport and rail has faltered – and as ridership has struggled to recover from pre-pandemic levels in many locations – this has resulted in rising private car and motorcycle use, increased congestion, and worsening pollution and greenhouse gas emissions.
- The persistence of the car-centric paradigm has led to more vehicles on the road, as well as to increasing vehicle size and decreasing vehicle occupancy, which have in turn offset any gains in fuel efficiency.
- Achieving net zero greenhouse gas emissions globally by 2050 will require large emission reductions in the transport sector as a whole and particularly from passenger vehicles and heavy trucks. To reach global net zero goals, CO_2 emission intensity must be reduced more than 94% for trucks and 98% for cars compared to 2020 levels, according to the International Energy Agency's (IEA) Net Zero scenario.
- The road transport sector accounted for 74% of transport greenhouse gas emissions in 2023 and remained far from being on track to a net zero scenario, with constant annual emissions growth of 1.8% to 2% for most years between 2010 and 2023. Road transport emissions neared their pre-pandemic (2019) levels already in 2022 and surpassed them in 2023, reaching 6.2 gigatonnes of CO_2 equivalent.
- Transport emissions from road freight have outpaced those from road passengers, as emissions from road freight grew 23% and from road passengers 16% from 2010 to 2023. This suggests that policies pursuing efficiency improvements and electrification have had a stronger impact for passenger vehicles than freight vehicles. CO_2 emissions from road passenger transport reached 3.75 gigatonnes in 2023, while emissions from road freight reached nearly 2.46 gigatonnes.
- As larger passenger vehicle sizes have gained popularity, their rising energy consumption has posed a growing risk to decarbonisation, leading the IEA to recommend that the auto industry decrease vehicle size. SUVs alone were responsible for more than one-quarter of the total growth in oil consumption globally during 2022-2023.
- Road transport emissions are extremely unequally distributed among countries, with high-income countries contributing the bulk of emissions. The countries with the highest levels of per capita road transport CO_2 equivalent emissions in 2023 were Luxembourg (6.4 tonnes), Qatar (5.1 tonnes), Saudi Arabia (4.4 tonnes), the United States (4.2 tonnes) and the United Arab Emirates (4 tonnes).
- Emission standards have helped limit emissions to some extent where they have been implemented, but much of the world remains uncovered by such standards.
- Decarbonising the power grid is critical for achieving transport decarbonisation, with the aim of supplying cleaner energy for both EV charging and battery production.
- Road safety, health and climate change are interrelated and can influence each other in various ways, with the most direct and severe impacts occurring from road crashes and air pollution.
- Factors contributing to the slow decline in road deaths and injuries include increased road congestion, higher speeds, driver distraction and fatigue from longer commute times.
- Efforts to improve the resilience of road infrastructure have lagged, even as economic losses from infrastructure damage due to climate-related events grew an estimated seven-fold between the 1970s and 2010, to USD 1.6 trillion.
- Traffic congestion returned to pre-pandemic levels already by 2021, and most cities have experienced worsening congestion since 2022.
- Autonomous vehicles have the potential to decrease transport emissions if they are shared and regulated; however, increases in vehicle size and distances travelled could lead to higher emission growth, although these impacts are uncertain.

KEY FINDINGS

Policy and investment developments

- Successful strategies to reduce road transport emissions and create healthier, more sustainable urban and rural areas include a mix of the Avoid-Shift-Improve (A-S-I) framework for both passenger and freight transport.
- Among "Avoid" and "Shift" policies, a few jurisdictions have adopted targets to reduce vehicle travel, particularly at the sub-national level.
- Building roads and establishing urban-rural connections can support economic development; however, if these are not pursued with a sustainable, resilient vision, they can lead to unsustainable auto-centric, sprawling development.
- Investment in inland transport infrastructure (road, rail and inland waterways) has been decreasing in some countries, although several continue to invest heavily in road transport.
- Policies have been adopted at various levels to address road safety, particularly aimed at speed management and sometimes linked to improving the sustainability of transport systems. Research has shown that lowering average speed limits by just 5% can result in a 20% reduction in road deaths.
- Between 2023 and 2025, an increasing number of jurisdictions adopted targets for reducing average vehicle emissions, as well as scrappage policies that help governments accelerate fleet renewal, reduce emissions and encourage the adoption of cleaner, more efficient vehicles.
- In some places, rules for vehicle emission reductions include flexibilities around compliance that hinder their effectiveness, while in other cases emission rules have been weakened or removed altogether.
- EV adoption has been the most common measure for reducing emissions in the road transport sector, since EVs produce far fewer emissions than traditional petrol vehicles but allow for continuation of the auto-centric model. In addition, several governments have adopted targets for full or partial ICE vehicle bans or EV targets, although typically these are only for vehicle sales rather than the overall stock.
- As EV uptake increases, governments have taken steps to support the deployment of charging infrastructure and battery swap stations. However, they may need to develop new taxation approaches to replace the losses in income from fuel taxes on ICE vehicles.
- By 2023, the number of countries with support measures for EVs surpassed those with biofuel blending mandates, which until then had been the most common policy for decarbonising road transport.
- The deployment of EVs will not address concerns such as traffic congestion, urban sprawl and the amount of public space devoted to vehicles. In some places, increases in parking fees in recent years have been correlated with higher use of walking, cycling and public transport.
- For freight transport, low-carbon options include the adoption of fuel-efficient technologies and alternative fuels, carbon pricing mechanisms, promotion of multi-modality, cargo consolidation centres, last-mile sustainable urban logistics and autonomous deliveries. Although policy progress has been slower for freight than passenger vehicles, some advances towards reducing emissions occurred in recent years.

Photo: Dennis Schroeder / NREL

Context, challenges and opportunities

Road transport is a crucial part of transport and mobility systems globally, yet persistent challenges remain in terms of sustainability, resilience, access and safety. Adaptation of road transport infrastructure to climate change continues to receive a small share of global climate finance, while the impacts of natural hazards on transport systems have increasingly large costs. Climate-related impacts have disproportionate effects on low- and middle-income countries, where inadequate roads often already restrict the movement of people and goods.

Increasing resilience and access to roads is critical to development, connectivity, equity and economic growth. Road transport remains the dominant mode for freight movement globally, highlighting the vulnerabilities for trade and commerce with increasing climate change impacts, extreme weather and geopolitical events.[1]

Road transport is the largest contributor to greenhouse gas emissions of all transport sub-sectors – contributing nearly three-quarters (74%) of total transport emissions in 2023.[2] Thus, policies aimed at reducing these emissions are essential to achieve decarbonisation goals and meet climate targets. To achieve an economy with net zero greenhouse gas emissions, road transport must also be net zero. Although some progress has been made through policy adoption and technological advancement, the pace and scale of global emission reductions remain insufficient to meet current net zero targets.[3]

Automobiles and motorised two- and three-wheelers are often the largest source of air and noise pollution in cities, with significant impacts on people's health and well-being as well as on the environment.[4] An estimated 99% of the global population is exposed to particulate matter ($PM_{2.5}$) levels above the safe guidelines of the World Health Organization (WHO), with low- and middle-income countries experiencing the worst exposure.[5] Resulting health costs have continued to rise, as mounting evidence has linked road transport emissions to long-term conditions including asthma, heart disease, dementia and stroke.[6] Auto-centric economies also support sedentary lifestyles, contributing to increased frequency of diabetes, chronic kidney disease and chronic obstructive pulmonary disease.[7]

High demand for motorised road transport can lead to declining road safety, with a greater likelihood of road crashes and fatalities.[8] In 2021, an estimated 1.19 million people died in road traffic crashes globally, and 50 million people were left injured, with most fatalities occurring among vulnerable road users such as pedestrians, cyclists and motorcyclists.[9] Road traffic crashes are the eighth leading cause of death worldwide and the primary cause of death for

young people aged 5-29.[10]

Low- and middle-income countries bear the brunt of these impacts, accounting for 93% of road deaths, with Africa seeing the highest rate of 18.8 fatalities per 100,000 people, above the global average of 15 fatalities per 100,000 people.[11] Annual road deaths globally fell 2% on average during 2010-2019, but this was still well below the 50% reduction target set under the United Nations Decade of Action for Road Safety.[12] The need to accelerate action has resulted in a shift in strategy between the first and second Decades of Action for Road Safety.[13]

With 85% of the world's lower-income population living in rural areas, governments have increasingly recognised the importance of improving rural transport and creating rural-urban connections to narrow the development gap.[14] Efforts to make roads more resilient to climate change also have continued, particularly in rural areas, with growing support from climate finance, although far below necessary levels.

Fossil fuels continued to account for around 95.4% of the energy used in road transport in 2023 – a share that has barely changed *in the past five decades* – and vehicle-centric models persist.[15] **A fundamental shift is necessary to transform this long-engrained approach to road transport.** Resistance to change remains a barrier in most places, even though examples reveal how sectoral transformation can occur, as well as the resulting benefits to climate, air quality, health, congestion relief, etc.

Alongside policies to advance zero-emission vehicle use, fuel efficiency standards, and renewable energy, governments at all levels need to prioritise policy and behaviour change measures that encourage shifts towards rail and inland waterways for freight transport and towards walking, cycling, informal (shared) and public transport for passenger transport – while reducing the need for total vehicle travel.[16] Some governments have begun taking strong actions to encourage such advancements, and co-ordination has improved through international frameworks. However, efforts remain insufficient in scale and pace and are far from what is needed to reach climate, sustainability and health goals.

Demand, use and access

Demand for both passenger and freight road transport has increased in recent years, characterised by shifts in mode share to more road vehicles, changes in patterns of vehicle-kilometres travelled, mainstreaming of electric vehicles (EVs), and increasing interest in artificial intelligence (AI)[i] **and autonomous vehicles.** Factors driving these trends include population growth, urbanisation, economic development, and concerns about air pollution and climate change. However, some locations – such as Paris (France) – have supported shifting away from motorised vehicles towards more people-centred planning, due to factors such as inflation, fuel prices, congestion, and the prioritisation of healthier and more sustainable cities.[17] Similarly, shifts from road to rail or inland waterways are being encouraged in some places. (See 4.2 Integrated Transport Planning.)

Global demand for passenger transport grew 10% between 2019 and 2025 (modelled values), reaching 68.3 trillion passenger-kilometres in 2025.[18] **Road transport alone accounted for an estimated two-thirds (67%) of passenger mobility globally in 2025, although this share varies highly by location and to some degree urban density.**[19] In many major cities (mostly in high-income countries), car ownership per capita has declined due to effective and convenient public transport services, and some cities ramped up their support for walking and cycling following the outbreak of the COVID-19 pandemic.[20]

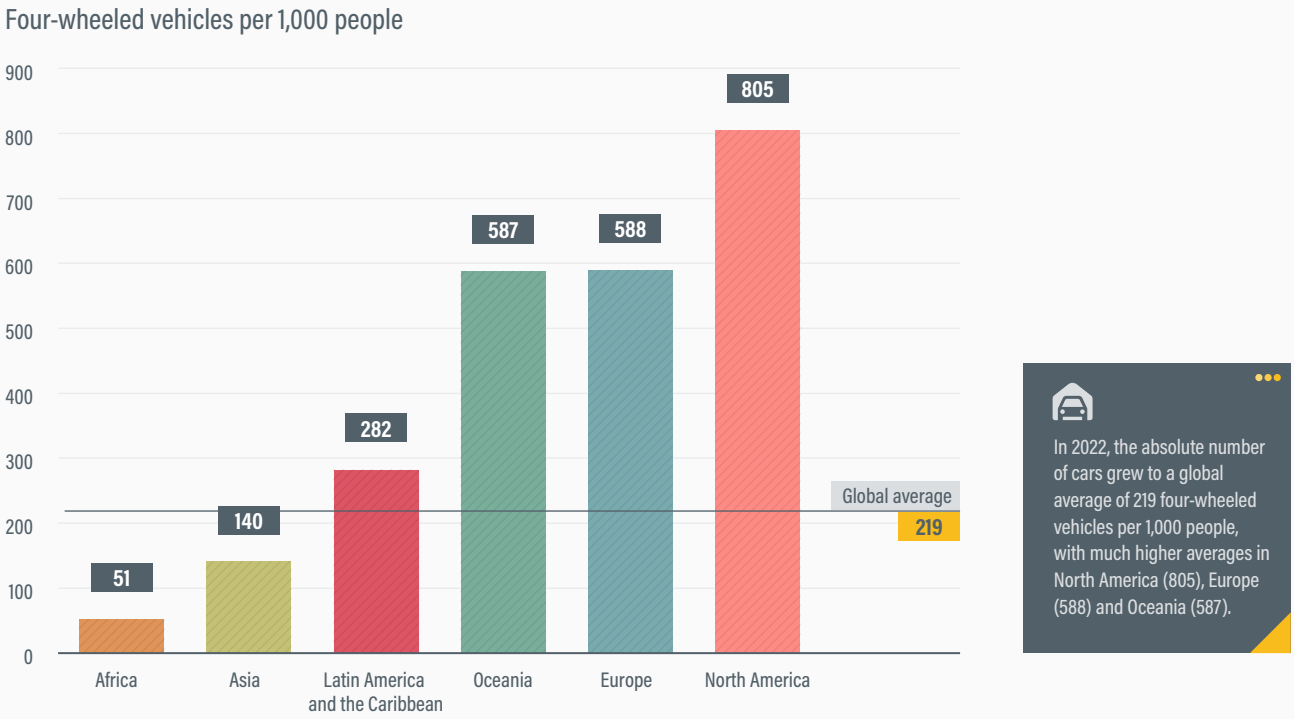
- Total passenger-kilometres travelled in private cars rose more than 10% between 2019 and 2024 in many countries, including North Macedonia (+29%), Slovenia (+25%), Hungary (17%) and Azerbaijan (+12%).[21]
- Countries where private car use decreased during this period included Finland (-9%), Italy and the Netherlands (both -8%) and Croatia (-5%).[22]

In 2022, the absolute number of cars grew to a global average of 219 four-wheeled vehicles per 1,000 people, with much higher averages in North America (805), Europe (588) and Oceania (587) (Figure 1)**.**[23] **In many low- and middle-income countries, most of the vehicle growth has been in two- and three-wheelers, which tend to outnumber cars in these locations.** However, the lack of available data makes it difficult to track global or regional trends for motorised two- and three-wheelers.

- In Africa, the motorisation rate was 51 four-wheeled vehicles per 1,000 people in 2022, well below the global average but climbing rapidly (up 34% since 2017).[24] More than three-quarters of the region's 72 million vehicles were concentrated in just 10 countries in 2022.[25]
- In South Africa, vehicle purchases among people under age 35 fell 8% annually between 2012 and 2022; however,

i AI integration refers to the incorporation of AI technologies into vehicle systems to improve driving functionality, safety, efficiency, and user experience. It includes features such as Advanced Driver Assistance Systems, autonomous driving capabilities, in-vehicle voice assistance, and predictive maintenance and diagnostics.

FIGURE 1. Vehicle ownership rates by region in 2022



Source: See endnote 23 for this section.

the desire for vehicles remains strong, and overall finance applications for cars increased from around 722,000 in 2021 to around 826,000 in 2023.[26]

- A third of Asian countries exceeded the global average motorisation rate in 2022, with a regional average of 140 four-wheeled vehicles per 1,000 people – up from 123 vehicles during 2016-2020.[27]
- In Europe, the motorisation rate was nearly three times the global average in 2022, at 589 four-wheeled vehicles per 1,000 people – up from 554 vehicles during 2016-2020.[28]
- Latin America and the Caribbean had a motorisation rate of 282 four-wheeled vehicles per 1,000 people in 2022, with nearly half of the region's countries exceeding the global rate.[29] In Brazil, the share of households with a car increased from 74% in 2019 to 79% in 2023.[30]
- The United States reached an all-time-high motorisation level in 2022 with 805 four-wheeled vehicles per 1,000 people – 4 times the global average and 15 times higher than in Africa.[31]
- In Oceania, the motorisation rate increased from 544 four-wheeled vehicles during 2016-2020 to 587 vehicles per 1,000 people in 2022.[32]

Despite advances in road infrastructure and connections, more than 1 billion people globally did not have access to all-weather roads as of 2019, particularly in low- and middle-income countries and in rural places.[33] Only 38% of the global rural population had access to all-weather roads as of 2019.[34] The lack of all-weather roads limits people's access to basic services and economic opportunities, while many existing roads face rapid deterioration due to poor maintenance, underfunding and inefficient execution.

- The share of the rural population with access to all-weather roads totalled 42.2% in small island developing states (2019), 40.8% in Asia (2020), 35.4% in Latin America and the Caribbean (2020) and just 31.3% in Africa (2020). (See Module 3 Regional Overviews and Spotlight on Small Island Developing States.)
- In Africa, where road transport accounted for 90% of passenger travel and 80% of freight transport in 2014, only around half of all roads had been paved as of that year.[35] (See 3.1 Africa Regional Overview.)

Global freight activity grew an estimated 8% between 2020 and 2025 (modelled values), surpassing 171 trillion tonne-kilometres in 2025.[36] Around 10% of total freight activity in 2025 was transported by road, below the shares for maritime transport (74%) and rail (11%).[37] However, one estimate found that road transport accounted for 22% of total freight activity in 2019.[38] (See 4.1 Freight Transport and Logistics.) Global trade volumes fell 1.2% in 2023, although the modal split and trends varied widely by location.[39]

- Road freight transport dominates in the European Union (EU-27), representing 53.8% of total freight transport activity in 2022, followed by intra-EU maritime transport at 28%.[40] Road freight in the EU-27 decreased 2.8% in 2023 and rail freight fell 6.6% (reflecting an ongoing decline in rail's share since 1995).[41]
- In the United States, road transport accounted for the largest share of freight activity (40.6%), followed by rail (28.6%) and pipelines (19.9%) in 2022.[42] In 2023, US road freight increased 6.6% while rail freight fell 2.6%.[43]

Emerging countries, particularly in Asia, continued to see increases in freight activity, although most of Asia's freight transport growth was in maritime shipping.[44] China continued to dominate shipping in the Asia-Pacific region but has also invested heavily in expanding road infrastructure.[45] Among countries in the Organization for Economic Co-operation and Development (OECD), road freight grew sharply above pre-pandemic levels in the Czech Republic (up 66% between 2019 and 2023), Bulgaria (+61%), and Slovenia (+32%), whereas it fell in Azerbaijan (-30.5%), the Slovak Republic (-22%) and Estonia (-13%).[46]

- In China, following a government stimulus package, the number of zero-emission medium- and heavy-duty trucks and buses spiked in 2024 to total more than 230,000 units sold, attaining a market share of around 80%.[47]
- Road freight accounted for more than one-quarter of India's oil import expenses in 2024 and was projected to grow four-fold in India by 2050, highlighting the economic potential of shifting to zero-emission trucks.[48]

Road vehicles regained their popularity as production and sales soared to pre-pandemic levels. Sales of all vehicles approached 93 million in 2023 – surpassing 2019 levels (92 million) – after falling sharply to 80 million in 2020 and growing only slightly to 82-83 million during 2021-2022.[49] The top five countries for car sales in 2023 were China, the United States, India, Japan, and Germany, indicating that advanced economies (rather than low- and middle-income countries) continue to further growth in vehicle emissions and pollution.[50]

- Global sales of passenger cars exceeded pre-pandemic (2019) levels in 2023, reaching 75.3 million, and totalled an estimated 77 million in 2024.[51] This was up more than 20% from a low of 63.8 million sales in 2020, during the height of the pandemic.[52]
- Car sales were impacted in 2020 and 2021 by slower global economic growth and the Russian Federation's invasion of Ukraine – which resulted in an automotive semiconductor shortage – and in 2022, sales numbers were low due to ongoing supply chain disruptions.[53]
- In China, car sales fell sharply in 2021-2022 due to the pandemic, shortages, and fears of economic recession, but by end-2023 the market had largely bounced back, with sales 21% higher than in 2021.[54]
- In 2024, China continued to be the largest market for car sales, with more than 31.4 million units sold.[55]

Electric car sales (including plug-in hybrid electric vehicles) reached a sales share of 22% in 2024, totalling a record 17.5 million units.[56] **However, growth was slower than in previous years due to stagnating sales in Europe, as government support was reduced or eliminated in some markets and EU-level carbon dioxide (CO_2) targets were not strengthened.**[57] Electric cars have advanced towards mainstream market status in an increasing number of countries.[58] (See 5.2 Road Vehicle Electrification for more information and regional trends on EVs.)

Larger vehicles such as sport-utility vehicles (SUVs) and pick-up trucks continued to rise in popularity (both conventional and electric models), due to their status appeal in many markets, potential comfort enhancements, and greater marketing efforts by manufacturers due to the larger profit margins.[59] **In 2023, SUVs surpassed a 50% market share in advanced economies for the first time and accounted for 48% of car sales globally, posing a growing challenge for public space, road safety and emissions.**[60] **Global SUV revenues were projected to reach USD 1 trillion by 2025.**[61] In some places, interest has risen in compact SUVs, which are seen as more practical than larger vehicles, especially in cities.[62] Policies aimed at discouraging larger vehicles directly impact road safety, as pedestrians are 200% more likely to be killed by SUVs than smaller vehicles – and 90% more likely to be injured by them.[63]

- SUVs weigh up to 300 kilograms more than an average medium-sized car, take up 0.3 square metres more space, emit 20% more CO_2, and increase the demand for basic metals and critical minerals needed for battery production in electric models (see section on Sustainability and Climate Trends).[64]
- In the US market, SUV growth is due largely to cultural factors and to low fuel prices supported by substantial government subsidies, as well as tax breaks for larger vehicles.[65]
- China has seen consistent growth in its SUV market since 2020.[66]

Global demand for two- and three-wheelers has continued to increase. Models with internal combustion engines (ICE) remain dominant in most markets, although electric models have gained ground, especially in Asia. Asia has led in two-wheeler growth, with annual sales of ICE models projected to grow 1.6% in 2024 to reach 57 million and then fall to around 56 million by 2028.[67] Although manufacturers continue to launch ICE models, several leading players have

invested heavily in electric models.[68] The electric two-wheeler market was expected to reach USD 128.6 billion in 2025 and USD 181.4 billion by 2029.[69]

- In China alone, more than 4.7 million electric two-wheelers were sold in 2024, while India's sales exceeded 2 million units that year.[70]
- For electric three-wheelers, India surpassed China in 2023 to become the global market leader with 580,000 units sold, while China reached 320,000.[71]

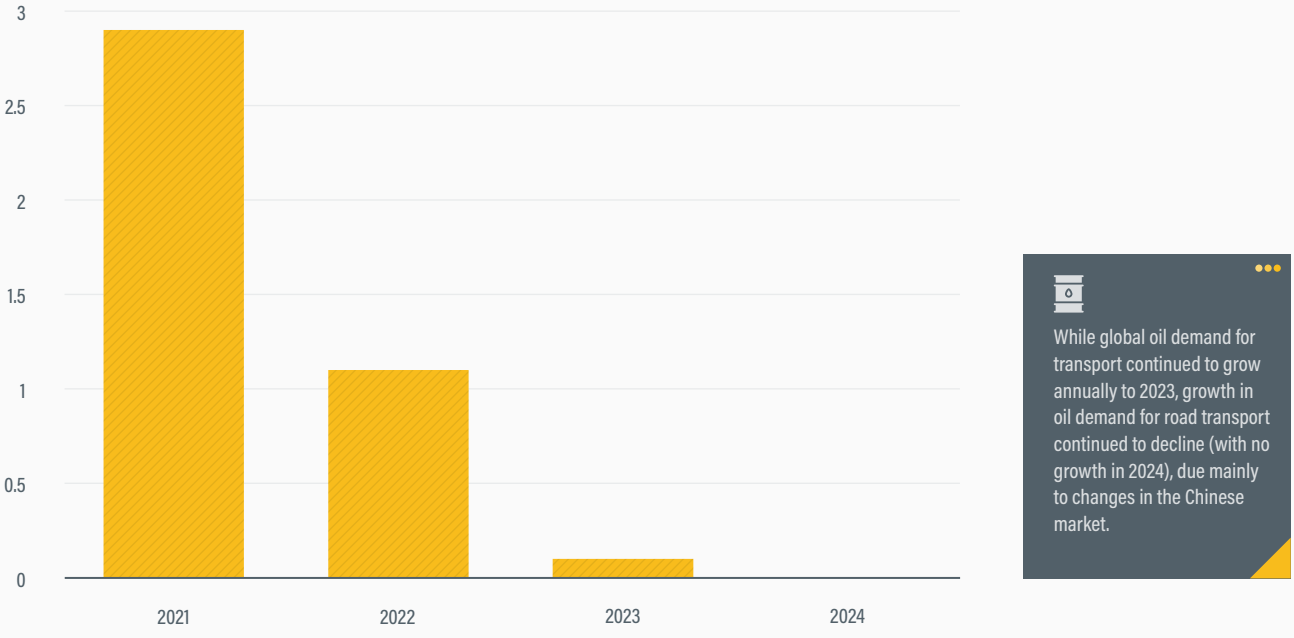
Despite the increase in electrification, global transport energy demand grew more than 21% between 2010 and 2023, with most of this growth being met by fossil fuels.[72] **Oil products supplied around 90% of the energy demand for transport in 2023.**[73] **Road transport alone accounted for 75% of transport energy consumption and 48% of global oil demand that year.**[74] (See 5.1 Transport Energy Sources.)

However, while global oil demand for transport continued to grow annually to 2023, growth in oil demand for road transport continued to decline (with no growth in 2024) (Figure 2), due mainly to changes in the Chinese market.[75] Oil use in the transport sector remained virtually unchanged in 2024 compared to 2019 levels, a trend attributed to increases in EVs, high-speed rail, efficiency improvements and teleworking.[76]

Integration of AI in passenger cars continued to advance, with the global market reaching USD 41 billion in 2024 and projected to grow nearly three-fold to USD 114.5 billion by 2029.[77] The sales share of connected vehicles in the global market increased from 93% in 2022 to 98% by 2025.[78] AI in freight and logistics has become indispensable for tasks such as route planning and forecasting of logistics planning.[79]

- The number of fully autonomous vehicles on the world's roads is expected to nearly double from 16,960 units in 2022 to 33,570 in 2025.[80]
- Level 1 (driver assistance) and Level 2 (partial) automation have become nearly ubiquitous in vehicles, increasing from a 92% market share in 2021-2022 to 97% in 2024-2025; meanwhile, Level 3 automation (performing most driving tasks but still requiring human intervention) remained in early stages.[81]

FIGURE 2. Growth in oil demand for road transport, 2021-2024



Source: See endnote 75 for this section.

Sustainability and climate trends

As access to convenient public transport and rail has faltered – and as ridership has struggled to recover from pre-pandemic levels in many locations – this has resulted in rising private car and motorcycle use, increased congestion, and worsening pollution and greenhouse gas emissions. In 2023, fossil fuels continued to account for 95.4% of the total energy demand in transport – a share that has barely changed in the past 50 years even as biofuels, EVs, fuel efficiency and renewable power have increased.[82]

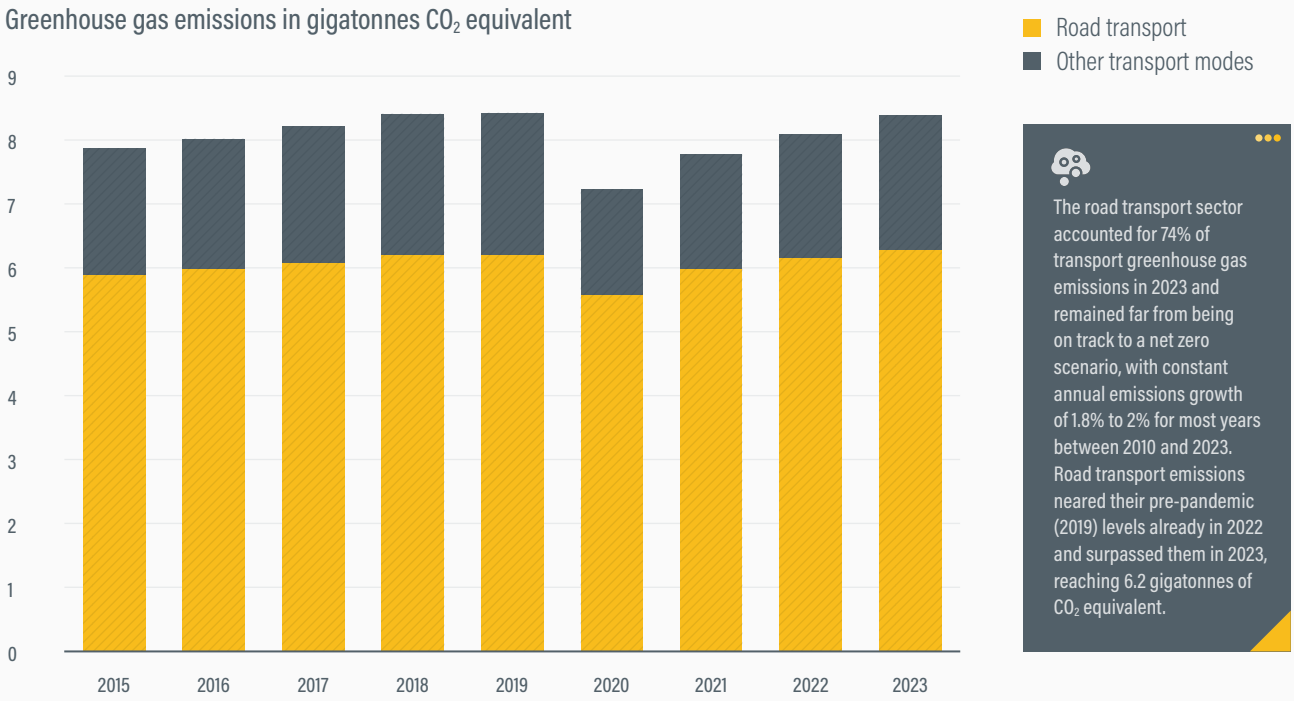
The persistence of the auto-centric paradigm has led to more vehicles on the road, as well as to increasing vehicle size and decreasing vehicle occupancy, which have in turn offset any gains in fuel efficiency.[83] These trends have resulted in increased air (and noise) pollution, greenhouse gas emissions, congestion and road crashes.[84] Urban sprawl and longer supply chains have worsened the problem. Still, vehicle electrification displaced 1.3 million barrels of oil per day in 2024 – equal to around half of the Republic of Korea's oil consumption – and EV progress was considered "on track" to meet 2030 climate targets.[85]

Achieving net zero greenhouse gas emissions globally by 2050 will require large emission reductions in the transport sector as a whole and particularly from passenger vehicles and heavy trucks. To reach global net zero goals, CO_2 emission intensity must be reduced more than 94% for trucks and 98% for cars compared to 2020 levels, according to the International Energy Agency's (IEA) Net Zero scenario.[86] Achieving the necessary reductions from road transport is essential for mitigating climate change but will require a concerted effort from governments, businesses and individuals.

The road transport sector accounted for 74% of transport greenhouse gas emissions in 2023 and remained far from being on track to a net zero scenario, with constant annual emissions growth of 1.8% to 2% for most years between 2010 and 2023.[87] **Road transport emissions neared their pre-pandemic (2019) levels already in 2022 and surpassed them in 2023, reaching 6.2 gigatonnes of CO_2 equivalent** (Figure 3).[88] Emissions from road transport continued to grow over the past decade despite the growth in EVs, renewable energy and regulations for cleaner vehicles.[89]

Transport emissions from road freight have outpaced those from road passengers, as emissions from road freight grew 23% and from road passengers 16% from 2010 to 2023.[90] **This suggests that policies pursuing efficiency improvements and electrification have had a stronger impact for passenger vehicles than freight vehicles.**

FIGURE 3. Greenhouse gas emissions from road transport compared to other modes, 2015-2023



Source: See endnote 88 for this section.

CO_2 emissions from road passenger transport reached 3.75 gigatonnes in 2023, while emissions from road freight reached nearly 2.46 gigatonnes.[91]

The CO_2 emission intensity of vehicles depends on factors such as the type of fuel used, vehicle size and weight, and level of fuel efficiency. Smaller, more fuel-efficient vehicles typically have lower emissions intensity than larger, less-efficient vehicles.[92] EVs bring significant emission benefits compared to ICE vehicles when considering the entire life cycle of the vehicle (from well to wheel), which accounts for resource consumption and emissions that occur during vehicle and infrastructure production in addition to operation. Measured this way, hybrid and electric vehicles can reduce emissions significantly – by around one-quarter for plug-in hybrids to more than three-quarters for battery electric vehicles powered by renewable electricity.[93] (See 5.2 Road Vehicle Electrification.)

As larger passenger vehicle sizes have gained popularity, their rising energy consumption has posed a growing risk to decarbonisation, leading the IEA to recommend that the auto industry decrease vehicle size.[94] Larger vehicles take up an increasing amount of public and private space, consume far more fuel, and contribute around 20% greater emissions than small- and medium-sized vehicles – cancelling out the energy efficiency and emission improvements made in the global passenger vehicle fleet over the past few decades.[95] Larger vehicles have become particularly popular in the United States for passenger transport, creating an ever-increasing carbon footprint. Light-duty trucks (weighing up to 8,500 pounds or 3,856 kilograms) have been the most popular passenger transport vehicle in most US states for some years and were responsible for the highest share of transport emissions in the country in 2022 (37%).[96]

SUVs alone were responsible for more than one-quarter of the total growth in oil consumption globally during 2022-2023, rising by more than 600,000 barrels per day (the equivalent of about one-quarter of Germany's oil consumption) – an increase of 20% from 2021-2022.[97] If the global SUV stock were a country, its 2023 emissions would make it the fifth largest emitter of CO_2, above the total annual emissions of Japan.[98]

Road transport emissions are extremely unequally distributed among countries, with high-income countries contributing the bulk of emissions. The countries with the highest levels of per capita road transport CO_2 equivalent emissions in 2023 were Luxembourg (6.4 tonnes), Qatar (5.1 tonnes), Saudi Arabia (4.4 tonnes), the United States (4.2 tonnes) and the United Arab Emirates (4 tonnes) (Figure 4)**.**[99] Despite vehicle emission standards in some of these

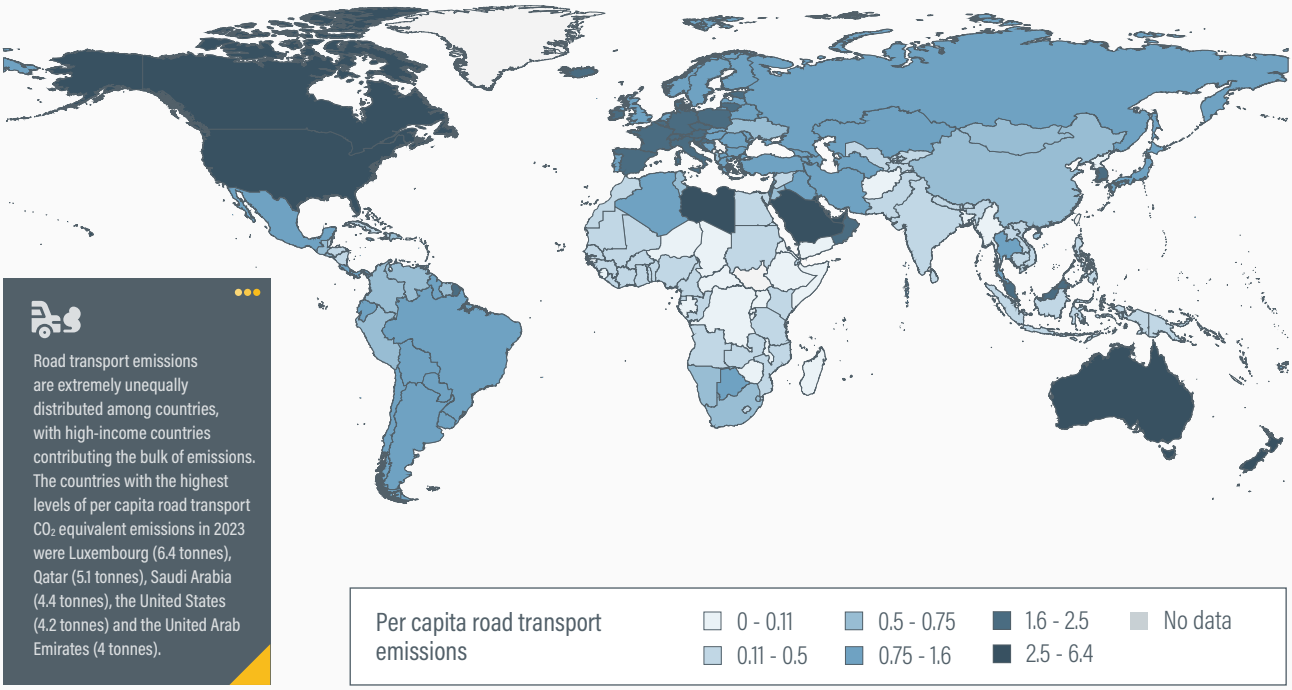
regions, their high motorisation levels and high kilometres-travelled in motorised vehicles lead to high per capita emission levels.

- The United States continued to contribute the highest transport emissions globally in absolute terms (1.74 gigatonnes of CO_2 equivalent) while also having one of the largest per capita values (4.2 tonnes) in 2023.[100]
- In Europe, where policies tend to require increasingly strict emission standards for road transport, the average CO_2 emissions of new cars sold continued to fall from 131 grams per kilometre (g/km) in 2020 and 115 g/km in 2021 to 107 g/km by 2023.[101]
- However, Europe as a whole recorded per capita transport greenhouse gas emissions of 1.66 tonnes of CO_2 equivalent in 2022, above the global average of 0.89 tonnes and the third highest among regions (after North America and Oceania).[102]
- In Australia, the emission intensity for new cars sold in 2023 averaged 150 g/km, similar to levels in Canada and the United States.[103] For all vehicles on the road in Australia in January 2024, the emission intensity was 193.7 g/km, virtually unchanged compared to new vehicles sold a decade earlier.[104]
- Australia had relatively high per capita transport emissions of 3.1 tonnes of CO_2 equivalent in 2023.[105]

Emission standards have helped limit emissions to some extent where they have been implemented, but much of the world remains uncovered by such standards. In many low- and middle-income countries, continued importation of vehicles through the second-hand market has resulted in a fleet with older vehicles that are more polluting and less safe than newer models.[106] (See Spotlight on Second-hand vehicles.)

- In 2019-2020 (latest data available), 85% of vehicles in Africa were used imports from Europe, the United States and Japan – often failing safety and emission standards in their home countries.[107] Overall, 80% of vehicles in Africa fell below Euro 4 emission standards.[108]
- In Asia, vehicle emission standards and fuel quality improvements have cut some pollutants by 2% annually between 2000 and 2022, while registrations of vehicles with emission standards at Euro 4 or above rose from 9% in 2010 to 89% in 2023.[109]
- The EU's CO_2 emission standards called for the end of ICE car sales starting in 2035 and for the near-complete phase-out of diesel heavy-duty vehicles by 2040.[110]

FIGURE 4. Per capita greenhouse gas emissions from road transport by country, 2023



Source: See endnote 99 for this section.

However, timelines have since been extended at both the EU and national levels due to fierce global competition, international tariff disputes, factory closures and job losses – potentially derailing emission reduction efforts.[111] European automakers have sought further concessions or even a complete moratorium of the ICE phase-out.[112]

- The average energy efficiency of new light-duty vehicles sold in Australia and New Zealand in 2021 trailed other high-income countries and regions such as the EU, Japan and the United States.[113] Both countries have targets to reduce emissions from new light-duty vehicles to 58–59 grams of CO_2 per kilometre by 2029.[114]

Decarbonising the power grid is critical for achieving transport decarbonisation, with the aim of supplying cleaner energy for both EV charging and battery production.[115] The electricity mix can have a substantial impact on EV emissions, with countries that have high shares of renewable or nuclear energy experiencing much lower emissions from EVs than from ICE vehicles.[116] High motorisation growth rates can contribute to lock-in of unsustainable development, whereas a transition to EVs alongside support for walking, cycling and public transport could take advantage of the transport-energy decarbonisation nexus.[117] (See 5.1 Transport Energy Sources.)

- In some regions, using an EV can reduce the average emissions per 100 kilometres by more than 90% compared to using an ICE vehicle, due to a cleaner electricity mix – such as in Switzerland (100% reduction), Norway (97%), France and Sweden (both 93%).[118]
- As of 2022, Latin America's power mix was an estimated 60% renewable electricity, with Costa Rica and Paraguay reaching shares of nearly 100% renewables; at the same time, region has one of the world's highest motorisation rates.[119]
- In countries where the electricity mix is dominated by fossil fuels, using an EV compared to an ICE vehicle can increase the average emissions per 100 kilometres, such as in Kosovo (95% increase), Poland (57%), Cyprus (39%) and Serbia (26%).[120]
- The carbon intensity of the power grid varies greatly by region, with Latin America and the Caribbean the lowest at 272.4 grams of CO_2 equivalent per kilowatt-hour in 2023, followed by North America (279 grams), Europe (283.9 grams), Africa (430 grams), Oceania (478.9 grams) and Asia (559.5 grams).[121] (See Module 3 Regional Overviews.)

Road safety, health and climate change are interrelated and can influence each other in various ways, with the most direct and severe impacts occurring from road crashes and air pollution (*Box 1 and Figure 5*)**.**[122] Speed management in particular has a direct impact on emissions and energy efficiency, as higher speeds increase the risk of traffic crashes and fatalities, and also result in higher fuel consumption, emissions and air pollution.[123] Effective speed management can reduce congestion and air pollution, leading to shorter travel times and fewer emissions from idling and stop-and-go traffic (in addition to decreasing road deaths, injuries and crashes).[124] Many countries have seen a trend towards 30 kilometre-per-hour speed limit zones in city centres and residential areas, as well as greater use of road speed limiters and speed cameras.[125] (See 1.7 Driving Health and Wellbeing Forward: The Critical Link with Transport.)

Box 1. Facts and figures on the human toll of road transport by region, with a focus on road safety and air pollution

Africa

The region has low motorisation compared to the rest of the world yet has the world's deadliest roads.

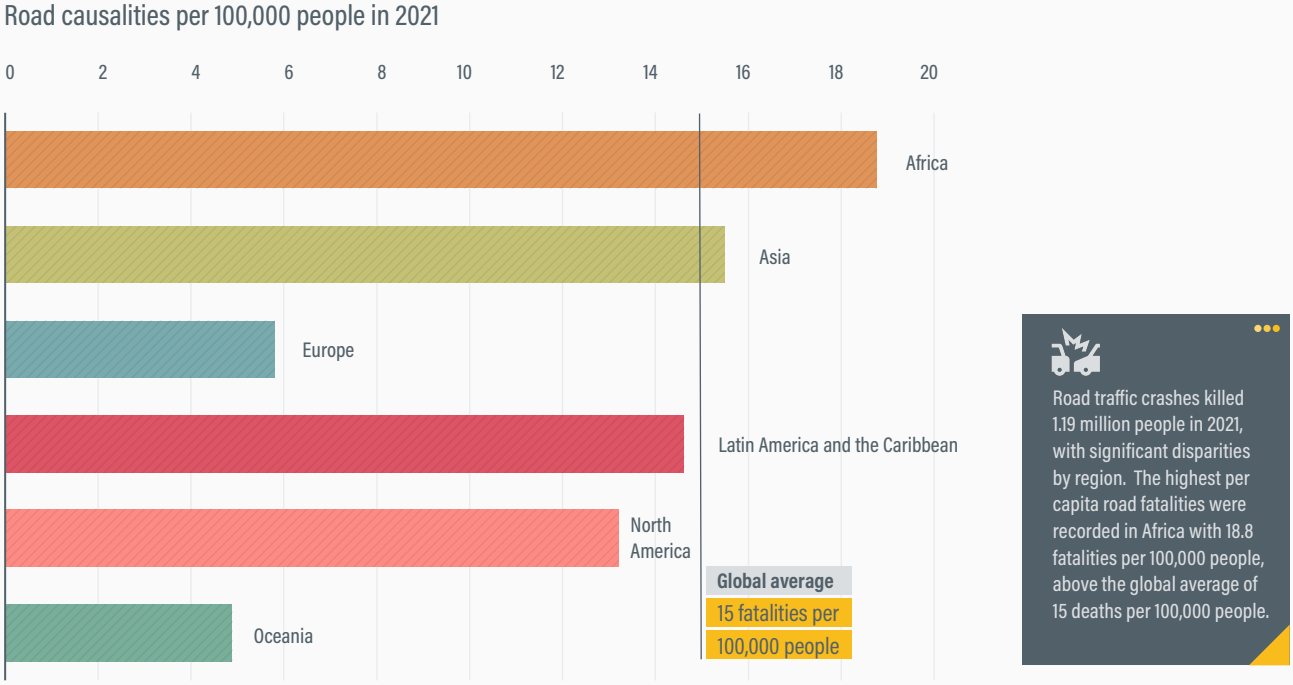
- In 2021, Africa averaged 18.8 road fatalities per 100,000 people – the highest rate globally, above the global average of 15 deaths (Figure 5).
- Over 50% of road fatalities involve vulnerable users: pedestrians, cyclists and motorcyclists.
- Several countries (e.g., Cameroon, Kenya, Morocco) are addressing road safety through policy reforms and innovative, context-specific initiatives.
- Transport caused 3.2% of air pollution and 1.01 premature deaths per 100,000 people in 2019, below the global averages of 6% and 2.3 deaths. (See 3.1 Africa Regional Overview.)

Asia

With half of the world's road deaths, road safety remains a public health challenge, while deadly air pollution from transport persists despite some progress.

- Road deaths averaged 15.5 per 100,000 people, above the global average of 15 deaths in 2021.
- Asia suffered more than half of the world's road deaths in 2021, with 35% being motorised two-wheeler users, and 22% pedestrians.
- Several countries (e.g., Laos, Nepal, the Philippines) are advancing road safety through multi-year action plans.
- 8% of air pollution comes from transport, leading to 3.2 premature deaths per 100,000 people in 2019, above the global averages of 6% and 2.3 deaths.
- Nearly all people in East and South-East Asia faced air pollution levels above the World Health Organization's (WHO) safe air standards in 2024.
- Vehicle emission standards and fuel quality improvements cut some pollutants 2% annually during 2000-2022.
- Vehicle registrations with Euro 4 or above emission standards rose from 9% in 2010 to 89% in 2023. (See 3.2 Asia Regional Overview.)

FIGURE 5. Road casualities per 100,000 people by region and compared to the global average



Europe

Despite declines, most countries are not on track to meet the region's road safety target, while harmful transport noise and pollution challenges continue to pose major health risks.

- The region has the lowest road traffic fatalities globally, at 5.8 deaths per 100,000 people, well below the global average of 15 deaths in 2021. Yet road fatalities were the leading cause of death for 5-29 year-olds in 2023. One person dies every seven minutes, and more than 62,000 people were killed on the roads every year as of 2021.
- Despite a 3% decrease in road fatalities in 2024, most EU countries are off-track to meet the region's goal of halving road fatalities by 2030.
- Transport accounted for 9% of air pollution and an estimated 4.1 premature deaths per 100,000 people in 2019, above the global averages of 6% and 2.3 deaths.
- More than 100 million Europeans were exposed to harmful transport-related noise, mainly from road traffic, in 2022, despite EU policies and regulations on motor vehicle and aircraft noise.
- Over 20% of the population lives in road traffic noise levels that exceed EU limits for harm to health and well-being; this rises to above 30% when considering stricter WHO thresholds (2024). (See 3.3 Europe Regional Overview.)

Latin America and the Caribbean

Road safety challenges persist, with pedestrians and cyclists bearing the brunt.

- The region's road traffic deaths averaged 14.6 per 100,000 people, near the global average (15); average deaths ranged from 5.1 in Trinidad and Tobago to 31.3 in Haiti in 2021.
- Pedestrians and cyclists accounted for nearly half of all road deaths in some countries in 2021.
- Only 7.8% of cities in the region met WHO air quality guidelines in 2024.
- Excessive exposure to particulate matter caused by transport contributed to nearly 180,000 premature deaths in 2019 – or nearly 6.1% of total deaths, similar to the global average (6%). (See 3.4 Latin America and the Caribbean Regional Overview.)

North America

Transport pollution remains more than double the global average, and road safety lags, with US roads among the least safe of high-income countries.

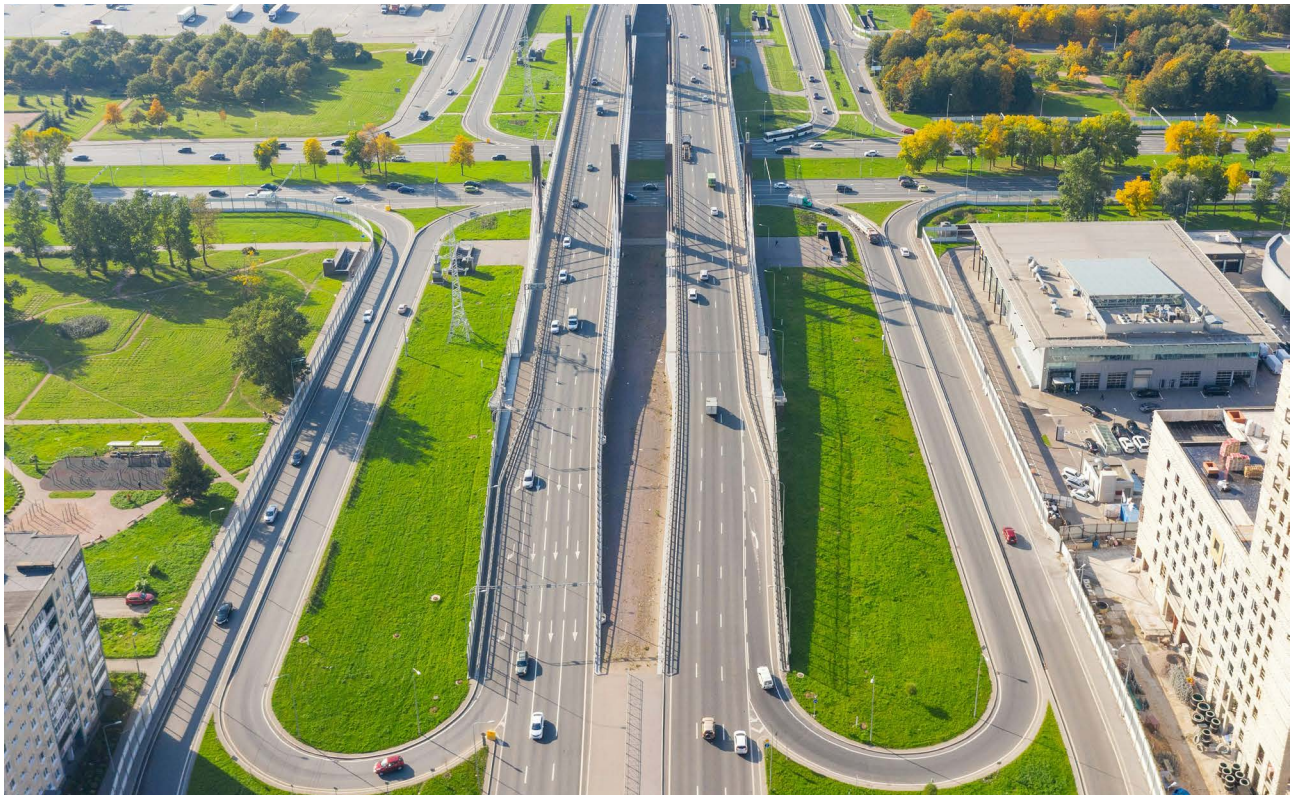
- Transport accounted for 12.6% of the region's air pollution in 2019, compared with a global average of 6%.
- In the United States, transport contributed 15% of air pollutant emissions, resulting in 2.29 premature deaths per 100,000 people, consistent with the global average of 2.3.
- In Canada, transport contributed 9.8% of air pollution, resulting in 1.01 premature deaths per 100,000, half the global average.
- North America recorded 13.2 road casualties per 100,000 people in 2021, slightly below the global average of 15 road deaths.
- Road traffic fatalities and injuries cost 1.9% of Canada's gross domestic product (GDP) and 5% of the US GDP in 2021.
- Less than 40% of roads assessed in the region meet the recommended three-star safety standards for pedestrians and cyclists, compared to 60% for motorcyclists and more than 80% for vehicle occupants.
- The United States had among the worst road safety records in 2021 among high-income countries, ranking just behind Saudi Arabia, the Bahamas and Guyana.
- In 2021, 42,939 people died in US road crashes, with around 20% of the deaths being pedestrians or cyclists; pedestrian fatalities in the country reached a record high. (See 3.5 North America Regional Overview.)

Oceania

Road deaths and transport-related air pollution are well below the world average.

- The region's transport sector contributed 2% of air pollutant emissions and 0.3 premature deaths per 100,000 people in 2019, compared to global averages of 6% and 2.3 deaths.
- Road casualties in Oceania were three times less than the global average in 2021, with 4.9 deaths per 100,000 people compared to 15 globally. (See 3.6 Oceania Regional Overview.)

Source: See endnote 122 for this section.



Factors contributing to the slow decline in road deaths and injuries include increased road congestion, higher speeds, driver distraction and fatigue from longer commute times.[126] Globally, road deaths increased 4.5% between 2020 and 2023, although they remained 5.5% below the pre-pandemic levels of 2019.[127] Most countries have maintained lower road fatality numbers, although road deaths increased 10% or more in 2023 compared to pre-pandemic levels in many places, such as Ireland (+23%), Switzerland (+22%), Türkiye (+16%), Armenia (+13%), the United States (+11%) and Estonia (+10%).[128]

Efforts to improve the resilience of road infrastructure have lagged, even as economic losses from infrastructure damage due to climate-related events grew an estimated seven-fold between the 1970s and 2010, to USD 1.6 trillion.[129] Multilateral development banks committed USD 24.7 billion for adaptation and resilience projects in 2023, and the World Bank delivered USD 10.3 billion in 2024.[130] To overcome the persistent finance gap, an estimated annual investment of USD 6.9 trillion in sustainable infrastructure will be necessary by 2030.[131]

Traffic congestion returned to pre-pandemic levels already by 2021, and most cities have experienced worsening congestion since 2022.[132] Increased transport demand can lead to greater congestion and delays and associated economic and health costs, especially when density is close to capacity.[133] One estimate found that 55% of urban areas experienced greater congestion in 2024 than in 2023, whereas just 28% of cities had a reduction in delays.[134] (See 1.7 Driving Health and Wellbeing Forward: The Critical Link with Transport.)

- In 2024, Istanbul topped the list of cities worldwide with the most hours lost due to congestion (105 hours per driver per year), followed by New York City and Chicago (102 hours each) and London (101 hours).[135]
- The losses due to congestion come at a significant cost to economic productivity, with delays in Germany and the United States averaging 43 hours lost per driver per year – around *a full work week* – and 61 hours in the United Kingdom.[136]
- Congestion in Kampala (Uganda) cost the city USD 1.5 million per day in 2020, or 4.2% of its GDP.[137]

Autonomous vehicles have the potential to decrease transport emissions if they are shared and regulated; however, increases in vehicle size and distances travelled could lead to higher emission growth, although these impacts are uncertain.[138] If autonomous vehicles are used mainly for ride hailing, carpooling, or public transport, they could help reduce the number of single-occupancy vehicles on the road and the overall vehicle-kilometres travelled. If they are privately owned and encourage sprawling development, they are likely to increase total vehicle-kilometres travelled and worsen congestion.[139]

Policy and investment developments

Successful strategies to reduce road transport emissions and create healthier, more sustainable urban and rural areas include a mix of the Avoid-Shift-Improve (A-S-I)[ii] framework for both passenger and freight transport.[140] A 2023 study on ambitious but feasible emission mitigation strategies for road transport by 2050 shows that "Avoid" and "Shift" measures would contribute as much as 18% of greenhouse gas reductions, keeping the allocated carbon budget for road transport within 1.7 degrees Celsius of global warming by 2050 (Figure 6).[141]

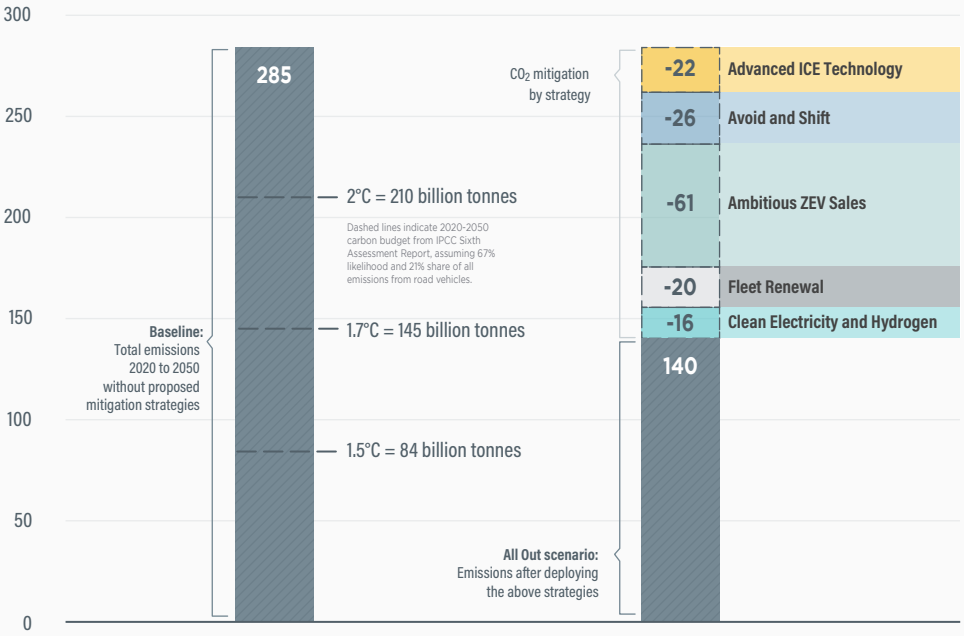
- "Avoid" measures are most important and meant to come first, followed by "Shift" and then "Improve". This prioritisation is due to not only climate benefits but also health, economic and social benefits.[142]
- The most successful "Improve" strategies combine carbon or fuel taxes with incentives for zero-emission vehicles, but prioritising measures that incentivise walking, cycling and public transport for passenger transport ("Avoid" and "Shift" measures) can maximise emission reductions and many other benefits; for freight, this means prioritising water-, rail-, and electrified road-based freight and solutions such as cargo bikes for last-mile deliveries.[143]
- Alongside "Improve" measures, support for renewable energy is crucial for decarbonising the energy supply for motorised vehicles.
- Applying the A-S-I framework can help with more holistic, sustainable planning and investment to support a shift from the auto-centric model towards more liveable environments.[144]

Among "Avoid" and "Shift" policies, a few jurisdictions have adopted targets to reduce vehicle travel, particularly at the sub-national level.

- A 2024 executive order in the US state of Maryland strengthened a target to reduce vehicle miles travelled 20% by 2050 as part of its climate strategy, including measures such as infrastructure improvements and land-

FIGURE 6. Mitigation potential of feasible emission reduction strategies for road transport

Cumulative well-to-wheel CO_2 transportation emissions (billion tonnes) projected from 2020 to 2050



Successful strategies to reduce road transport emissions and create healthier, more sustainable urban and rural areas include a mix of the Avoid-Shift-Improve framework for both passenger and freight transport. "Avoid" and "Shift" measures would contribute as much as 18% of greenhouse gas reductions, keeping the allocated carbon budget for road transport within 1.7 degrees Celsius of global warming by 2050.

Source: See endnote 141 for this section.

ii The Avoid-Shift-Improve framework has been central to sustainable, low-carbon transport for more than a decade. It follows an implicit hierarchy, with appropriate and context-sensitive "Avoid" measures (which avoid and reduce the need for motorised travel) intended to be implemented first, followed by "Shift" measures (which shift to more sustainable modes) and finally by "Improve" measures (which improve transport modes). See https://slocat.net/asi and H. Dalkmann and C. Brannigan (2007), Transport and Climate Change, Module 5e: Sustainable Transport – A Sourcebook for Policy-Makers in Developing Cities, GIZ GmbH, https://changing-transport.org/wp-content/uploads/2007_dalkmann_brannigan_transportandclimatechange.pdf.

use changes to improve alternatives to driving.[145]
- Similar regulations were adopted in 2022 in the US states of California (reducing vehicle miles travelled 25% by 2030) and Colorado (reducing vehicle miles travelled 6-9% by 2030).[146]
- In 2024, Glasgow (United Kingdom) set a target to reduce vehicle kilometres travelled 30% by 2030, while the national target in Scotland aims to reduce them 20% by 2030.[147]

Building roads and establishing urban-rural connections can support economic development; however, if these are not pursued with a sustainable, resilient vision, they can lead to unsustainable auto-centric, sprawling development.[148] Paradoxically, where road networks already exist, building more roads and widening existing roads leads to increased traffic.[149] Recognising these challenges, countries across all income levels have begun shifting their approaches and implementing rural transport programmes.

- Wales (United Kingdom) passed a new transport strategy in 2021 that subsequently guided the revision of the region's transport appraisal guidance in 2024.[150] These efforts resulted in new approaches that prioritised an accessible, sustainable and efficient transport system while discouraging large-scale road infrastructure projects.[151]
- As of 2023, 11 low- and middle-income countries had adopted UN-Habitat guidelines for strengthening urban-rural planning, and 20 had strengthened urban-rural connections.[152]

Investment in inland transport infrastructure (road, rail and inland waterways) has been decreasing in some countries, although several continue to invest heavily in road transport.[153] High-income countries in particular have had low ratios of transport infrastructure investment relative to GDP and stable investment levels – a sign of mature transport systems.[154]

- At least four countries allocated more than 2% of their GDP to transport infrastructure (nearly all of it to road infrastructure) in 2023, including Azerbaijan, China, North Macedonia and Serbia.[155]
- Among high-income countries, Hungary and Norway had the highest ratios of transport infrastructure investment to GDP in 2022 (1.8% and 1.4%, respectively) as well as the highest growth in transport investment compared to one decade earlier.[156]
- Azerbaijan, Bulgaria, Georgia and Serbia had high ratios of transport infrastructure investment to GDP due to their critical location for connectivity and trade between Central Asia and Eastern Europe; overall, China had the highest transport infrastructure investment as a share of GDP in 2022.[157]

Policies have been adopted at various levels to address road safety, particularly aimed at speed management and sometimes linked to improving the sustainability of transport systems. Research has shown that lowering average speed limits by just 5% can result in a 20% reduction in road deaths.[158] In 2023, the WHO released guidelines for reducing speeding globally to decrease road injuries and deaths.[159]

- Sub-national governments that have enacted recent speed management plans include the cities of Durango (United States) and Meaford (Canada) in 2024, and the US state of Nevada in 2022.[160]
- In 2024, Lima (Peru) launched a comprehensive urban mobility programme that included several measures aimed at reducing speeds and improving safety.[161]
- Kumasi (Ghana) launched a speed management plan in 2024 with concrete measures to strengthen road safety efforts.[162]

Between 2023 and 2025, an increasing number of jurisdictions adopted targets for reducing average vehicle emissions, as well as scrappage policies that help governments accelerate fleet renewal, reduce emissions and encourage the adoption of cleaner, more efficient vehicles. A few countries had vehicle scrappage policies that incentivised trading in an older polluting vehicle for a newer, cleaner model.

- In early 2025, Brazil implemented the first phase of emission standards with substantial limit reductions for vehicles, increasing in stringency to 2032.[163]
- Morocco adopted the Euro 6 emission standard starting in January 2023, and Thailand adopted the Euro 5 emission standard starting in January 2024.[164]
- The EU planned to impose stricter standards on auto manufacturers in 2025, with carmakers expected to close their gap in compliance with the targets during the year; most were close to meeting the targets by the first half of 2024, while some (such as Volvo Cars) had already achieved it.[165]
- US targets for reducing the average CO_2 emissions of new passenger cars contributed to a consistent decline in emissions between 2000 and 2023, with a 2035 target of 0 grams per kilometre.[166] However, manufacturers had no pressure to further reduce emissions following a significant reduction in 2021, so reductions in subsequent years occurred at a slower pace.[167]
- India enacted a scrappage policy at the national level that mandates fitness tests for older vehicles and offers incentives for scrapping unfit ones, aiming to reduce air pollution and promote safer, cleaner vehicles.[168]
- France and Romania also had scrappage policies at the national level, while at the city level, the 14 German cities

with the poorest air quality had a government-backed trade-in incentive.[169]

In some places, rules for vehicle emission reductions include flexibilities around compliance that hinder their effectiveness, while in other cases emission rules have been weakened or removed altogether.

- In 2025, the European Commission launched a new Industrial Action Plan for the automotive sector that outlines a strategy to accelerate the uptake of zero-emission vehicles in corporate fleets; however, the plan also includes increased flexibility on compliance with the emission target.[170]
- Mexico enacted a CO_2 emission standard for light-duty vehicles in 2024, but the standard's compliance flexibilities show it will be insufficient to reach the country's Nationally Determined Contribution (NDC) and 2030 decarbonisation goals.[171]
- In the United States, the new administration in 2025 reversed steps towards the decarbonisation of road transport adopted in previous administrations, including removing vehicle emission rules that would have required manufacturers to offer an increasing number of EVs.[172]

EV adoption has been the most common measure for reducing emissions in the road transport sector, since EVs produce far fewer emissions than traditional petrol vehicles but allow for continuation of the auto-centric model.[173] **In addition, several governments have adopted targets for full or partial ICE vehicle bans or EV targets, although typically these are only for vehicle sales rather than the overall stock.** During 2022-2023, total investments of USD 275 billion in EVs and USD 195 billion in batteries were announced globally, boosting confidence in the electrification of road transport across markets.[174] In the United States, the new administration withdrew a previous target for 50% EVs in new vehicle sales by 2030.[175] (See 5.1 Transport Energy Sources and 5.2 Road Vehicle Electrification.)

As EV uptake increases, governments have taken steps to support the deployment of charging infrastructure and battery swap stations. However, they may need to develop new taxation approaches to replace the losses in income from fuel taxes on ICE vehicles. The UK government estimates that much of the USD 46 billion (GBP 37 billion) in fuel and vehicle excise duties collected in 2020 would be lost as the fleet transitions to EVs (which did not face similar taxes in order to encourage uptake).[176] (See 5.2 Road Vehicle Electrification.)

By 2023, the number of countries with support measures for EVs surpassed those with biofuel blending mandates, which until then had been the most common policy for decarbonising road transport.[177] A total of 60 countries had biofuel blending mandates by the end of 2023, up from 56 countries in 2022 (but still below the 65 countries in 2021).[178] Ten countries introduced new or revised mandates in 2023, with most trends towards increasing the mandated blending shares, although these are not always enforced.[179] (See 5.1 Transport Energy Sources.)

The deployment of EVs will not address concerns such as traffic congestion, urban sprawl and the amount of public space devoted to vehicles.[180] **In some places, increases in parking fees in recent years have been correlated with higher use of walking, cycling and public transport.**[181] Parking occupies a great deal of public space, sometimes far outnumbering the actual vehicle fleet.[182] A growing number of European cities (especially in France) have implemented higher parking fees to counter the trend towards SUVs and other larger vehicles ("auto obesity").[183] (See 4.2 Integrated Transport Planning.)

For freight transport, low-carbon options include the adoption of fuel-efficient technologies and alternative fuels, carbon pricing mechanisms, promotion of multi-modality, cargo consolidation centres, last-mile sustainable urban logistics and autonomous deliveries.[184] **Although policy progress has been slower for freight than passenger vehicles, some advances towards reducing emissions occurred in recent years.** A comprehensive and integrated approach to decarbonising freight transport could provide significant environmental and social benefits, but policies targeting heavy-duty vehicles have lagged behind those for light-duty vehicles.

- As of 2025, just five countries – Canada, China, India, Japan and the United States – had national fuel economy standards for heavy-duty vehicles, and no additional countries have adopted such standards since 2017.[185]
- In 2024, the EU approved a 90% CO_2 emission reduction target for new heavy-duty vehicles by 2040.[186]
- Jurisdictions that adopted targets for zero-emission heavy-duty vehicles included Ireland (targeting 35% of registrations by 2030) and the US state of California (targeting 100% of sales by 2042).[187]
- In 2023, the United States adopted tax credits for zero-emission commercial and heavy-duty vehicles, but the future of the policy was unclear due to the change in administration in 2025.[188]
- New York City (United States) transitioned its entire heavy-duty vehicle fleet to 100% renewable diesel in 2024.[189]

Partnerships in action

- The organisation **Bridges to Prosperity** is dedicated to rural infrastructure development, connecting rural communities through trail bridges and complementary infrastructure to increase resilience and to unlock access to health care, education and markets.[190]
- The Asian Development Bank's **Green Roads Tool Kit**, published in 2024, provides a collection of good practices for development and management of roads including concerns for sustainability, resilience and inclusivity.[191]
- In 2023, **ICLEI–Local Governments for Sustainability** set up an "ecologistics community" to encourage sustainable urban freight in cities globally, including the development of indicators to serve as a guide for local governments.[192]
- The **International Road Assessment Programme (iRAP)** published new guidance in 2024 for safe and inclusive road design aimed at road engineers and infrastructure designers in the Kyrgyz Republic, Tajikistan and Uzbekistan.[193]
- The **International Transport Forum (ITF)** produced a policy report in 2023 on taxation during the transition to electric vehicles and options for reforming vehicle and road-use taxes.[194]
- The **Road Asset Management Committee** of the International Road Federation (IRF) brings together a network of practitioners to share knowledge and develop improved practices for better management of road assets globally.[195]
- **UN-Habitat** launched a small funding call in 2024 for initiatives to enhance road safety in Africa and Mediterranean cities.[196]
- The **UN Road Safety Fund** supported Senegal in 2025 through its Ten-Step Plan for Safer Road Infrastructure following successful implementation in Tanzania in 2023.[197]
- In 2023, the **World Road Association (PIARC)** published a report on case studies of rural roads for development in Africa to raise awareness and offer solutions for improving rural development and road infrastructure, highlighting the importance of roads for accessibility and mobility.[198]
- The **ZEFES project**, launched by the International Road Transport Union (IRU) in 2023, aims to demonstrate real-world applications of battery electric vehicles and fuel cell electric vehicles in Europe for long-haul freight transport.[199]

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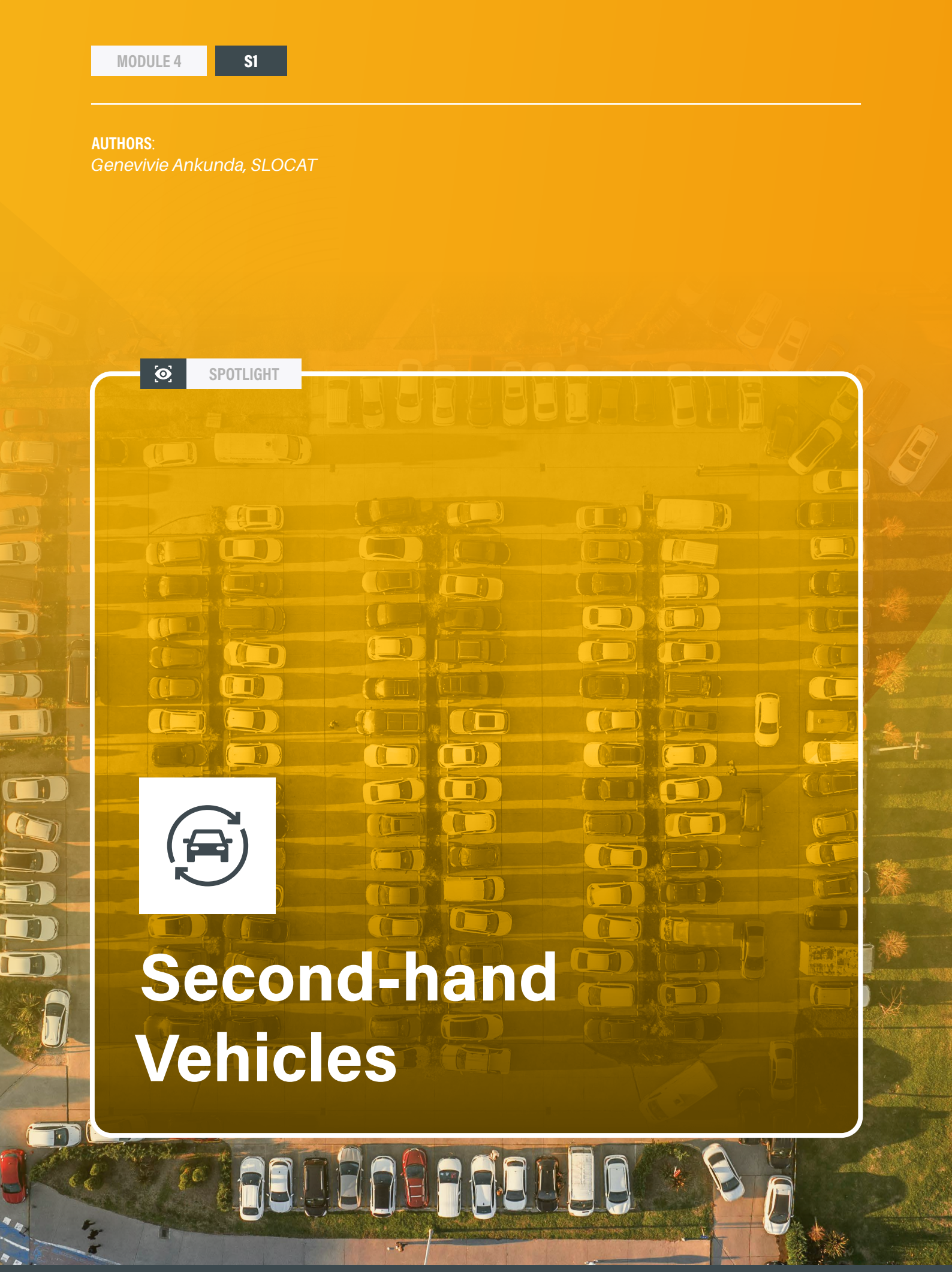
SPOTLIGHT



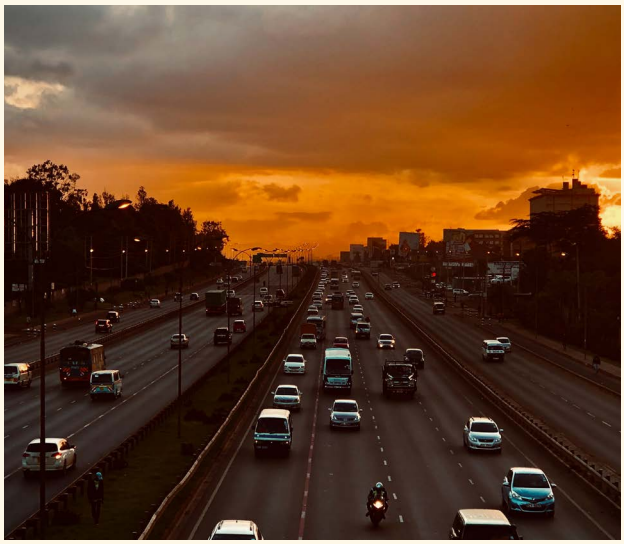
Second-hand Vehicles

KEY FINDINGS

- Globally, the primary method of acquiring an internal combustion engine (ICE) vehicle has been through the acquisition of a second-hand vehicle, such that the used car market has become larger than the new car market in some countries.
- Second-hand vehicles play a dual, contradictory role in transport sustainability. On one hand, the second-hand market allows improved access to mobility by providing lower-cost vehicle options, and enables the extension of vehicle lifespans. On the other hand, the export of high-emission vehicles, many of which are not roadworthy, has major safety implications for users, as well as negative environmental impacts for importing countries.
- Trade in used electric vehicles presents opportunities for faster, more affordable transfer of cleaner technologies (including electric vehicles) to low-income countries and to low-income households in high- and middle-income countries.
- Optimising the second-hand vehicle market requires strengthening regulations to avoid the import and export of unsafe vehicles that are near the end of life; ensuring battery longevity in used electric vehicles; and addressing the environmental cost of older, less efficient ICE vehicles and the disposal of end-of-life vehicles and components.

Demand, use and access

- The global used vehicle market has expanded steadily in recent years, driven by factors such as economic shifts, changing consumer preferences and advancements in technology.
- An estimated 23 million used light-duty vehicles were exported to the Global South from the four major exporting countries between 2015 and 2022. Of these, 34.5% were from Japan, 31.1% from the European Union (EU), 23.9% from the United States and 10.5% from the Republic of Korea.
- Although the EU, the United States and the Republic of Korea led exports of used light-duty vehicles as of 2022, exports from China have risen exponentially and in the next ten years are projected to exceed the combined exports from all countries in the Organisation for Economic Co-operation and Development (OECD).
- The largest exporters of used heavy-duty vehicles have been Japan, the EU, and the Republic of Korea, which exported 2.4 million units between 2015 and 2022, comprising 90% trucks and 10% buses.
- Half of all used light-duty vehicle exports went to low-income (18%) and lower-middle income countries (32%) between 2015 and 2018; meanwhile, most used heavy-duty vehicles (60%) have been traded in high-income or upper-middle income countries.
- Africa was the largest importer of second-hand light-duty vehicles between 2015 and 2022, receiving around 7.5 million units (33%). African countries represented 6 of the top 10 importing countries of used light-duty vehicles from the EU during that period. The next highest importing regions were Eastern Europe, the Caucasus, and Central Asia (around 5.4 million units, or 24%), Asia-Pacific (3.7 million units, 16%), the Middle East (3.3 million units, 15%) and Latin America and the Caribbean (2.8 million units, 12%).



KEY FINDINGS

- Although Africa was the leading importer of used vehicles, the region received only 1% of the used battery electric vehicles exported between 2015 and 2022 (1,431 units), signalling limited opportunities for clean transport technology transfer and trickle-down electrification. The largest importer of battery electric vehicles in this period was the region of Eastern Europe, the Caucasus and Central Asia.
- Imported used vehicles accounted for more than 60% of the vehicles added to Africa's fleet annually as of 2020. In 2018, 85% of the region's vehicle fleet was used imports. African countries also have the highest median age of used vehicle imports, at more than 15 years, compared to less than 3 years in Norway.
- Two- and three-wheelers are an increasingly popular component of Africa's second-hand vehicle fleets. Although specific data are not available, the growing share of used two- and three-wheelers in some countries' fleets calls for closer monitoring, data collection and reporting to prevent harmful environmental and safety effects.
- Factors driving the growing used vehicle market globally include supply constraints, technological and price shifts, changing vehicle preferences, environmental policies, and price disparities between new and used vehicles.

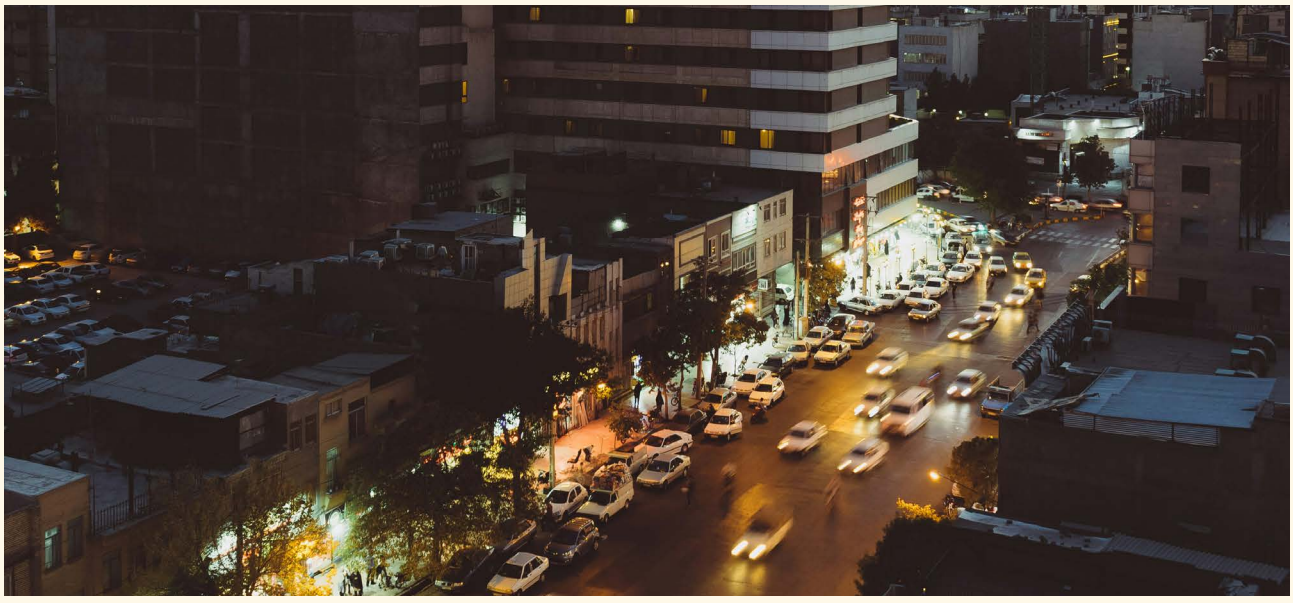
Sustainability and climate trends

- The poor quality of used vehicles exported to emerging markets raises environmental, safety, and public health concerns and contributes to overall emissions from road transport.
- In 2020, light-duty and heavy-duty vehicles together emitted more than 5,000 million tonnes of CO_2, accounting for more than 70% of total transport emissions.
- Older vehicles produce significantly more air pollutant emissions than new vehicles, particularly if they lack good maintenance and high-quality components. As of 2019, more than 80% of Africa's road vehicles fell below the Euro 4 vehicle emission standards, while also lacking valid roadworthiness.
- In addition to higher pollution rates, inspections of vehicles being exported to Africa found numerous vehicles to be unsafe, having been involved in accidents or with severe structural damage.
- In 2021, an estimated 1.19 million people were killed in road traffic crashes globally; such crashes were the leading cause of death for young people aged 5-29 and the 12th leading cause of death among all age groups as of 2021. The vast majority (90%) of the deaths in 2021 were in low- and middle-income countries, even though these countries accounted for only 54% of the global vehicle fleet that year.
- Although the used vehicle trade supports resource efficiency in automobile production, the importing countries carry the burden of dismantling and responsibly disposing of used vehicles when they reach their end of life, to avoid environmental damage. Externalising this responsibility to low-skilled informal waste workers, usually with limited or no protective equipment, exposes the workers to personal and occupational health and safety problems.
- Although second-hand vehicles are cheaper and have reduced foreign exchange requirements for importing countries, a growing dependence on used car imports has hindered the development of domestic auto manufacturing industries in many places.
- As high-income economies switch to electric vehicles, growing numbers of low-demand used ICE vehicles are being exported to emerging economies; this will likely undermine importers' efforts to shift to electric vehicles.
- The supply and pricing of second-hand vehicles has evolved in some regions. In the United States, the price of "lightly used vehicles" hit record highs in 2025, in part because the shortage of semiconductor chips during the COVID-19 pandemic affected the supply of then-new (later used) vehicles. This trend is expected to continue, given the potential effects of expanding tariffs on vehicle supply chains.
- The used vehicle market provides employment opportunities for large numbers of people in the sales and after-sales sectors in both exporting and importing countries, although data on the latter are limited.

KEY FINDINGS

Policy and investment developments

- In 2023, the EU – as a leading exporter of used vehicles – proposed stricter export requirements through its regulation on end-of-life vehicles, covering all aspects of a vehicle from design, to market placement, to treatment during disposal.
- The Safer and Cleaner Used Vehicles for Africa project, launched in 2022, aims to improve road safety and reduce pollution by promoting the import of safer and more environmentally friendly used vehicles into Africa.
- In 2020, the Economic Community of West African States (ECOWAS) adopted a used vehicles policy for the region, setting age limits of 10 years for heavy-duty vehicles and 5 years for light-duty vehicles, as well as a minimum Euro IV emission standard for all imported vehicles. The policy has a 10-year implementation period to 2030. In 2022, the East African Community similarly adopted the Euro IV standard for new and used heavy-duty and light-duty vehicles as well as in-use emission limits.
- However, wider regional harmonisation of policies and standards is critical for enforcement of these policies, especially in light of the African Continental Free Trade Area (AfCFTA). As of 2021, 55% of African countries did not regulate imports of used heavy-duty vehicles and/or lacked a comprehensive set of regulations.
- Harmonisation of policies for heavy-duty and light-duty vehicles is critical to maximise the environmental gains from restricting imports of high-polluting vehicles.
- Several importing and exporting countries of second-hand vehicles have included regulations and measures related to these vehicles in their national policies, including in Nationally Determined Contributions (NDCs) towards reducing greenhouse gas emissions under the Paris Agreement. These measures include restricting or banning used vehicle imports (based on age, mileage or emission standards), fiscal instruments, inspection licensing and certification, and selective technology bans.
- At the national level, several countries have put in place import bans or penalties on second-hand vehicles, based on either age or mileage. Apart from the complete import bans by Egypt and South Africa, age restrictions are the most prevalent in Africa.
- Subsidies for second-hand electric vehicles can bring equity benefits and complement subsidies for new electric vehicles, and are essential for optimal policy outcomes in the transition to net zero greenhouse gas emissions.
- Innovations in battery life-cycle management are critical for used electric vehicles.



Context, challenges and opportunities

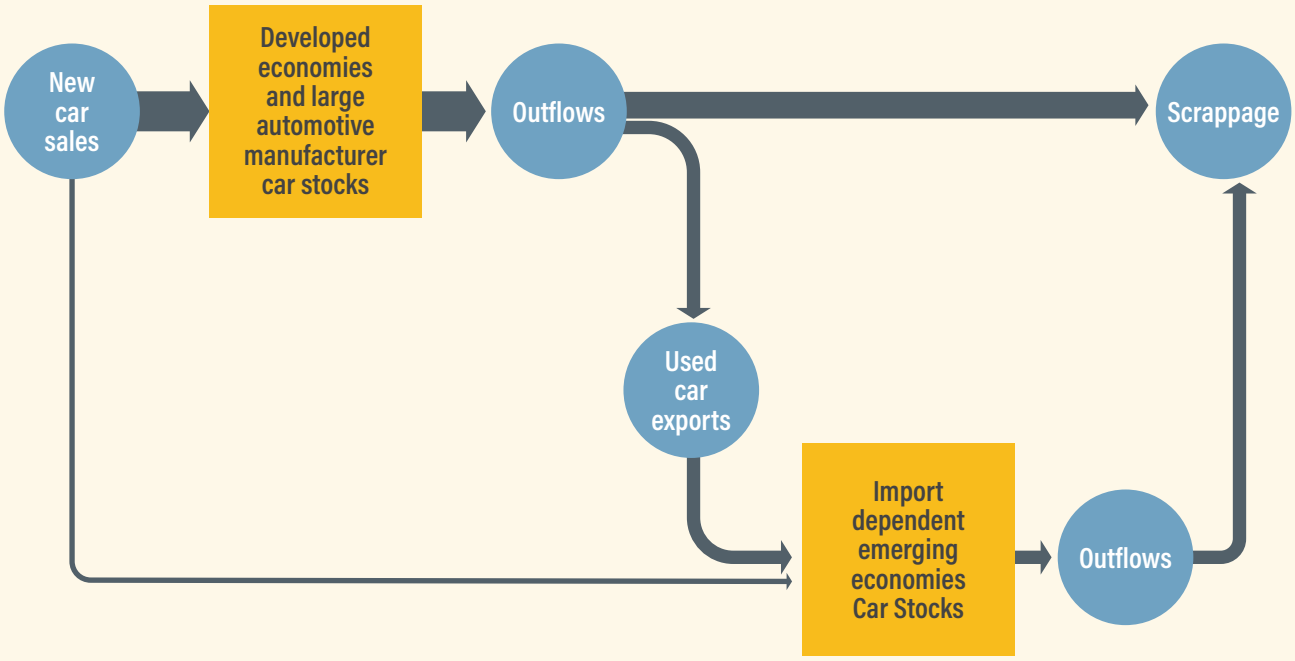
Second-hand vehicles, also known as used or previously owned (pre-owned) vehicles, are vehicles that have been registered by at least one previous owner and are resold or traded after their initial purchase from a manufacturer or dealership. Individuals acquire second-hand vehicles in various ways, including buying them domestically from previous owners or vehicle resellers and purchasing vehicle imports from other countries or regions (Figure 1).[1]

Globally, the primary method of acquiring an internal combustion engine (ICE) vehicle has been through the acquisition of a second-hand vehicle, such that the used car market has become larger than the new car market in some countries.[2] According to the latest data available, 23 million used light-duty vehicles were traded between 2015 and 2022, and 2.9 million used heavy-duty vehicles were traded between 2015 and 2020.[3] In the United States, around 62% of low-income households acquire vehicles by buying used, while in the European Union (EU) the share is 80% overall (90% in low- and middle-income groups).[4] Although many low- and middle-income countries rely on imports of used buses and trucks, a high share of used heavy-duty vehicles is traded in high-income and upper-middle-income countries.[5]

Second-hand vehicles play a dual, contradictory role in transport sustainability. On one hand, the second-hand market allows improved access to mobility by providing lower-cost vehicle options, and enables the extension of vehicle lifespans. This helps to reduce or slow the production of new vehicles and batteries, the associated carbon dioxide (CO_2) emissions, and the 112 million tonnes of materials required to produce 80 million vehicles annually (as of 2024).[6]

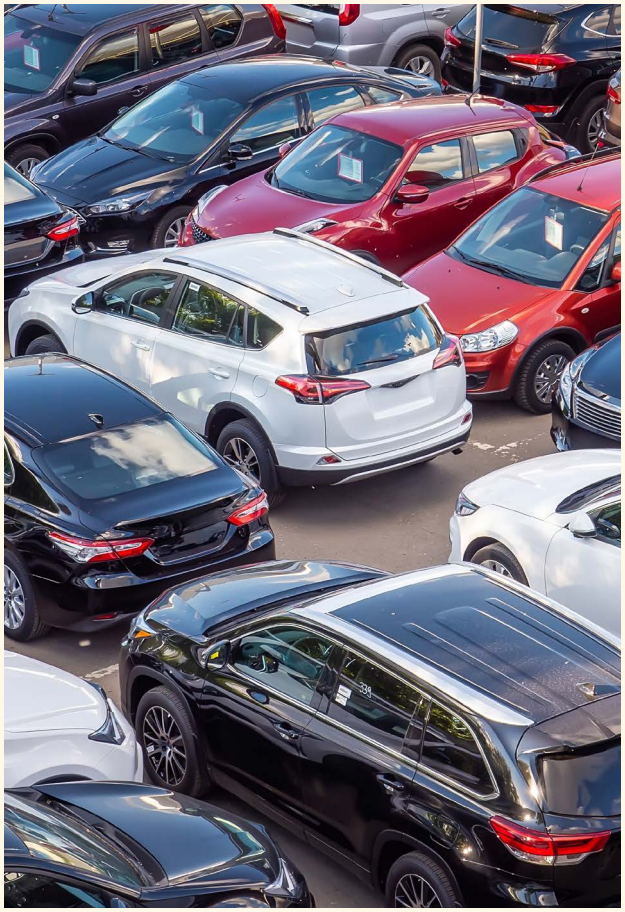
On the other hand, the export of high-emission vehicles, many of which are not roadworthy, has major safety implications for users, as well as negative environmental impacts for importing countries. These impacts, coupled with the implications of the overall growth in private vehicle ownership for climate and sustainability, likely tips the scale against the benefits accrued. In the freight sector, these negative effects are amplified by the nature of the vehicles, their emissions and the market dynamics: for most trucks, the owner-operators struggle to make a living and thus rely on old, poorly maintained, unsafe vehicles.

FIGURE 1. Schematic flowchart of global vehicle flows



Note: The thickness of the arrows qualitatively depicts the volume of the vehicle flows. Used vehicle exports/imports within a region are not shown.

Source: See endnote 1 for this section.



Demand, use and access

The global used vehicle market has expanded steadily in recent years, driven by factors such as economic shifts, changing consumer preferences and advancements in technology. The size of the used car market is projected to increase from USD 1.90 trillion in 2024 to USD 2.70 trillion by 2030.[11]

- Between 2008 and 2021, the quantity of cars imported into the United States increased more than 10-fold, from 8,100 units to 81,000 units.[12] US car exports, meanwhile, declined during this period, rising from 950,000 in 2008 to a peak of 980,000 units in 2017, then falling to 933,000 units in 2023.[13]
- Car exports from the United Kingdom have grown sharply from around 19,000 units in 2000 to 780,000 units in 2022.[14]
- In Japan, car exports increased from 840,000 units in 2010 to 1.3 million units in 2022.[15]

An estimated 23 million used light-duty vehicles were exported to the Global South from the four major exporting countries between 2015 and 2022.[16] Of these, 34.5% were from Japan, 31.1% from the EU, 23.9% from the United States and 10.5% from the Republic of Korea.[17] However, the volume of used vehicles exports could be even higher, given that these data are sometimes underreported.[18]

- In 2022, these four high-income countries exported 3.1 million used light-duty vehicles, representing a 29% increase from 2.4 million in 2015 and a rebound to levels prior to the COVID-19 pandemic.[19]
- The EU was the highest exporter of used light-duty vehicles in 2021 and 2022, overtaking Japan, which was the leading exporter from 2015 until 2020.[20]

Although the EU, the United States and the Republic of Korea led exports of used light-duty vehicles as of 2022, exports from China have risen exponentially and in the next ten years are projected to exceed the combined exports from all countries in the Organisation for Economic Co-operation and Development (OECD).[21] Further analysis is required to assess the impact of this trend – coupled with the growth in "zero-mileage used cars" registrations in China – on the global used vehicle market.[22]

The largest exporters of used heavy-duty vehicles have been Japan, the EU, and the Republic of Korea, which exported 2.4 million units between 2015 and 2022, comprising 90% trucks and 10% buses[i].[23]

Trade in used electric vehicles presents opportunities for faster, more affordable transfer of cleaner technologies (including electric vehicles) to low-income countries and to low-income households in high- and middle-income countries. In the EU, in a case example where vehicle leasing companies electrify their fleets earlier, an estimated 18 million more households (in addition to the projected 33 million households) will have access to cheaper, second-hand battery electric vehicles by 2035.[7] Overall, second-hand vehicle exports from high-income countries and leading exporters are likely to rise with the increasing uptake of electric vehicles and the declining popularity of conventional ICE vehicles.[8]

Optimising the second-hand vehicle market requires strengthening regulations to avoid the import and export of unsafe vehicles that are near the end of life; ensuring battery longevity in used electric vehicles; and addressing the environmental cost of older, less efficient ICE vehicles and the disposal of end-of-life vehicles and components.[9] Innovations in battery life-cycle management are critical for used electric vehicles.[10]

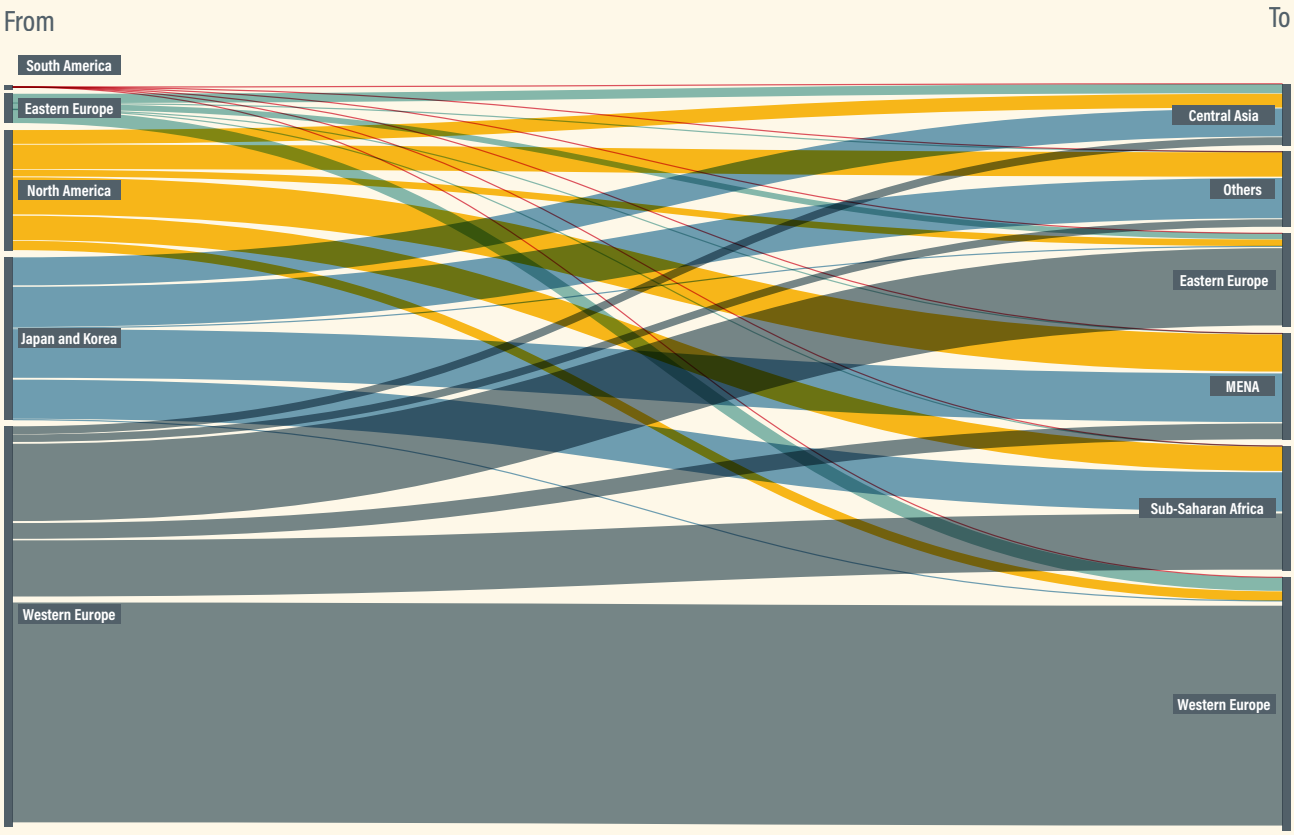
i These data are based on a first and recent (2024) attempt by the United Nations Environment Programme (UNEP) to quantify the volume of used heavy-duty vehicle trade, which is not yet subject to regular updates similar to those available for light-duty vehicles.

- In 2015, 2.9 million used heavy-duty vehicles were sold globally, almost as many as the 3.4 million new units manufactured and sold that year.[24]
- Between 2015 and 2020, Japan was the largest exporter of used heavy-duty vehicles, at around 1.3 million units (67,000 used buses and 1.2 million used trucks).[25]
- During this same period, the EU exported close to 1 million used heavy-duty vehicles (75,000 used buses and 898,000 used trucks), and the Republic of Korea exported 134,000 (106,000 buses and 28,000 trucks).[26]
- Another 1 million used heavy-duty vehicles were traded domestically within the EU between 2015 and 2020.[27]
- Of the three largest exporters, the Republic of Korea exported the largest number of used buses during this period, accounting for 40% of the total.[28]

Half of all used light-duty vehicle exports went to low-income (18%) and lower-middle income countries (32%) between 2015 and 2018; meanwhile, most used heavy-duty vehicles (60%) have been traded in high-income or upper-middle income countries.[29] Between 2015 and 2020, one-third of the world's used heavy-duty vehicles went to the EU, 20% were exported to Africa, and 20% went to Asia-Pacific, with the rest exported to other regions.[30] (Note that some recorded recipient countries are not the final destination for used vehicle imports, as some countries act as transit countries or re-export them elsewhere.)

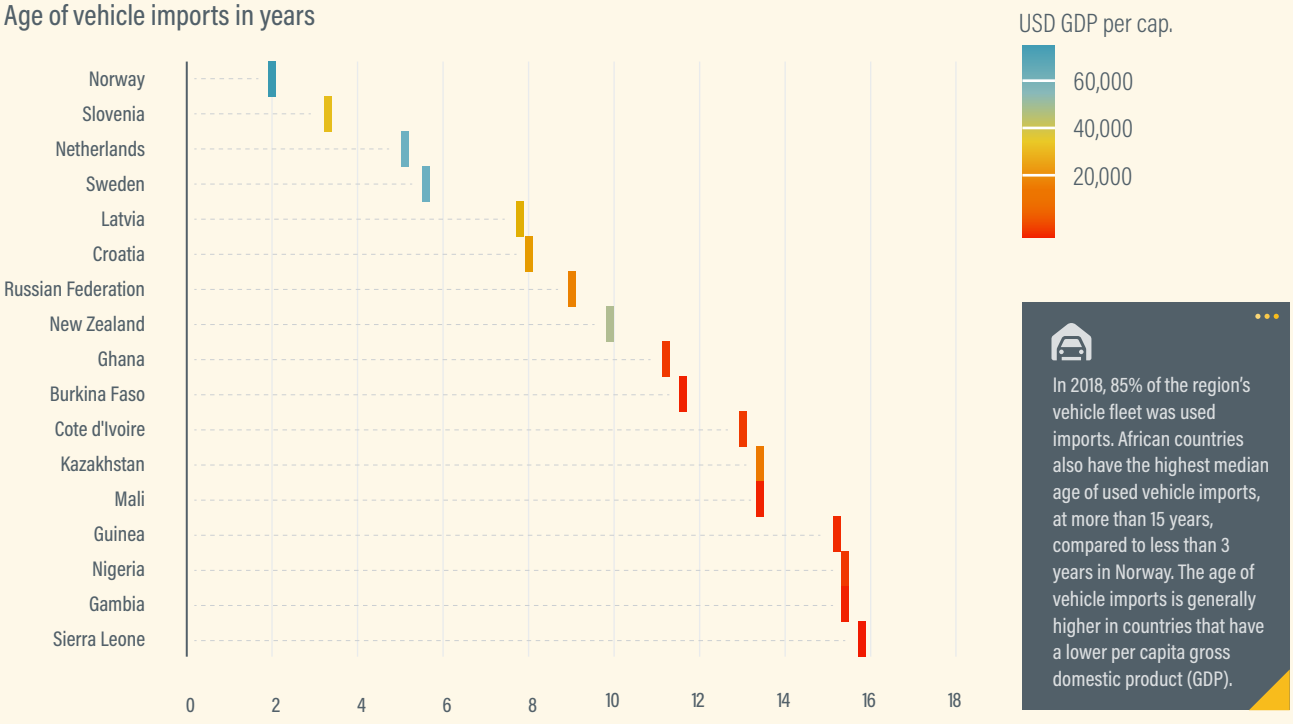
Africa was the largest importer of second-hand light-duty vehicles between 2015 and 2022, receiving around 7.5 million units (33%) (Figure 2)**.**[31] **African countries represented 6 of the top 10 importing countries of used light-duty vehicles from the EU during that period.**[32] **The next highest importing regions were Eastern Europe, the Caucasus, and Central Asia (around 5.4 million units, or 24%), Asia-Pacific (3.7 million units, 16%), the Middle East (3.3 million units, 15%) and Latin America and the Caribbean (2.8 million units, 12%).**[33]

FIGURE 2. Global used vehicle flows by region, 2015-2020



Source: See endnote 31 for this section.

FIGURE 3. Age of vehicle imports versus GDP in selected countries, 2020



Source: See endnote 39 for this section.

Although Africa was the leading importer of used vehicles, the region received only 1% of the used battery electric vehicles exported between 2015 and 2022 (1,431 units), signalling limited opportunities for clean transport technology transfer and trickle-down electrification.[34] **The largest importer of battery electric vehicles in this period was the region of Eastern Europe, the Caucasus and Central Asia.**[35]

Imported used vehicles accounted for more than 60% of the vehicles added to Africa's fleet annually as of 2020.[36] **In 2018, 85% of the region's vehicle fleet was used imports.**[37] **African countries also have the highest median age of used vehicle imports, at more than 15 years, compared to less than 3 years in Norway.**[38] The age of vehicle imports is generally higher in countries that have a lower per capita gross domestic product (GDP) (Figure 3).[39]

- In 2019, the oldest heavy-duty vehicle exports from the Netherlands had an average age of 17-20 years and were exported to Gambia, Guinea, Nigeria, and Sierra Leone, despite age restrictions for used vehicles in some African countries (15 years in Nigeria, 10 years in Ghana and 5 years in Côte d'Ivoire).[40]
- In Morocco, the average age of imported heavy-duty vehicles in 2019 was 7.7 years, despite an age limit restriction of 5 years.[41]
- In 2020, the average price of a used heavy-duty vehicle in Africa was close to USD 5,900, compared to USD 8,000 in Eastern Europe, the Caucasus, and Central Asia; USD 9,700 in the Middle East; USD 11,100 in Latin America and the Caribbean; and USD 11,200 in Asia Pacific.[42]
- In 2018, the average price of a used light-duty vehicle in Singapore was USD 21,000, nearly 16 times the average price in Lesotho (USD 1,300).[43]

Two- and three-wheelers are an increasingly popular component of Africa's second-hand vehicle fleets. Although specific data are not available, the growing share of used two- and three-wheelers in some countries' fleets calls for closer monitoring, data collection and reporting to prevent harmful environmental and safety effects. Meanwhile, a study from Uganda found that the surge in annual motorcycle registrations has occurred alongside a reduced reliance on used two-wheelers and a shift to newly imported or domestically assembled units.[44]

Factors driving the growing used vehicle market globally include supply constraints, technological and price shifts, changing vehicle preferences, environmental policies, and price disparities between new and used vehicles. Specific trends facilitating the market include:

- Limited supply or delayed procurement of new vehicles due to factors such as semiconductor shortages, coupled with soaring costs for new vehicles and auto parts due to advancements in driver-assisted technologies and navigation functions.[45]
- Growing global market shares for larger and heavier vehicles, which have increased the supply of second-hand smaller cars for export.[46]
- Electric vehicle adoption, particularly in leading used vehicle exporting regions such as China, Europe, the Republic of Korea, Japan and North America.[47]
- High vehicle replacement rates in countries where the vehicle market is largely saturated and where vehicle replacement is highly encouraged and in some cases incentivised (as in Japan).[48]
- The effects of the implementation of urban low-emission zones on the demand for low-emission cars, including second-hand electric vehicles.[49] (See 4.1 Integrated Transport Planning.)
- Limited access to new vehicle options or lack of effective demand for new vehicles, significant price disparities between new and used vehicles, and cost-effective repair services due to lower labour costs in many importing regions.[50]
- The prevalence of low-density sprawling urban developments, as well as inadequate prioritisation of investment in public transport systems.[51]

Sustainability and climate trends

The poor quality of used vehicles exported to emerging markets raises environmental, safety, and public health concerns and contributes to overall emissions from road transport. In 2023, the transport sector, excluding international aviation and shipping, accounted for 13.5% of global greenhouse gas emissions.[52] The auto industry alone contributed more than 10% of the world's CO_2 emissions, in addition to consuming 112 million tonnes of materials annually to produce around 80 million vehicles (as of 2024).[53]

In 2020, light-duty and heavy-duty vehicles together emitted more than 5,000 million tonnes of CO_2, accounting for more than 70% of total transport emissions.[54] Although the heavy-duty vehicle fleet is much smaller than the light-duty fleet, it is a major contributor to air pollution, road crashes, high fuel consumption, and black carbon and CO_2 emissions.[55] (See 4.8 Road Transport.)

Older vehicles produce significantly more air pollutant emissions than new vehicles, particularly if they lack good maintenance and high-quality components.[56] **As of 2019, more than 80% of Africa's road vehicles fell below the Euro 4 vehicle emission standards, while also lacking valid roadworthiness.**[57] In some cases, used vehicle dealers remove the after-treatment systems for vehicle exhaust to

bypass emission control systems or retain precious components, resulting in higher air pollution.[58]

- In Kampala (Uganda) – where heavy-duty vehicles average 26 years, minibuses 25 years, light-duty vehicles 19 years and motorcycles 4 years – road transport is a key contributor to ambient air pollution, accounting for 60% of nitrogen dioxide (NO_x) emissions and up to 24% of particulate matter ($PM_{2.5}$) emissions in 2021.[59]
- A 2025 study found that ambient air pollution in Kampala exceeds the World Health Organization's limits for particulate matter by up to 8-12 times.[60] More than half of the petrol passenger cars assessed had average NO_x emissions above 1,000 micrograms per kilometre (consistent with pre-Euro certifications), suggesting the malfunctioning or removal of catalytic converters.[61] Diesel minibuses had NO_x emissions more than nine times above Euro 4 limits, as well as high black carbon emissions.[62]
- Inspections of vehicles exported to Africa from the Netherlands showed that several vehicles had their catalytic converters removed before shipment, and the vehicles lacked diesel particulate filters because of their old age.[63]

In addition to higher pollution rates, inspections of vehicles being exported to Africa found numerous vehicles to be unsafe, having been involved in accidents or with severe structural damage.[64] Concerns included ineffective braking systems, non-operational lights and indicators, missing airbags and severely worn tyres.[65]

- A study of used heavy-duty vehicles exported from the Netherlands to Africa found that most vehicles were worn out, had very high mileage (above 250,000 kilometres) and lacked valid roadworthiness certificates at the time of export.[66]
- Even in cases where such certificates are available, importing economies rarely have appropriate testing procedures to ensure that faulty, dangerous or highly polluting vehicles are properly maintained and meet roadworthiness standards (Box 1).[67]

Box 1. Who is setting roadworthiness standards, and who is governing them?

A clear, unambiguous legal framework is an essential foundation for introducing and implementing vehicle roadworthiness standards. Internationally, the World Forum for Harmonization of Vehicle Regulations (WP.29), a working party of the Inland Transport Committee of the United Nations Economic Commission for Europe, is responsible for harmonising vehicle regulations and rules on vehicle performance, vehicle parts and equipment, vehicle safety, environmental pollution, energy efficiency, anti-theft and security. Key areas of concern include:

- Active safety of vehicles and their parts (crash avoidance), aimed at improving the behaviour, handling and equipment of vehicles so as to decrease the possibility of a road crash.
- Passive safety of vehicles and their parts (crashworthiness), aimed at minimising the risk and severity of injury to the occupants of a vehicle or to other road users in the event of a crash.
- Environmental considerations, aimed at addressing the environmental performance (e.g., emissions of gaseous pollutants, particulates and CO_2, noise levels) of vehicles with conventional propulsion engines, hydrogen and fuel cell vehicles, hybrid-electric vehicles and electric vehicles.

The 1997 Agreement on Periodical Technical Inspections provides the legal framework and procedures for the adoption of uniform UN Rules for carrying out technical inspections of vehicles that are in use and for delivering international inspection certificates. By 2020, the 1997 Agreement had 16 contracting parties, and four UN Rules had been established under its umbrella, for heavy-duty vehicles, light-duty vehicles and passenger cars. These Rules may be useful for countries aiming to introduce or strengthen a periodic inspection system based on international expertise

At the national level, high-income countries, manufacturing countries, and larger vehicle markets typically set their own roadworthiness standards and vehicle design manuals. For example, the United Kingdom uses four types of manuals – for light vehicles, motorcycles, heavy goods vehicles and public service vehicles (buses and coaches) – and the European Commission's Roadworthiness Package (RWP) consists of directives for Periodical Technical Inspections (PTI), Roadside Inspections (RSI) and vehicle registrations. Low- and middle-income and importing countries typically adapt legislation from bigger markets, in some cases altering it to local driving conditions. This is mainly to ensure that the countries remain economically viable for vehicle exporters.

Even with harmonised standards in place, studies show that in-depth controls at ports are very difficult without essential information exchange across countries and among customs, export declarations and national vehicle registers.

Source: See endnote 67 for this section.

In 2021, an estimated 1.19 million people were killed in road traffic crashes globally; such crashes were the leading cause of death for young people aged 5-29 and the 12th leading cause of death among all age groups as of 2021.[68] **The vast majority (90%) of the deaths in 2021 were in low- and middle-income countries, even though these countries accounted for only 54% of the global vehicle fleet that year.**[69] (See 1.7. Driving Health and Wellbeing Forward: The Critical Link with Transport and 4.8 Road Transport.)

- Africa had the highest rate of road traffic fatalities at 18.7 deaths per 100,000 people in 2021, followed by Asia (15.5 deaths) and Latin America and the Caribbean (14.6 deaths).[70]
- Half of all road deaths and injuries in Africa affect unprotected road users such as pedestrians, cyclists, motorcyclists and their passengers.[71]

Although the used vehicle trade supports resource efficiency in automobile production, the importing countries carry the burden of dismantling and responsibly disposing of used vehicles when they reach their end of life, to avoid environmental damage. Externalising this responsibility to low-skilled informal waste workers, usually with limited or no protective equipment, exposes the workers to personal and occupational health and safety problems.[72] These risks are heightened by the inadequacy or absence of recycling and safe disposal facilities across Sub-Saharan Africa, where in 2020 more than 85% of municipal solid waste was uncontrolled.[73] The importance of safe disposal of materials and liquids from vehicles will only increase with the shift towards electric vehicles that tend to contain even more hazardous materials.

Although second-hand vehicles are cheaper and have reduced foreign exchange requirements for importing countries, a growing dependence on used car imports has hindered the development of domestic auto manufacturing industries in many places. (See 3.1 Africa Regional Overview.) In Africa, domestic vehicle production rose 16% in 2021, yet the region contributed only 1.2% of global vehicle output as of 2023; manufacturing is concentrated in Algeria, Egypt, Morocco, and South Africa, with some vehicle assembly in Angola, Ethiopia and Ghana.[74]

As high-income economies switch to electric vehicles, growing numbers of low-demand used ICE vehicles are being exported to emerging economies; this will likely undermine importers' efforts to shift to electric vehicles. Even where used electric vehicles are available for export, demand for them is limited by a lack of extensive charging infrastructure networks in some importing countries.[75]

The supply and pricing of second-hand vehicles has evolved in some regions. In the United States, the price of "lightly used vehicles" hit record highs in 2025, in part because the shortage of semiconductor chips during the COVID-19 pandemic affected the supply of then-new (later used) vehicles.[76] This trend is expected to continue, given the potential effects of expanding tariffs on vehicle supply chains.[77]

The used vehicle market provides employment opportunities for large numbers of people in the sales and after-sales sectors in both exporting and importing countries, although data on the latter are limited. Second-hand cars also provide increasing opportunities for the aftermarket sector, as these vehicles require more frequent maintenance, repairs and parts replacements.[78]

- The United States was home to more than 300,000 used car dealers as of May 2025, while Japan had an estimated 30,000 major used car dealerships in 2023, excluding the ubiquitous smaller firms engaged in the industry.[79]
- In the Middle East and Africa, the market share of the auto repair and maintenance services sector has grown steadily, reaching 2% (USD 18.1 billion) in 2023.[80]

Policy and investment developments

A key way for countries to address the negative and potentially exploitative impacts of second-hand vehicles is to stop exporting vehicles that are no longer roadworthy and that fail environment and safety inspections; meanwhile, importing countries must adopt up-to-date, minimum harmonised standards and regulations.[81] Several international, regional and national mechanisms have been enacted or proposed.

In 2023, the EU – as a leading exporter of used vehicles – proposed stricter export requirements through its regulation on end-of-life vehicles, covering all aspects of a vehicle from design, to market placement, to treatment during disposal (Box 2).[82] The proposal was envisaged to greatly impact the quality of EU used vehicle exports by prohibiting the export of end-of-life vehicles; requiring used vehicles to have a valid roadworthiness certificate at the point of export; establishing an enforcement and information exchange system; and helping importing countries comply with their national regulations.[83]

Box 2. End-of-Life Vehicles Regulation of the European Commission

In July 2023, the European Commission proposed the End-of-Life Vehicles Regulation, which outlines circularity requirements covering the entire life cycle of a vehicle – from design to final end-of-life treatment – in line with the objectives of the European Green Deal and the circular economy action plan.

As of July 2025, committees of the European Parliament had advanced the new regulations by adopting a final compromise amendment to the proposal including improving end-of-life management of the vehicles and enforcement of rules. They also strengthened the export rules to allow only used vehicles classified as "not end-of-life" to be exported, accompanied by the required documents for customs clearance. The report is expected to be adopted in September 2025.

As of 2025, only a fraction of the 6.5 million vehicles that reach their end-of-life annually in the EU were actually dismantled at authorised treatment facilities, with others likely being dismantled illegally, abandoned or exported illegally. Digital tools and stricter penalties are needed to trace car movements across and beyond Europe, to curb the illegal import of polluted vehicles.

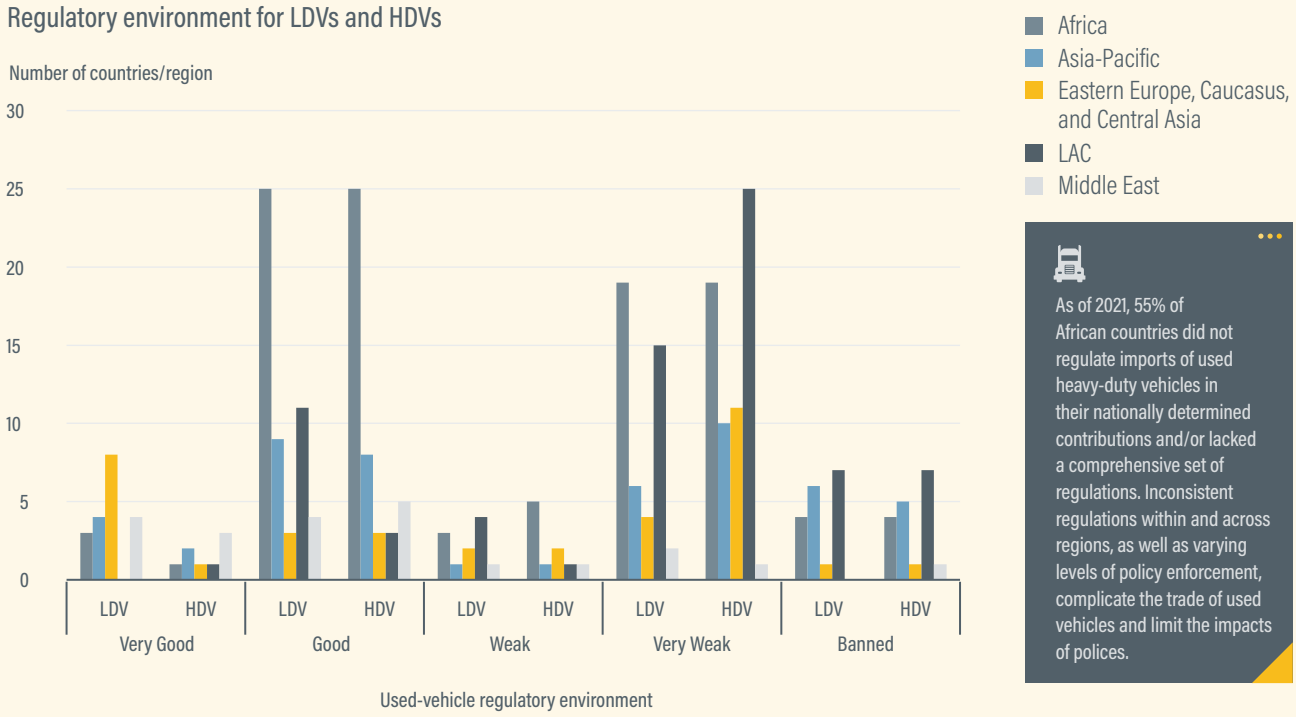
Source: See endnote 82 for this section.

This is complementary to the EU Waste Shipment Regulation, which prohibits the export of hazardous waste to non-OECD countries and aims to ensure that waste exported outside the EU does not create adverse effects on the environment or public health in the destination countries.[84] Enforcement of this regulation would stop the export of end-of-life vehicles, which in some cases constitute hazardous waste.[85]

The Safer and Cleaner Used Vehicles for Africa project, launched in 2022, aims to improve road safety and reduce pollution by promoting the import of safer and more environmentally friendly used vehicles into Africa.[86] The project is led by UNEP and the UN Economic Commission for Europe and is supported by partners including the UN Road Safety Fund, the Climate and Clean Air Coalition, the FIA Foundation and the International Motor Vehicles Inspection Committee (CITA). Specifically, it aims to:

- regulate the transfer of used vehicles to Africa by helping recipient countries develop and implement national used vehicle standards and regulations (including existing global vehicle standards and regulations), bringing significant road safety benefits for car occupants, road users, and pedestrians as well as co-benefits for the environment and economy, and
- provide a platform for major exporters of used vehicles and African importing countries to shift the paradigm on the

FIGURE 4. Regulatory environments for light-duty and heavy-duty vehicles, by region, as of 2023



As of 2021, 55% of African countries did not regulate imports of used heavy-duty vehicles in their nationally determined contributions and/or lacked a comprehensive set of regulations. Inconsistent regulations within and across regions, as well as varying levels of policy enforcement, complicate the trade of used vehicles and limit the impacts of polices.

Source: See endnote 91 for this section.

export/import of used vehicles and to develop standards and policies on the transfer of used vehicles.[87]

In 2020, the Economic Community of West African States (ECOWAS) adopted a used vehicles policy for the region, setting age limits of 10 years for heavy-duty vehicles and 5 years for light-duty vehicles, as well as a minimum Euro IV emission standard for all imported vehicles.[88] The policy has a 10-year implementation period to 2030. In 2022, the East African Community similarly adopted the Euro IV standard for new and used heavy-duty and light-duty vehicles as well as in-use emission limits.[89]

However, wider regional harmonisation of policies and standards is critical for enforcement of these policies, especially in light of the African Continental Free Trade Area (AfCFTA). As of 2021, 55% of African countries did not regulate imports of used heavy-duty vehicles in their nationally determined contributions and/or lacked a comprehensive set of regulations.[90] Inconsistent regulations within and across regions, as well as varying levels of policy enforcement, complicate the trade of used vehicles and limit the impacts of policies (Figure 4).[91]

Harmonisation of policies for heavy-duty and light-duty vehicles is critical to maximise the environmental gains from restricting imports of high-polluting vehicles. Countries often prioritise age restrictions for light-duty vehicles over heavy-duty vehicles, due mainly to cost considerations and to the limited model and market availability of the latter. This is inefficient for two key reasons: heavy-duty vehicles are more emission- and energy-intensive per kilometre than light-duty vehicles, and heavy-duty vehicles travel much farther on average than any other vehicle type annually.[92]

Several importing and exporting countries of second-hand vehicles have included regulations and measures related to these vehicles in their national policies, including in Nationally Determined Contributions (NDCs) towards reducing greenhouse gas emissions under the Paris Agreement. These measures include restricting or banning used vehicle imports (based on age, mileage or emission standards), fiscal instruments, inspection licensing and certification, and selective technology bans.

- Belize's third-generation NDC of June 2025 includes an action on possibly restricting the import of older, less efficient vehicles as a way to mitigate emissions from the transport sector.[93]
- Lesotho's second NDC from February 2025 highlights the regulation of imported used cars to reduce the number of poor-performing vehicles entering the country.[94]

- In its third-generation NDC of May 2025, the Republic of Moldova highlights the introduction of stricter emission standards for imported second-hand vehicles as a strategy to promote energy efficiency.[95]

At the national level, several countries have put in place import bans or penalties on second-hand vehicles, based on either age or mileage. Apart from the complete import bans by Egypt, Seychelles, and South Africa, age restrictions are the most prevalent in Africa.[96]

- In January 2025, the government of Sudan lifted restrictions on the import of used vehicles in an effort to ease economic pressures stemming from the ongoing conflict.[97]
- In 2023, Ethiopia banned the importation of both new and used ICE vehicles, while Morocco adopted Euro 6/VI vehicle emission standards.[98]
- In 2021, Nigeria banned the importation of vehicles older than eight years, but the age limit was later raised to 15 years.[99]
- In 2019, Libya restricted imports of light-duty and heavy-duty vehicles to those with a maximum age of 10 years.[100]

A 2022 study found that solely imposing bans and penalties on used vehicle imports does not yield meaningful, sustained gains in other areas such as reduced road traffic deaths, air pollution or shifts to zero-emission vehicles.[101] The study recommends policy alternatives such as investment in and subsidies for public transport, and pursuing integrated transport planning instead of vehicle-dependent systems.[102]

Subsidies for second-hand electric vehicles can bring equity benefits and complement subsidies for new electric vehicles, and are essential for optimal policy outcomes in the transition to net zero greenhouse gas emissions.[103]

- In 2020, the Netherlands introduced a USD 2,070 (EUR 2,000) subsidy for used electric vehicles, which contributed to a 40.3% increase in registrations of both new and used electric vehicles in 2024.[104] As of 2025, the country's electric vehicle subsidies were all discontinued following depletion of the allocated budget.[105]
- In 2024, Luxembourg introduced a USD 1,553 (EUR 1,500) subsidy for used electric vehicles that are more than three years old.[106]
- In the United Kingdom, a 2025 report on decarbonising road transport called for grants on used electric vehicles to combat the volatile market, as rapid technological advancements and price drops for new models have made second-hand electric vehicles more affordable but less predictable in value.[107]

Innovations in battery life-cycle management are critical for used electric vehicles. Volvo, which has committed to becoming a fully electric car company and aims for at least 30% recycled content in new models by 2030, is developing processes to refurbish and recycle batteries from used electric vehicles, reducing reliance on unsustainable lithium and cobalt mining.[108]

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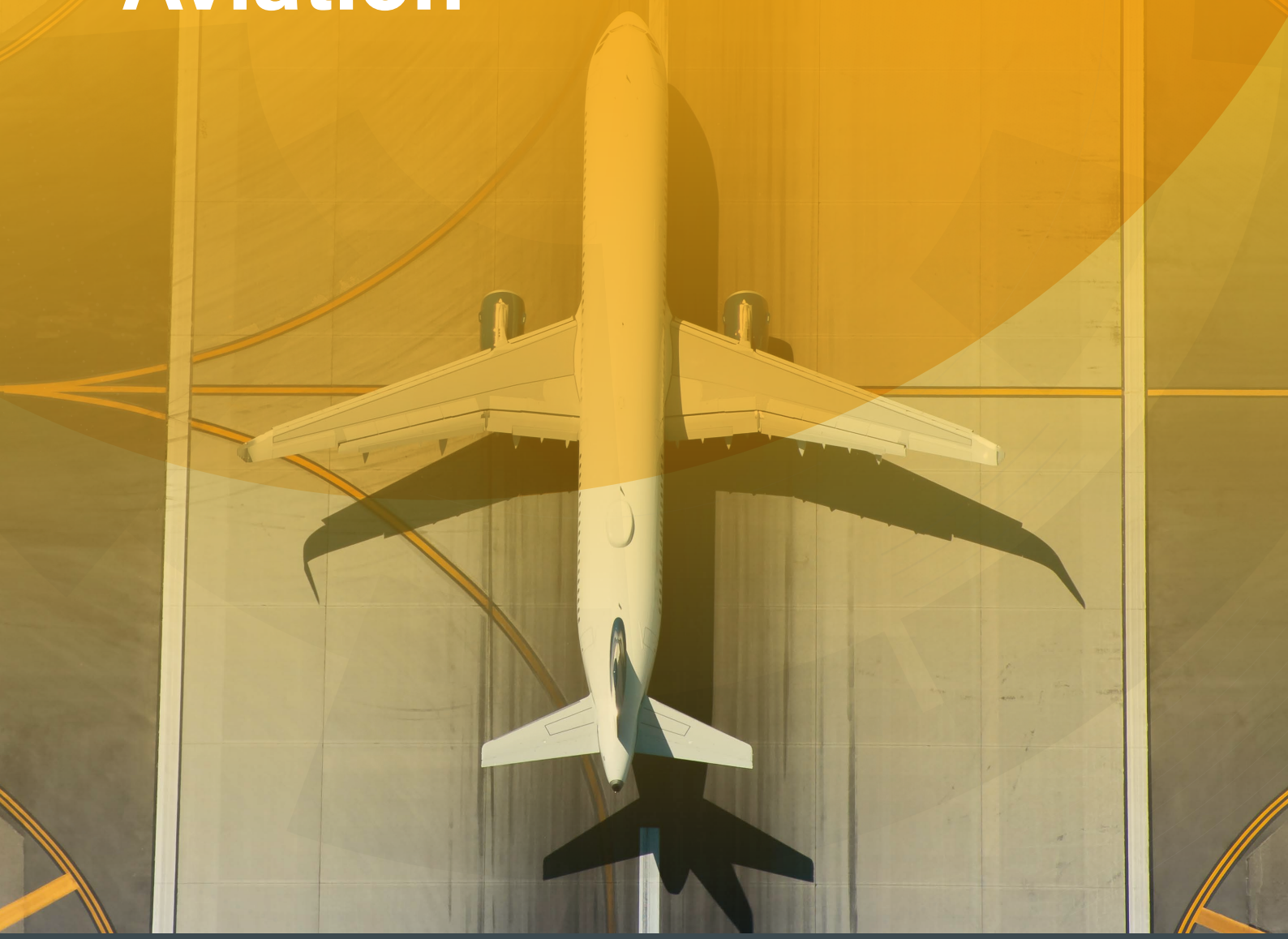
A more in-depth analysis of the aviation sector will be published soon

Aviation



KEY FINDINGS

Demand, use and access

- The air passenger market has demonstrated resilience and recent growth. Global revenue pssenger-kilometres, a standard measure of passenger traffic, increased 10.4% in 2024 and pushed total traffic 3.8% above the pre-pandemic levels of 2019, indicating a full recovery across all regions.
- Evidence of strong aviation demand was reflected in record passenger load factors, as airlines used their capacity more efficiently than ever before to reach new highs both in December 2024 (84.0%) and for the full year (83.5%). Although high load factors are positive from an operational efficiency perspective, efficiency improvements risk being overshadowed by the scale of rising demand for aviation, highlighting the core challenge of reducing absolute emissions in a growing market.
- International passenger traffic was a major driver of aviation's 2024 recovery, climbing 13.6% despite ongoing geopolitical tensions and airspace restrictions that necessitated adjustments to global networks. Domestic markets also contributed to the sector's growth, expanding 5.7% globally in 2024.
- Aviation has played a minor role in global freight transport, representing only 1% of the global trade volume and just 0.1% of global freight tonne-kilometres in 2021. Even so, cargo flights remain a key revenue stream for the airline industry, with commercial airlines making around 5-10% of their total revenue from hauling freight.
- Freight aviation volumes experienced strong performance in 2024, with industry-wide cargo tonne-kilometres increasing 11.3%, setting a new record above 2021's volumes and above the pre-pandemic levels of 2019. Contributing factors included booming e-commerce demand and continued disruptions in maritime shipping.
- Available cargo capacity (in tonne-kilometres) hit a record high in the third quarter of 2024, supporting a rise in cargo load factors.
- Global aviation's recovery masks significant regional differences in demand growth, with particular dynamism in developing economies. The Asia Pacific region experienced a 16.9% increase in passenger traffic in 2024, driven by strong domestic markets in China and India, but international travel in the region remained below 2019 levels. Africa ranked second with a 13.2% increase in passenger traffic and notable growth on the Africa-Asia route.
- Strong passenger growth in Asia Pacific and Africa suggests a potential long-term shift in aviation expansion towards developing and emerging economies. China and India (and Asia Pacific as a whole) are projected to account for nearly half (46%) of the 42,430 new passenger and freighter deliveries in the 2024-2043 period. This has implications for future global emission trajectories, as these regions generally have lower historical emissions but higher growth potential. It underscores the critical need for globally inclusive and equitable decarbonisation strategies that support sustainable development alongside climate action.
- In addition to economic and demographic factors, geopolitical events have influenced regional aviation patterns, posing threats to the stability needed for long-term investments in decarbonisation. Both demand forecasts and effective decarbonisation planning must account for this volatility.
- Direct risks to airline operations and demand can stem from policy instability following major elections, potential trade disputes (e.g., US tariffs), a shifting global power balance (potentially leading to more conflict), and even reduced political commitment to climate action.
- Behavioural factors and consumer preferences are increasingly influencing travel choices, including a potential shift from air travel to high-speed rail for shorter journeys.
- The cost of air travel is a significant factor influencing demand, and decarbonisation efforts are widely expected to exert upward pressure on prices. The deployment of SAF, which currently costs 2-8 times more than conventional fuel, is a primary driver of anticipated cost increases.

KEY FINDINGS

Sustainability and climate trends

- The global transition towards net zero aviation will inevitably have consequences; it is not solely a technical and economic challenge, but also carries significant social and equity implications. These must be carefully managed to ensure fairness and to minimise negative impacts on connectivity, equity in access, and economic growth related to jobs and tourism.

- In 2024, aviation supported an estimated 11.6 million direct jobs and 20.4 million indirect jobs globally and contributed USD 4.1 trillion (3.9%) to the global gross domestic product (GDP) – reflecting the strong link between economic prosperity and air travel growth.

- Aviation's role in facilitating global connectivity supports economic growth, enables trade and tourism, fosters international collaboration, and provides access to essential services and humanitarian aid. Overall, the sector supports many of the 17 United Nations Sustainable Development Goals (SDGs), including SDG 8 (Decent Work and Economic Growth) and SDG 17 (Partnerships). Maintaining these positive contributions while mitigating the sector's emissions and supporting climate action (SDG 13) is a key aspect of a sustainable and just transition.

- As both air passenger and air cargo demand recovered in 2023, aviation-related greenhouse gas emissions rose to reach 90% of their 2019 (pre-pandemic) peak level. Aviation emissions grew in nearly all regions to just over 900 million tonnes of carbon dioxide (CO_2) equivalent, of which around 10% was from cargo planes.

- International aviation emitted 498 million tonnes of CO_2 equivalent, while domestic aviation contributed 406 million tonnes. Aviation's CO_2 equivalent emissions were expected to surpass their 2019 level in 2025.

- Aviation contributed only around 2.2% of the total global CO_2 emissions from human activities in 2023; however, the sector's absolute volume of emissions was still substantial. Between 1990 and 2023, air traffic grew 5% annually on average, while CO_2 emissions from aviation grew 2%, indicating some efficiency gains but still resulting in a net increase in emissions over the period. The sector's demand growth rate has outpaced overall emission reductions in many economies.

- Around 80% of the CO_2 emissions from aviation originate from flights of more than 1,500 kilometres, distances that generally cannot be substituted by rail. This has profound implications for decarbonisation strategies and underscores the importance of developing and deploying scalable solutions that can effectively reduce emissions from medium- and long-haul flights; the leading solution is SAF, and potentially also future fuel-efficient aircraft and propulsion technologies.

- The International Civil Aviation Organization (ICAO) has adopted a Long-term Global Aspirational Goal (LTAG) for the international aviation sector of achieving net zero carbon emissions by 2050. To meet this goal, the ICAO and its Member States strive to reduce CO_2 emissions in international aviation 5% by 2030 through the use of cleaner fuels such as SAF, without specific obligations or commitments in the form of emission reduction goals attributed to individual members.

- The aviation sector would need to adhere to stringent carbon budgets to align with the goals of the Paris Agreement to keep global temperature rise below 1.5 degrees Celsius (°C) and well below 2°C. As of 2023, the global commercial aviation fleet already in service was set to emit around 9 gigatonnes of CO_2 over its lifetime, or nearly half the indicative carbon budget of 18.4 gigatonnes of CO_2 that is required for the sector to align with a net zero emission pathway. New aircraft delivered from 2024 onwards might exhaust the sector's 1.5°C carbon budget by 2032.

- Aviation's carbon budget constraints underscore that relying solely on incremental efficiency gains and SAF deployment in conventional aircraft may be insufficient, particularly to achieve the ambitious 1.5°C target. This points to an urgent need either for much sooner and larger-scale deployment of genuinely zero-emission aircraft (powered by hydrogen or electricity), or for the delivery of aircraft from the mid-2030s onwards that operate exclusively on 100% SAF, with extremely low life-cycle emissions.

- The risk of remaining dependent on the current (high-carbon) pathway is significant. The continued production and delivery of new aircraft designed primarily for fossil fuels, even if they incorporate efficiency improvements, locks in emissions for decades due to the long operational lifespan of aircraft (20-30 years).

- Models of future CO_2 emission trajectories for the aviation sector illustrate the critical levers for decarbonisation, based on varying assumptions about technology, policy and demand. If current growth trends continue without significant intervention, aviation's CO_2 emissions could potentially triple by 2050. The stark contrast between

KEY FINDINGS

potential net zero pathways and the possibility of emissions tripling highlights the transformative nature of the changes required and the high stakes involved in failing to implement effective mitigation measures.

- Operational improvements such as enhancing the efficiency of air traffic management and aircraft operations can yield immediate fuel savings and emission reductions. Collectively, operational efficiencies offer a maximum emission reduction potential of 10%.

- Fleet renewal remains a cornerstone of aviation's decarbonisation strategy. New-generation aircraft delivered by major manufacturers such as Airbus, Boeing, COMAC and Embraer are a reported 20-30% more efficient than the older models they replace. However, the rate of fuel efficiency improvement (around 1% per year) has stagnated since 2020. If all cost-effective technologies are adopted, annual fuel burn reductions of up to 2.2% are technically possible through 2034, although current trends are slower.

- Airlines have invested heavily in new aircraft, with more than 19,360 new planes delivered since 2009 and a production backlog of around 15,700 new-technology aircraft set to enter the fleet from 2023 onwards. The combination of new technology, operational efficiencies and infrastructure improvements avoided an estimated 14.6 billion tonnes of CO_2 between 1990 and 2023.

- Research and development continue to target further incremental improvements. Disruptive technologies such as battery electric and hydrogen propulsion hold promise for zero-emission flight but face large hurdles to widespread adoption by 2050, with commercial deployment not expected before the late 2030s. Their contribution to overall aviation fuel consumption and emission reduction by 2050 is projected to be limited in most scenarios.

- The critical timing gap reinforces the importance of SAF, which is widely regarded as the most significant near- to medium-term solution for decarbonising aviation. Global SAF production more than doubled in 2024 to 1 million tonnes (1.3 billion litres) – up from around 0.5 million tonnes (600 million litres) in 2023 – and is projected to double again to 2.1 million tonnes (2.7 billion litres) in 2025 (albeit starting from a very low base).

- Despite its rapid growth rate, SAF's share of total global aviation fuel consumption was only around 0.15% in 2023, rising to 0.3% in 2024 and a projected 0.7% in 2025.

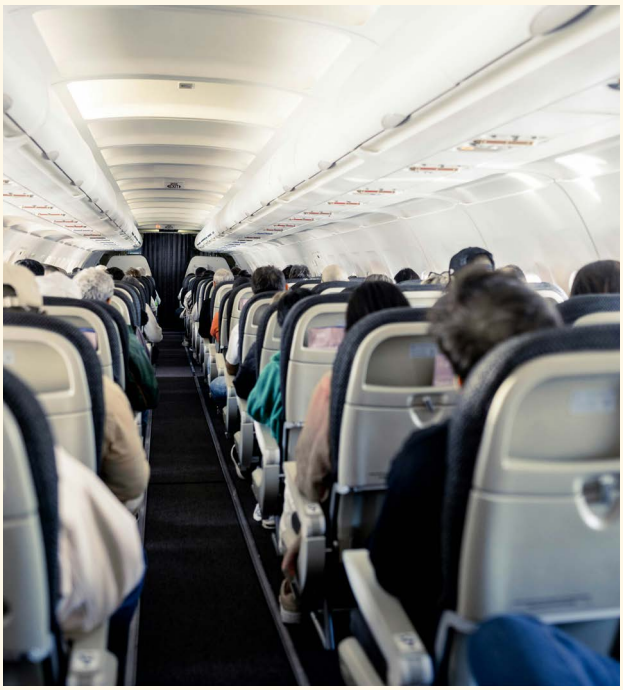
- Scaling SAF production to meet 2050 targets is a monumental undertaking, requiring an estimated USD 1.5 trillion in capital investment over 30 years.

- Demand signals for SAF have arisen from policy mandates in the European Union (EU) and the United Kingdom, goals in the United States, and growing voluntary commitments from airlines. Yet securing the necessary long-term off-take agreements remains a hurdle.

- Beyond CO_2 emissions, aviation impacts the climate greatly through non-CO_2 effects, including the release of nitrogen oxide (NO_x) emissions at altitude and the formation of persistent condensation trails (contrails) and contrail-induced cirrus clouds. These effects could equal or exceed the total climate warming impact of aviation's CO_2 emissions alone.

- Despite the growing recognition of non-CO_2 effects and the initiation of monitoring requirements, the implementation of large-scale trials and mitigation strategies to address these effects appears less advanced compared to measures targeting CO_2. Translating this into effective, globally co-ordinated mitigation action remains a key challenge and opportunity for the coming years.

- In addition to mitigating its own climate impact, the aviation sector must adapt to the unavoidable consequences of climate change already under way, including increasing disruptions from more frequent and intense extreme weather events. Initiatives are emerging to study these impacts and to develop adaptation strategies.



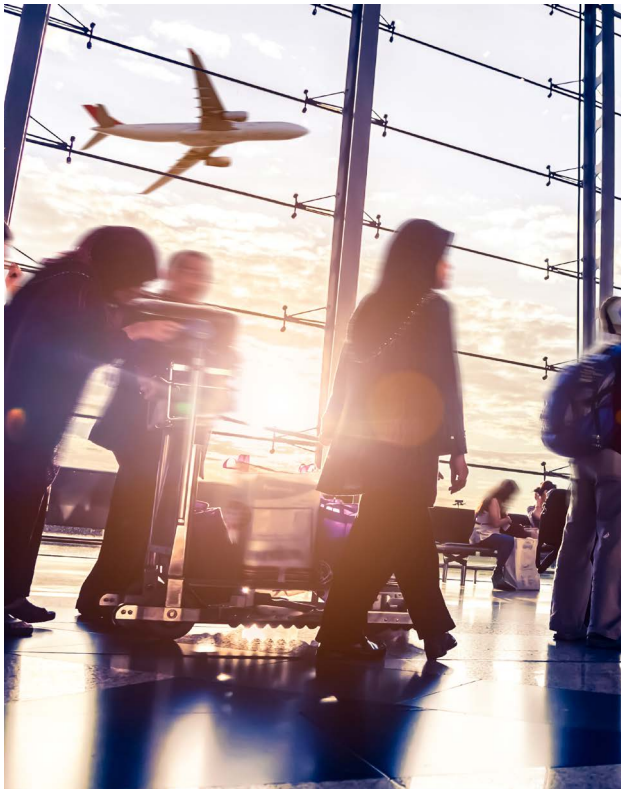
KEY FINDINGS

Policy and investment developments

- In 2022, the ICAO Assembly adopted its Long-Term Aspirational Goal (LTAG) for international aviation to achieve net zero carbon emissions by 2050. This global goal signals a collective ambition to align the sector with the global warming targets of the Paris Agreement, although it is not binding on individual member states.
- To support the LTAG, in November 2023 the third ICAO Conference on Aviation and Alternative Fuels adopted the "ICAO Global Framework for Sustainable Aviation Fuels (SAF), Lower Carbon Aviation Fuels (LCAF) and other Aviation Cleaner Energies". The Framework includes a collective global aspirational vision to reduce CO_2 emissions in international aviation 5% by 2030 through the use of cleaner energy sources, compared to a baseline that assumes zero use of cleaner energy.
- The EU has taken a leading role in translating international goals into binding regional legislation with its landmark ReFuelEU Aviation regulation, in effect since January 2025 and part of the "Fit for 55" climate package. The regulation sets legally binding minimum shares of SAF that must be blended into aviation fuel supplied at EU airports, starting at 2% in 2025 and rising to 6% in 2030, 20% in 2035 and 70% by 2050.
- ReFuelEU creates the world's largest mandated market for SAF and provides a strong, long-term demand signal intended to drive investment in production, particularly within the EU; however, implementation challenges remain due to the high costs.
- In January 2025, the incoming Trump administration issued an executive order halting the disbursement of funds for implementing the 2024 US Aviation Climate Action Plan. In July 2025, the so-called One Big Beautiful Bill Act reduced SAF production incentives from USD 1.75 per gallon to USD 1 per gallon.
- Some European countries have implemented or considered demand-side measures that restrict short-haul flights where viable transport alternatives exist. In France, a 2022 law prohibits domestic flights on routes where a direct train journey of less than 2 hours and 30 minutes is available. Policy analysis has explored extending this ban to routes with train alternatives under five hours, which could greatly increase the number of affected routes and potential emission savings. However, critics argue that airlines may simply reallocate the freed-up slots to longer, potentially more carbon-intensive international flights; thus, short-haul bans should be implemented alongside broader measures that address potential rebound effects or emission leakage.
- Although the adoption of SAF and other decarbonisation technologies is expected to increase the cost of flying, it can also serve as a key means to moderate the growth in aviation demand. As of 2018, the demand for aviation from 1% of the world's population produced 50% of the sector's emissions, while around 80% of people had never set foot on a plane.
- Research from 2022 found that, globally, the wealthiest 5% of people accounted for 55% of aviation activity and emissions. However, the impact of higher flying costs will vary across regions and socio-economic groups. Addressing these distributional effects is crucial to maintain public support and ensure that the transition is perceived as fair.
- Policies aimed at mitigating these impacts could include targeted subsidies for essential routes, progressive taxation schemes that shield infrequent flyers, and using the revenue from aviation taxes to support lower-income groups or invest in alternative transport infrastructure.
- Some countries are applying the "polluter pays" principle more directly to aviation, including through aviation fuel taxes, national ticket taxes, frequent flyer levies and international solidarity levies to internalise the environmental costs of flying, moderate demand and generate revenue to fund climate mitigation or cleaner technologies such as SAF.
- With a small percentage of the population accounting for a large share of flights and emissions, frequent flyer levies are seen as an equitable tool targeting those who fly most frequently and often farthest (typically, higher-income individuals). This contrasts with the potentially regressive impact of flat taxes or general price increases resulting from SAF adoption, which could disproportionately affect those who rely on flying for essential connectivity.
- Despite the substantial revenue potential of taxes and levies, which could be channelled towards climate finance or subsidising SAF, significant implementation hurdles remain. These include persistent legal complexities surrounding fuel tax exemptions and the challenge of international co-ordination for global levies.
- As of December 2023, within the broad "transport services" sector, 337 companies globally had validated targets for emission reductions under the Science Based Targets initiative (SBTi), which provides a framework for companies to set emission reduction targets aligned with climate science.

KEY FINDINGS

- In July 2024, Air New Zealand, only the second carrier globally to have its targets validated under the SBTi aviation framework, abandoned its SBTi-validated goal to reduce its carbon intensity 28.9% below 2019 levels by 2030 (including a 16.3% cut in absolute emissions). Although the carrier reaffirmed its long-term goal of net zero emissions by 2050, its decision to abandon the 2030 goal underscores the practical difficulties the industry faces in delivering deep emissions cuts in the near term, given the state of technology deployment, fuel supply chains and enabling policies.
- Major aircraft manufacturers play a pivotal role in decarbonisation through the development and delivery of more efficient aircraft and enabling the use of future fuels.
- Ensuring that all manufacturers accept their life-cycle responsibility and set ambitious targets covering the in-use emissions of the aircraft they sell is critical for driving progress. Airbus' adoption of a specific Scope 3 intensity reduction target reflects an important signal.
- There are two main carbon market schemes in the aviation sector: the EU Emissions Trading System (ETS) and the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). To avoid double-claiming benefits under the different schemes, airlines must carefully account for SAF use.
- This fragmentation of carbon reduction efforts for aviation, lacking a single, globally consistent carbon price signal, potentially leads to compliance complexities and competitive distortions.
- Financial support mechanisms are crucial enablers of the SAF transition, given the high cost of the fuels and the significant investment risks associated with developing new technologies and production facilities.
- Although the primary focus of aviation decarbonisation is on avoiding and reducing emissions at the source, there is growing recognition of the potential role of carbon dioxide removal (CDR) in addressing the residual emissions that remain after maximising reduction efforts.
- Decarbonising aviation is not an isolated challenge but requires unprecedented levels of collaboration across multiple stakeholder groups. This need for collaboration stems from the sheer complexity of the transition. Collaboration also faces challenges, as different stakeholders have varying, sometimes conflicting, interests.
- Building aviation's resilience requires a collaborative effort across the interconnected aviation network to ensure operational continuity and safety in a changing climate. There is a need for aviation stakeholders (airports, airlines, air navigation service providers) to conduct systematic climate risk assessments and develop adaptation plans. This involves understanding local climate projections, assessing vulnerabilities, prioritising risks and identifying adaptation measures.
- National adaptation plans are also beginning to incorporate transport sector strategies.



Context, challenges and opportunities

Measurable progress has been made since 2023 in addressing the climate impacts of aviation. However, achieving the sector's ambitions for net zero carbon emissions by 2050 remains a monumental challenge. Demand from both air passengers and air cargo has rebounded strongly, surpassing levels prior to the COVID-19 pandemic in 2020, driven especially by growth in developing economies. Although operational efficiencies are being pursued and fleet renewals continue to deliver incremental gains, these efforts alone will not be enough to counteract the emissions generated by rising traffic volumes in the coming decades, especially in low- and middle-income countries.

Sustainable aviation fuel (SAF) has emerged as the central pillar of the industry's decarbonisation strategy in the near to medium term. Production volumes have grown rapidly, with SAF supplies doubling to 1 million tonnes in 2024, but they remain a tiny fraction (less than 1%) of aviation's total fuel consumption.[1] Scaling SAF production to meet ambitious policy targets (e.g., 5-10% by 2030) requires overcoming hurdles related to high costs, securing sustainable feedstocks (beyond constrained waste oil supplies), attracting massive investment and accelerating the deployment of advanced conversion technologies such as power-to-liquids (e-fuels). Ensuring the environmental integrity of SAF through robust life-cycle analysis and certification remains critical.

Policy frameworks have advanced since 2023. The International Civil Aviation Organization's (ICAO) Global Framework provides high-level guidance and aspirational vision, and several regions have created greater market pull for SAF, including the European Union (EU) (through ReFuelEU), the United Kingdom (through legally binding mandates for SAF) and the United States.[2] The diversity of national policy approaches underscores the need for greater international harmonisation. Carbon market mechanisms such as the EU Emissions Trading System are being strengthened, and the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) provides a global framework for carbon offsetting. Financial mechanisms are evolving beyond support for research and development (R&D) and towards de-risking commercial investment through instruments such as revenue guarantees.

Major manufacturers are actively developing disruptive technologies such as hydrogen and electric propulsion, but widespread deployment faces substantial technical and economic barriers within the 2050 time frame. Analysis of the emissions already committed from existing and planned conventional aircraft underscores the urgency of accelerating this transition, as current trajectories risk exceeding climate budgets as early as the mid-2030s.[3] In addition, impacts on global warming from sources other than carbon dioxide (CO_2) – such as nitrogen oxide (NO_x) emissions at altitude and the formation of persistent condensation trails (contrails) – have gained policy attention, with monitoring requirements commencing, but large-scale mitigation strategies appear less developed.

Decarbonising the aviation sector carries significant socio-economic consequences. Rising ticket prices, while potentially progressive in cost distribution, necessitate careful consideration of the equity impacts on people's connectivity and access. Managing the transition in the aviation labour market and ensuring environmental justice in fuel production are crucial components of an equitable shift. Finally, the sector must pro-actively adapt its activities, such as airport infrastructure and aircraft operations, to the increasing physical risks posed by climate change (flooding, extreme heat, turbulence, etc.).

So far, the scale and pace of change required to align aviation with a pathway to keep the average global temperature rise within 1.5 degrees Celsius (°C), or even to align it with a net zero emission pathway by 2050, remain immense. Bridging the gap requires sustained and intensified efforts across all fronts: accelerating the scale-up of SAF with robust sustainability safeguards, pushing the boundaries of technological innovation for both conventional and future aircraft, implementing effective and globally co-ordinated policies that include carbon pricing and demand management, mobilising

substantial and well-directed finance, and ensuring that the transition is environmentally sound and socially equitable. Continued collaboration among governments, industry, finance and research institutions is paramount to navigating this critical transformation.

Demand, use and access

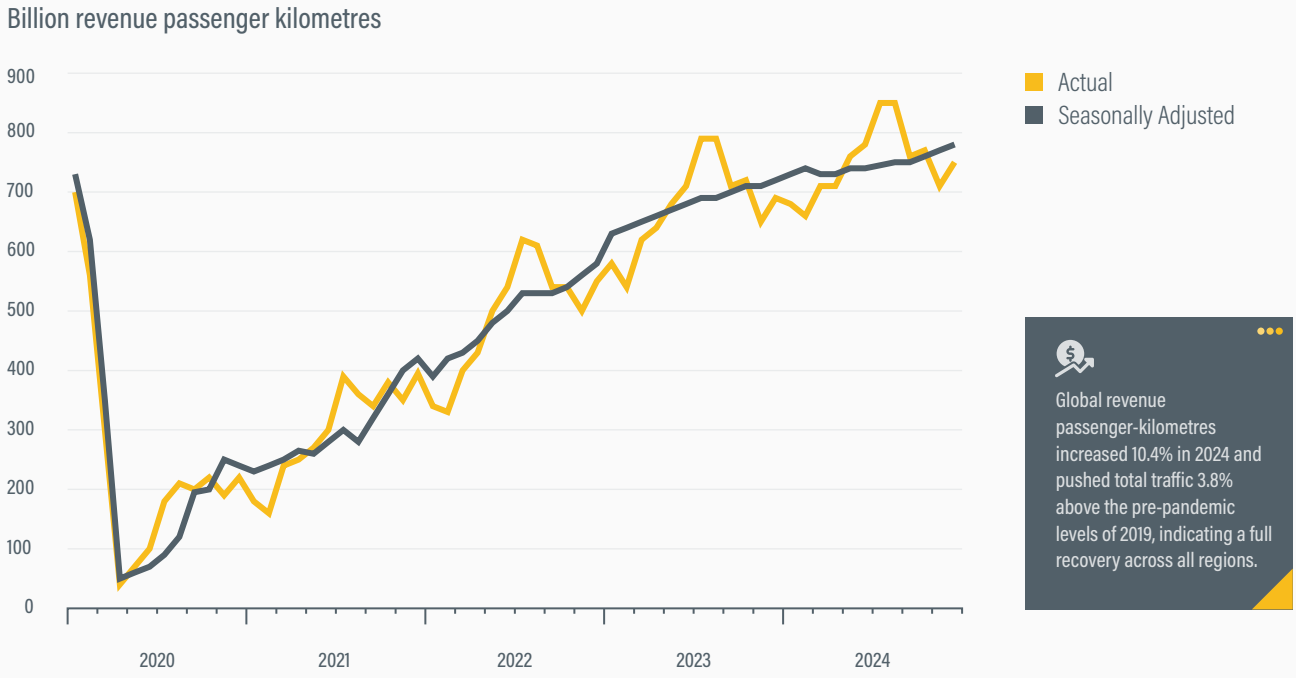
The air passenger market has demonstrated resilience and recent growth. Global revenue passenger-kilometres, a standard measure of passenger traffic, increased 10.4% in 2024 and pushed total traffic 3.8% above the pre-pandemic levels of 2019, indicating a full recovery across all regions (Figure 1).[4]

Evidence of strong aviation demand was reflected in record passenger load factors, as airlines used their capacity more efficiently than ever before to reach new highs both in December 2024 (84.0%) and for the full year (83.5%).[5] Although high load factors are positive from an operational efficiency perspective, efficiency improvements risk being overshadowed by the scale of rising demand for aviation, highlighting the core challenge of reducing absolute emissions in a growing market.

International passenger traffic was a major driver of aviation's 2024 recovery, climbing 13.6% despite ongoing geopolitical tensions and airspace restrictions that necessitated adjustments to global networks.[6] Domestic markets also contributed to the sector's growth, expanding 5.7% globally in 2024.[7] In the United States, domestic aviation grew 9% in 2023 to a record high of 1.25 billion passenger-kilometres.[8] However, the strong global growth trajectory showed signs of deceleration in 2024 compared to the initial sharp recovery in 2023, settling into rates more aligned with pre-pandemic long-term trends.[9]

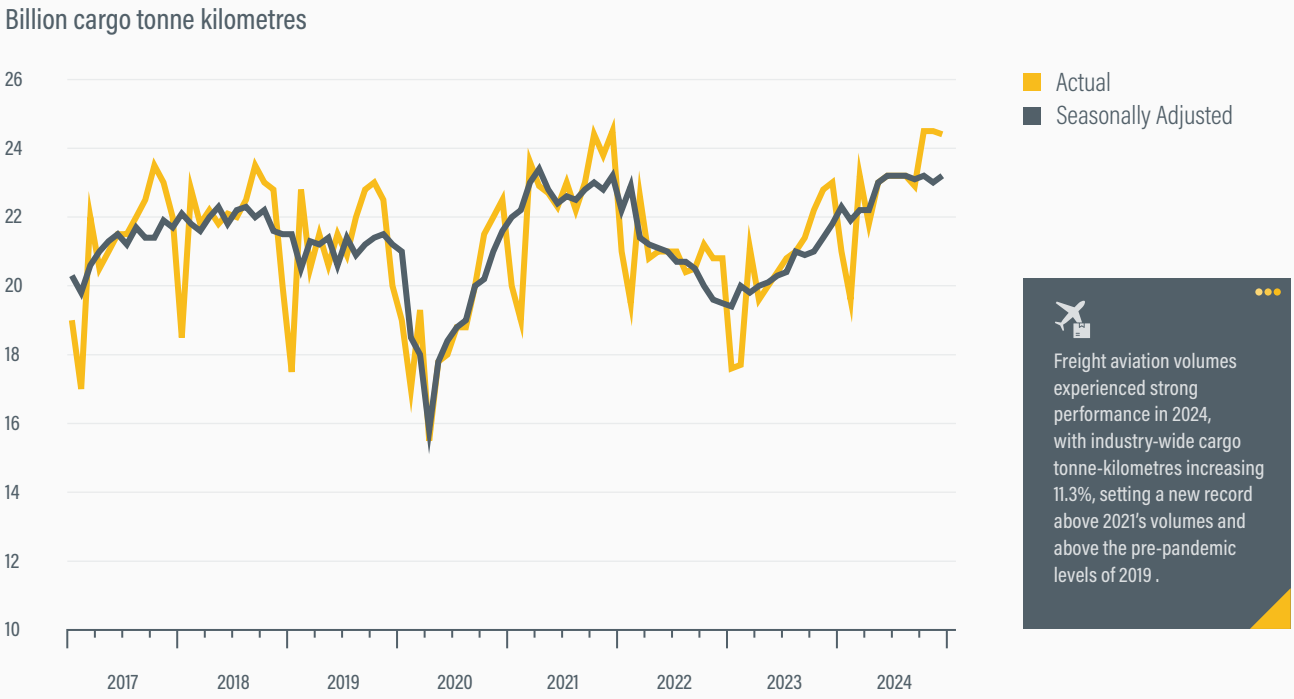
Aviation has played a minor role in global freight transport, representing only 1% of the global trade volume and just 0.1% of global freight tonne-kilometres in 2021.[10] Even so, cargo flights remain a key revenue stream for the airline industry, with commercial airlines making around 5-10% of their total revenue from hauling freight.[11]

FIGURE 1. Aviation passenger volumes (in billion revenue passenger kilometres), 2020-2024



Source: See endnote 4 for this section.

FIGURE 2. Freight aviation volumes (in billion cargo tonne kilometres), 2017-2024



Source: See endnote 12 for this section.

Freight aviation volumes experienced strong performance in 2024, with industry-wide cargo tonne-kilometres increasing 11.3%, setting a new record above 2021's volumes and above the pre-pandemic levels of 2019 (Figure 2).[12] **Contributing factors included booming e-commerce demand and continued disruptions in maritime shipping.** However, as with passenger traffic, the momentum in air cargo appeared to slow by the end of 2024.[13]

Available cargo capacity (in tonne-kilometres) hit a record high in the third quarter of 2024, supporting a rise in cargo load factors.[14] This capacity growth was due mainly to the increased availability of belly-hold space on recovering passenger flights.[15] Global air cargo yields saw their first annual increase since late 2022.[16]

Global aviation's recovery masks significant regional differences in demand growth, with particular dynamism in developing economies. The Asia Pacific region experienced a 16.9% increase in passenger traffic in 2024, driven by strong domestic markets in China and India, but international travel in the region remained below 2019 levels.[17] **Africa ranked second with a 13.2% increase in passenger traffic and notable growth on the Africa-Asia route.**[18]

- Air traffic in the Middle East benefited from airspace restrictions elsewhere in the world (provoked by conflicts), leading to greater traffic on Europe-Asia routes and substantial cargo growth in the region.[19]
- Europe experienced steady passenger growth and strong cargo volumes, while Latin America had moderate passenger growth but significant cargo growth.[20]
- North America had the slowest passenger growth in 2024 but experienced a late-year surge in domestic demand and moderate cargo growth.[21]

Strong passenger growth in Asia Pacific and Africa suggests a potential long-term shift in aviation expansion towards developing and emerging economies. China and India (and Asia Pacific as a whole) are projected to account for nearly half (46%) of the 42,430 new passenger and freighter deliveries in the 2024-2043 period.[22] **This has implications for future global emission trajectories, as these regions generally have lower historical emissions but higher growth potential. It underscores the critical need for globally inclusive and equitable decarbonisation strategies that support sustainable development alongside climate action.**

In addition to economic and demographic factors, geopolitical events have influenced regional aviation

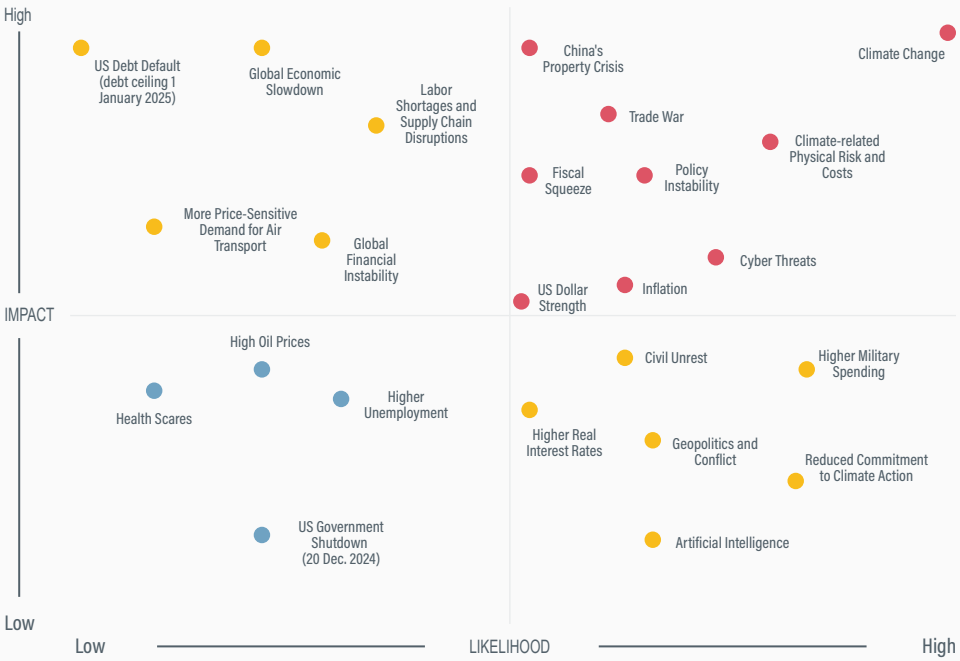
patterns, posing threats to the stability needed for long-term investments in decarbonisation. Both demand forecasts and effective decarbonisation planning must account for this volatility.[23] **Direct risks to airline operations and demand can stem from policy instability following major elections, potential trade disputes (e.g., US tariffs), a shifting global power balance (potentially leading to more conflict), and even reduced political commitment to climate action** (Figure 3)**.**[24] These factors pose indirect risks to sustainability initiatives by fostering economic (and investment) uncertainty, shifting policy priorities away from climate action and potentially disrupting supply chains for new technologies, critical minerals and sustainable fuels.

- Conflicts leading to airspace restrictions – such as the curtailment of international flights over the Russian Federation following its invasion of Ukraine in 2022 – have directly altered global air traffic patterns, while disrupting others.[25]
- Political tensions, such as between the United States and China, have limited airline capacity on certain routes and impacted the recovery of international travel in regions such as Asia Pacific.[26]

Behavioural factors and consumer preferences are increasingly influencing travel choices, including a potential shift from air travel to high-speed rail for shorter journeys. The resurgence in international travel, particularly from the Asia Pacific region, reflects pent-up demand as travel restrictions related to the COVID-19 pandemic eased. Record-breaking load factors also point to a strong underlying desire to travel. For high-speed rail, evidence of a shift exists on specific routes: in Spain, the decision of airline Vueling to terminate its Madrid-Barcelona flights explicitly cited the growing market share of high-speed rail, which reduced the journey to as little as 2 hours and 30 minutes.[27]

The cost of air travel is a significant factor influencing demand, and decarbonisation efforts are widely expected to exert upward pressure on prices. The deployment of SAF, which currently costs 2-8 times more than conventional fuel, is a primary driver of anticipated cost increases.[28] Modelling of a decarbonisation scenario suggests that higher ticket prices will likely moderate the rise in demand, with passenger growth in Europe expected to fall from a baseline of 2.0% per year to 1.4% per year due to cost impacts.[29]

FIGURE 3. Assessment of potential risks to the global economy that can affect aviation, as of 2025



In addition to economic and demographic factors, geopolitical events have influenced regional aviation patterns, posing threats to the stability needed for long-term investments in decarbonisation. Both demand forecasts and effective decarbonisation planning must account for this volatility. Direct risks to airline operations and demand can stem from policy instability following major elections, potential trade disputes (e.g., US tariffs), a shifting global power balance (potentially leading to more conflict), and even reduced political commitment to climate action.

Source: See endnote 24 for this section.

Sustainability and climate trends

The global transition towards net zero aviation will inevitably have consequences; it is not solely a technical and economic challenge, but also carries significant social and equity implications. These must be carefully managed to ensure fairness and to minimise negative impacts on connectivity (particularly for remote regions or island states), equity in access, and economic growth related to jobs and tourism.[30]

In 2024, aviation supported an estimated 11.6 million direct jobs and 20.4 million indirect jobs globally and contributed USD 4.1 trillion (3.9%) to the global gross domestic product (GDP) – reflecting the strong link between economic prosperity and air travel growth.[31] A further 17.2 million jobs were induced by the spending of aviation employees in the wider economy, and aviation also supported 37.3 million jobs through tourism.[32] The sector's extensive supply chain amplifies its impact on job creation worldwide.

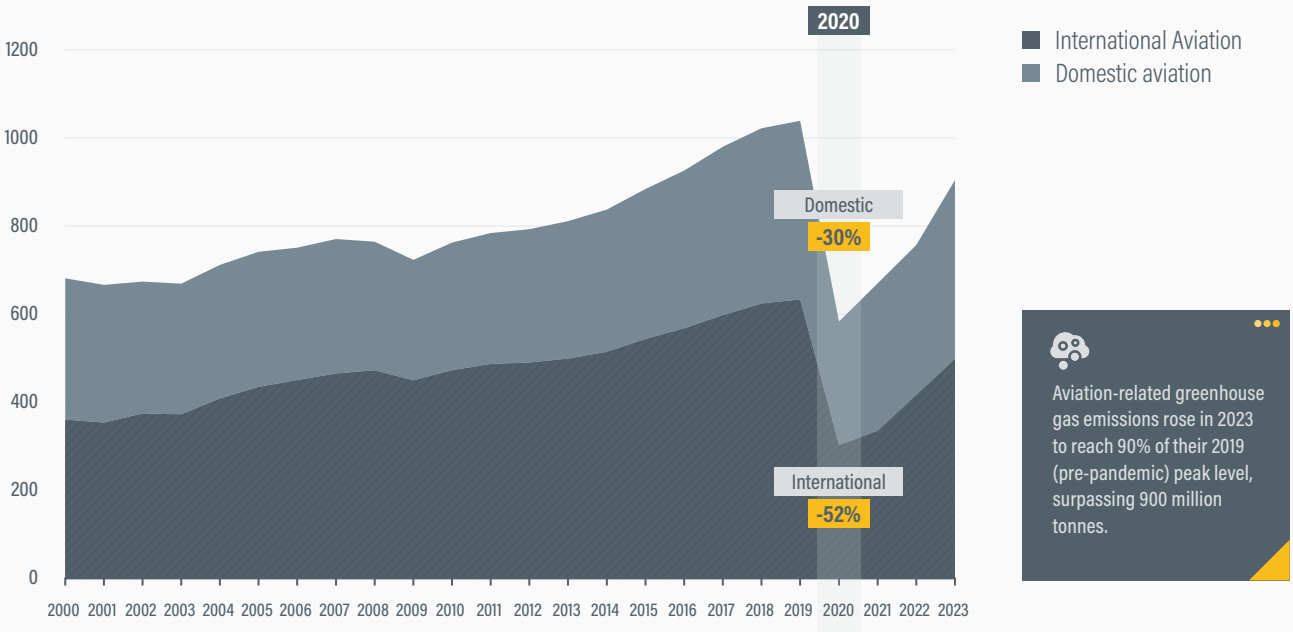
- Regional estimates for the Asia Pacific region, based on other methodologies, found that air transport (domestic, regional and international) employed 42 million people in 2023 and contributed USD 890 billion to the region's GDP.[33]
- Air transport in Asia – and related job opportunities – have expanded rapidly, driven by rising middle-class demand, low-cost carrier networks and international tourism. (See 3.2 Asia Regional Overview.)

Aviation's role in facilitating global connectivity supports economic growth, enables trade and tourism, fosters international collaboration, and provides access to essential services and humanitarian aid. Overall, the sector supports many of the 17 United Nations Sustainable Development Goals (SDGs), including SDG 8 (Decent Work and Economic Growth) and SDG 17 (Partnerships). Maintaining these positive contributions while mitigating the sector's emissions and supporting climate action (SDG 13) is a key aspect of a sustainable and just transition.

As both air passenger and air cargo demand recovered in 2023, aviation-related greenhouse gas emissions rose to reach 90% of their 2019 (pre-pandemic) peak level (Figure 4)**.**[34] **Aviation emissions grew in nearly all regions to just over 900 million tonnes of CO_2 equivalent, of which around 10% was from cargo planes.**[35] **International aviation emitted 498 million tonnes of CO_2 equivalent, while domestic aviation contributed 406 million tonnes.**[36] **Aviation's CO_2 equivalent emissions were expected to surpass their 2019 level in**

FIGURE 4. Global aviation emissions (domestic and international), 2000-2023

Greenhouse gas emissions from aviation in million tonnes CO_2 equivalent



Source: See endnote 34 for this section.

2025.[37] Historically, the sector's emissions grew 2.2% annually on average between 2000 and 2019, then dropped from more than 1,000 million tonnes in 2019 to less than 600 million tonnes in 2020, in the context of the COVID-19 pandemic.[38]

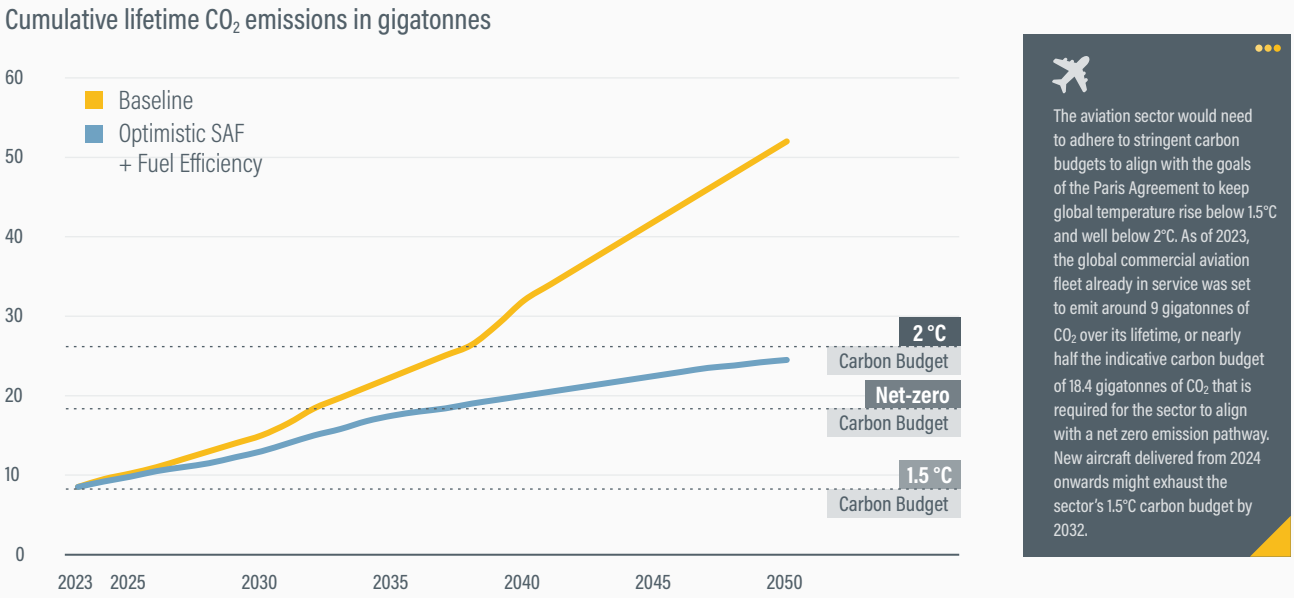
Aviation contributed only around 2.2% of the total global CO_2 emissions from human activities in 2023; however, the sector's absolute volume of emissions was still substantial.[39] **Between 1990 and 2023, air traffic grew 5% annually on average, while CO_2 emissions from aviation grew 2%, indicating some efficiency gains but still resulting in a net increase in emissions over the period.**[40] **The sector's demand growth rate has outpaced overall emission reductions in many economies.**[41]

- In 2024, rising energy demand, particularly aviation fuel consumption, contributed to an increase in global oil-related CO_2 emissions, even as the overall growth in energy-related CO_2 emissions slowed compared to 2023.[42]
- In the EU, aviation has experienced the fastest emission growth among transport modes in recent decades, contributing 13.9% of the region's transport greenhouse gas emissions in 2022 (the second largest source after road transport).[43] (See 3.3 Europe Regional Overview.)

Around 80% of the CO_2 emissions from aviation originate from flights of more than 1,500 kilometres, distances that generally cannot be substituted by rail.[44] **This has profound implications for decarbonisation strategies and underscores the importance of developing and deploying scalable solutions that can effectively reduce emissions from medium- and long-haul flights; the leading solution is SAF, and potentially also future fuel-efficient aircraft and propulsion technologies.** The impact on global aviation emissions of a modal shift from air to high-speed rail appears limited, based on the available information.

The International Civil Aviation Organization has adopted a Long-term Global Aspirational Goal (LTAG) for the international aviation sector of achieving net zero carbon emissions by 2050.[45] **To meet this goal, the ICAO and its Member States strive to reduce CO_2 emissions in international aviation by 5% by 2030 through the use of cleaner fuels such as SAF, without specific obligations or commitments in the form of emission reduction goals attributed to individual members.**[46] Analysis of cumulative emissions reveals the immense scale of the challenge.

FIGURE 5. Consumption of aviation carbon budget from cumulative lifetime emissions of projected fleet



Source: See endnote 48 for this section

The aviation sector would need to adhere to stringent carbon budgets to align with the goals of the Paris Agreement to keep global temperature rise below 1.5°C and well below 2°C.[47] **As of 2023, the global commercial aviation fleet already in service was set to emit around 9 gigatonnes of CO_2 over its lifetime, or nearly half the indicative carbon budget of 18.4 gigatonnes of CO_2 that is required for the sector to align with a net zero emission pathway** (Figure 5)**.**[48] **New aircraft delivered from 2024 onwards might exhaust the sector's 1.5°C carbon budget by 2032.**[49]

For flights within and departing the EU-27, the United Kingdom, and the European Free Trade Association region, cumulative net aviation CO_2 emissions between 2020 and 2050 would total around 3.3 gigatonnes under the region's proposed net zero pathway.[50] This is 52% below the 6.9 gigatonnes of emissions that would result in a reference scenario without climate action.[51]

Aviation's carbon budget constraints underscore that relying solely on incremental efficiency gains and SAF deployment in conventional aircraft may be insufficient, particularly to achieve the ambitious 1.5°C target. This points to an urgent need either for much sooner and larger-scale deployment of genuinely zero-emission aircraft (powered by hydrogen or electricity), or for the delivery of aircraft from the mid-2030s onwards that operate exclusively on 100% SAF, with extremely low life-cycle emissions.[52]

The risk of remaining dependent on the current (high-carbon) pathway is significant. The continued production and delivery of new aircraft designed primarily for fossil fuels, even if they incorporate efficiency improvements, locks in emissions for decades due to the long operational lifespan of aircraft (20-30 years).[53] This inertia makes the transition progressively harder and increases the likelihood that the sector will need to rely on large-scale, potentially costly, and technologically nascent carbon dioxide removal (CDR) technologies towards 2050 to balance the residual emission budget.[54]

Models of future CO_2 emission trajectories for the aviation sector illustrate the critical levers for decarbonisation, based on varying assumptions about technology, policy and demand.[55] **If current growth trends continue without significant intervention, aviation's CO_2 emissions could potentially triple by 2050.**[56] **The stark contrast between potential net zero pathways and the possibility of emissions tripling highlights the transformative nature of the changes required and the high stakes involved in failing to implement effective mitigation measures.** The divergence across scenarios underscores the high degree of uncertainty about the sector's future emission trajectory.

- The ICAO projects that by 2050, aviation's CO_2 emissions will drop to 200 million tonnes of residual emissions (those that remain unabated, even after maximising reduction efforts), achieved through aircraft technologies (21%), operations (11%) and fuels (55%).[57]

- The International Energy Agency's (IEA) Net Zero Emissions (NZE) Scenario envisions around 210 million tonnes of CO_2 emissions by 2050, achieved through efficiency improvements, policies favouring high-speed rail and curbing business travel, and increases in SAF and hydrogen-based synthetic fuels.[58]
- The European industry roadmap Destination 2050 outlines the achievement of net zero CO_2 emissions by 2050 for flights within and departing the EU-27, United Kingdom and European Free Trade Association region, to be attained through SAF (35%), aircraft and engine technology (27%), optimised operations (6%) and demand reduction due to higher prices; the remaining 10% reduction (around 29 million tonnes) is through carbon removals outside the sector.[59]
- The Air Transport Action Group (ATAG) envisions net zero emissions by 2050, achieved through SAF (53-71%), technology improvements (12-34%), operational improvements (7-10%) and market-based measures (6-8%).[60]
- The International Council on Clean Transportation's (ICCT) Budget-Based Scenarios for aviation are focused on carbon budget alignment, aggressive SAF uptake and efficiency, and the need for zero-emission aircraft or 100% low-emission SAF for new deliveries by the mid-2030s.[61]

Operational improvements such as enhancing the efficiency of air traffic management and aircraft operations can yield immediate fuel savings and emission reductions. Collectively, operational efficiencies offer a maximum emission reduction potential of 10%.[62] Initiatives to modernise airspace management include the US Next Generation Air Transportation System (NextGen) and Europe's Single European Sky ATM Research (SESAR).[63] Improving data quality, automation and weather information systems can further enable flight path optimisation and more fuel-efficient routing.

Fleet renewal remains a cornerstone of aviation's decarbonisation strategy. New-generation aircraft delivered by major manufacturers such as Airbus, Boeing, COMAC and Embraer are a reported 20-30% more efficient than the older models they replace.[64] **However, the rate of fuel efficiency improvement (around 1% per year) has stagnated since 2020.**[65] **If all cost-effective technologies are adopted, annual fuel burn reductions of up to 2.2% are technically possible through 2034, although current trends are slower.**[66] The efficiency lull exists in part because manufacturers have focused on refining existing models rather than launching new "clean sheet" designs, which limits incorporation of the latest technologies.[67]

Airlines have invested heavily in new aircraft, with more than 19,360 new planes delivered since 2009 and a production backlog of around 15,700 new-technology aircraft set to enter the fleet from 2023 onwards.[68] **The combination of new technology, operational efficiencies and infrastructure improvements avoided an estimated 14.6 billion tonnes of CO_2 between 1990 and 2023, according to industry sources.**[69]

Research and development continue to target further incremental improvements. Disruptive technologies such as battery electric and hydrogen propulsion hold promise for zero-emission flight but face large hurdles to widespread adoption by 2050, with commercial deployment not expected before the late 2030s.[70] **Their contribution to overall aviation fuel consumption and emission reduction by 2050 is projected to be limited in most scenarios.**[71] This is because of challenges related to energy density, range, payload capacity, infrastructure requirements, and the long timelines for aircraft development, certification and fleet turnover.

The critical timing gap reinforces the importance of SAF, which is widely regarded as the most significant near- to medium-term solution for decarbonising aviation. Global SAF production more than doubled in 2024 to 1 million tonnes (1.3 billion litres) – up from around 0.5 million tonnes (600 million litres) in 2023 – and is projected to double again to 2.1 million tonnes (2.7 billion litres) in 2025 (albeit starting from a very low base).[72] SAF offers a "drop-in" replacement for conventional jet fuel with substantially lower life-cycle emissions (see 5.1 Transport Energy Sources). Tracking its production is key to assessing progress (for example, through the ICAO's Cleaner Energy Tracker Tools).[73]

Despite its rapid growth rate, SAF's share of total global aviation fuel consumption was only around 0.15% in 2023, rising to 0.3% in 2024 and a projected 0.7% in 2025.[74] **Scaling SAF production to meet 2050 targets is a monumental undertaking, requiring an estimated USD 1.5 trillion in capital investment over 30 years.** [75]

Demand signals for SAF have arisen from policy mandates in the EU and the United Kingdom, goals in the United States, and growing voluntary commitments from airlines. Yet securing the necessary long-term off-take agreements remains a hurdle. SAF producers typically require bankable contracts of 10 or more years to secure financing for new plants. However, off-takers (such as airlines) often prefer shorter-term contracts due to price and volume uncertainties. This mismatch contributed to a slowdown in off-take agreement announcements in 2023/2024 after a peak in 2022.[76]

Beyond CO_2 emissions, aviation impacts the climate greatly through non-CO_2 effects, including the release of nitrogen oxide (NO_x) emissions at altitude and the formation of persistent condensation trails (contrails) and contrail-induced cirrus clouds. These effects could equal or exceed the total climate warming impact of aviation's CO_2 emissions alone (Figure 6).[77]

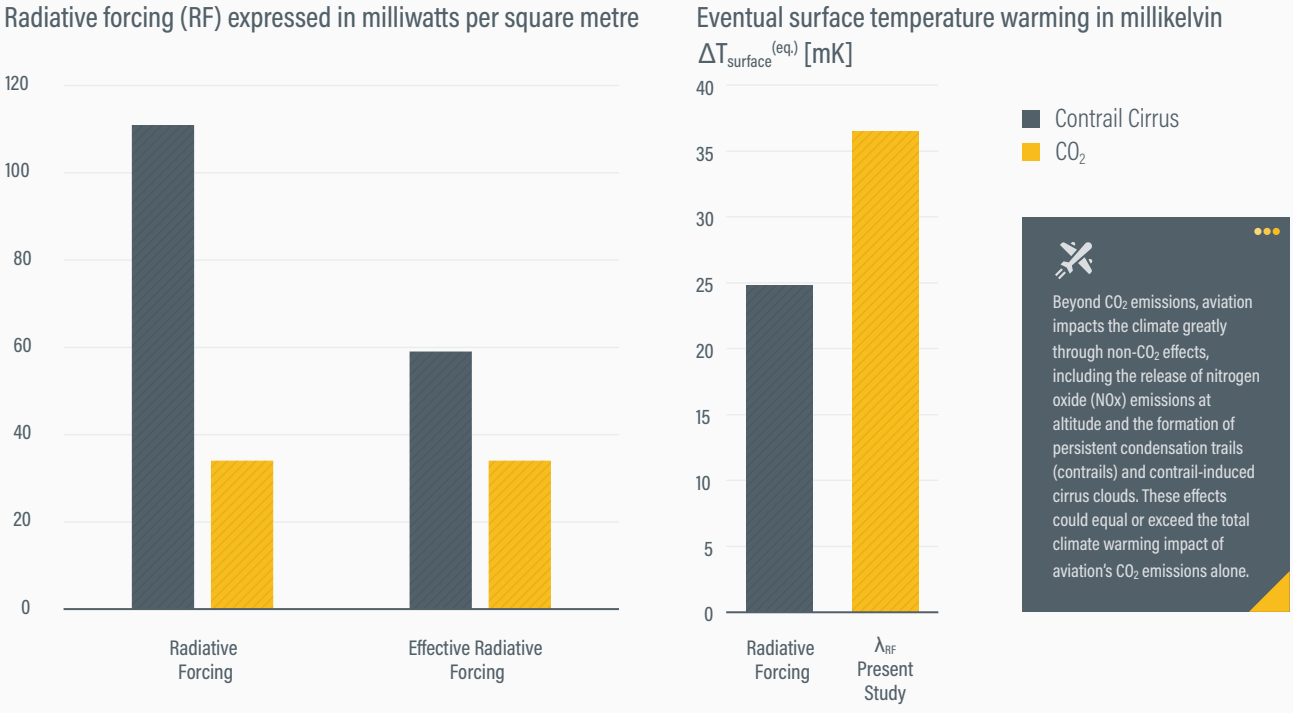
Despite the growing recognition of non-CO_2 effects and the initiation of monitoring requirements, the implementation of large-scale trials and mitigation strategies to address these effects appears less advanced compared to measures targeting CO_2.[78] Translating this into effective, globally co-ordinated mitigation action remains a key challenge and opportunity for the coming years, provided uncertainties related to ice super-saturated regions to avoid are properly quantified.[79] Data are lacking on the widespread implementation or regulatory status of operational measures such as flight rerouting to avoid contrail-prone atmospheric regions, and on changes in fuel composition (potentially a co-benefit of certain SAF with lower aromatic content).[80]

In addition to mitigating its own climate impact, the aviation sector must adapt to the unavoidable consequences of climate change already under way, including increasing disruptions from more frequent and intense extreme weather events. Initiatives are emerging to study these impacts and to develop adaptation strategies.[81] In Europe, physical risks facing aviation infrastructure and operations include increased temperatures (leading to reduced aircraft performance, heat damage to pavements, increased demand for cooling, and heat stress for personnel/passengers); changes in storms and precipitation (causing operational disruptions such as delays, cancellations and diversions); flooding of airfields and infrastructure; damage from wind and lightning; disruption to ground access; and sea-level rise (threatening coastal airports with inundation and loss of capacity).[82] Additional impacts include changes in wind patterns (affecting routes and turbulence), shifts in biodiversity (such as increased risk of bird strikes), changes in icing conditions and potential desertification effects.[83]

Policy and investment developments

In 2022, the ICAO Assembly adopted its Long-Term Aspirational Goal (LTAG) for international aviation to achieve net zero carbon emissions by 2050.[84] This global goal signals a collective ambition to align the sector with the

FIGURE 6. Estimation of the contrail cirrus climate impact on global surface temperature



Source: See endnote 77 for this section.

global warming targets of the Paris Agreement, although it is not binding on individual member states. The ICAO provides the primary platform for co-ordinating global action on the aviation sector's efforts to address climate change. Although the LTAG has global application, initial participation is explicitly non-binding on individual ICAO members (whereas the net zero regulations recently adopted by the International Maritime Organization also apply worldwide but are mandatory across the maritime sector from October 2025).[85]

To support the LTAG, in November 2023 the third ICAO Conference on Aviation and Alternative Fuels adopted the "ICAO Global Framework for Sustainable Aviation Fuels (SAF), Lower Carbon Aviation Fuels (LCAF) and other Aviation Cleaner Energies".[86] The Framework includes a collective global aspirational vision to reduce CO_2 emissions in international aviation 5% by 2030 through the use of cleaner energy sources, compared to a baseline that assumes zero use of cleaner energy.[87] This framework outlines a comprehensive strategy, emphasising that cleaner energy sources such as SAF are expected to make the largest contribution to CO_2 reductions by 2050. Its four building blocks are: policy and planning, regulatory framework, implementation support and financing.[88]

The EU has taken a leading role in translating international goals into binding regional legislation with its landmark ReFuelEU Aviation regulation, in effect since January 2025 and part of the "Fit for 55" climate package. The regulation sets legally binding minimum shares of SAF that must be blended into aviation fuel supplied at EU airports, starting at 2% in 2025 and rising to 6% in 2030, 20% in 2035 and 70% by 2050.[89]

ReFuelEU creates the world's largest mandated market for SAF and provides a strong, long-term demand signal intended to drive investment in production, particularly within the EU; however, implementation challenges remain due to the high costs. Within the overall SAF share, a specific, escalating sub-mandate for e-SAF aims to accelerate the development and deployment of this advanced, potentially highly sustainable pathway; it starts at an average of 1.2% for 2030-2031, rising to 5% in 2035 and 35% by 2050.[90]
(See 5.1 Transport Energy Sources for national-level efforts on SAF.)

In January 2025, the incoming Trump administration issued an executive order halting the disbursement of funds for implementing the 2024 US Aviation Climate Action Plan.[91] In July 2025, the so-called One Big Beautiful Bill Act reduced SAF production incentives from USD 1.75 per gallon to USD 1 per gallon.[92] The bill reinforced crop-based production using corn and soybeans, resulting in increases in food prices and emissions from land use.[93]

Some European countries have implemented or considered demand-side measures that restrict short-haul flights where viable transport alternatives exist. In France, a 2022 law prohibits domestic flights on routes where a direct train journey of less than 2 hours and 30 minutes is available.[94] Policy analysis has explored extending this ban to routes with train alternatives under five hours, which could greatly increase the number of affected routes and potential emission savings.[95] However, critics argue that airlines may simply reallocate the freed-up slots to longer, potentially more carbon-intensive international flights; thus, short-haul bans should be implemented alongside broader measures that address potential rebound effects or emission leakage.[96]

Although the adoption of SAF and other decarbonisation technologies is expected to increase the cost of flying, it can also serve as a key means to moderate the growth in aviation demand. As of 2018, the demand for aviation from 1% of the world's population produced 50% of the sector's emissions, while around 80% of people had never set foot on a plane.[97] Research from 2022 found that, globally, the wealthiest 5% people accounted for 55% of aviation activity and emissions.[98] However, the impact of higher flying costs will vary across regions and socio-economic groups.[99] Addressing these distributional effects is crucial to maintain public support and ensure that the transition is perceived as fair.[100]

Policies aimed at mitigating these impacts could include targeted subsidies for essential routes, progressive taxation schemes that shield infrequent flyers, and using the revenue from aviation taxes to support lower-income groups or invest in alternative transport infrastructure. In western Europe, the highest-income households (over USD 103,505 or EUR 100,000 per year) are at least six times more likely to take three or more return flights per year than those on the lowest incomes (under USD 20,701 or EUR 20,000 per year).[101] Among the lowest-income group in western Europe, nearly 70% of households do not fly in any given year, compared with just over 20% among the highest-income households.[102]

Some countries are applying the "polluter pays" principle more directly to aviation, including through aviation fuel taxes, national ticket taxes, frequent flyer levies and international solidarity levies to internalise the environmental costs of flying, moderate demand and generate revenue to fund climate mitigation or cleaner technologies such as SAF.[103] Growing consideration of direct pricing mechanisms indicates a potential shift towards making passengers and airlines bear a greater share of the climate cost of aviation, with the aim of ensuring a just transition.[104]

With a small percentage of the population accounting for a large share of flights and emissions, frequent flyer levies are seen as an equitable tool targeting those who fly most frequently and often farthest (typically, higher-income individuals).[105] This contrasts with the potentially regressive impact of flat taxes or general price increases resulting from SAF adoption, which could disproportionately affect those who rely on flying for essential connectivity.[106] The Global Solidarity Levies Task Force is co-ordinating growing international momentum to implement levies on aviation (either fuel or tickets, and potentially frequent flyer levies) to generate predictable funding – estimated at USD 6.2 billion to USD 20.7 billion (EUR 6-20 billion) annually for climate adaptation and mitigation in vulnerable countries.[107]

Despite the substantial revenue potential of taxes and levies, which could be channelled towards climate finance or subsidising SAF, significant implementation hurdles remain. These include persistent legal complexities surrounding fuel tax exemptions (despite arguments for their permissibility) and the challenge of international co-ordination for global levies. While recognising the need to support the reduction and stabilisation of CO_2 emissions from all sources, ICAO and its Member States have expressed concern on the use of international aviation as a potential source for the mobilisation of revenue for climate finance to other sectors, in order to ensure that international aviation would not be targeted in a disproportionate manner.[108]

As of December 2023, within the broad "transport services" sector, 337 companies globally had validated targets for emission reductions under the Science Based Targets initiative (SBTi), which provides a framework for companies to set emission reduction targets aligned with climate science.[109] The SBTi published an "Interim 1.5°C Aviation Pathway" in February 2023, enabling airlines and potentially other companies in the sector to set science-based net zero targets.[110] However, the exact number of aviation companies with validated targets under this pathway is not specified.

- The SBTi Corporate Net-Zero Standard (CNZS) is under revision, with potentially significant changes introduced for target setting for Scope 3 emissions, clearer integration of carbon removals, as well as reporting on progress in achieving targets.[111] The revision will be crucial for the SBTi to remain one of the most widely recognised standards and a reference for companies to set science-based targets.

- A separate assessment noted that more than three-quarters of the world's 20 largest airlines have now established public targets for SAF uptake.[112]

In July 2024, Air New Zealand, only the second carrier globally to have its targets validated under the SBTi aviation framework, abandoned its SBTi-validated goal to reduce its carbon intensity 28.9% below 2019 levels by 2030 (including a 16.3% cut in absolute emissions).[113] **Although the carrier reaffirmed its long-term goal of net zero emissions by 2050, its decision to abandon the 2030 goal underscores the practical difficulties the industry faces in delivering deep emissions cuts in the near term, given the state of technology deployment, fuel supply chains and enabling policies.** Stated reasons for Air New Zealand's shift included delays in the delivery of new, more fuel-efficient aircraft due to global manufacturing issues; the prohibitive cost and insufficient availability of SAF; and challenging policy settings.[114] Other airlines may similarly question their ambitious 2030 targets if the necessary conditions for success do not materialise rapidly.

Major aircraft manufacturers play a pivotal role in decarbonisation through the development and delivery of more efficient aircraft and enabling the use of future fuels. Their strategies and targets reflect the key technological pathways being pursued.

- Airbus is focused on improving its fleet efficiency (around a 25% gain in the latest generation), achieving 100% SAF capability by 2030 and advancing key technologies for next-generation aircraft.[115] It researches non-CO_2 impacts and invests in carbon removals. Airbus has SBTi-validated targets, including a 63% absolute reduction in operational (Scope 1 and 2) emissions by 2030 and a 46% reduction in the emissions intensity (Scope 3) of its commercial aircraft in service by 2035.[116] The company links its activities to contributing to various UN SDGs.[117]
- Through its "Cascade Climate Impact Model", Boeing is prioritising fleet renewal (newest jets 20-30% more efficient), operational efficiency improvements (working with airlines and air traffic management providers), SAF enablement (targeting 100% compatibility by 2030, investing in testing, and partnering on production) and advancing future technologies.[118] Key technology projects include the Transonic Truss-Braced Wing (TTBW) demonstrator with the US space agency NASA.[119]
- Embraer aims for carbon neutrality in its operations (Scope 1 and 2) by 2040 (including 100% renewable energy use by 2030) and supports the industry goal of net zero aviation by 2050.[120] Its strategy focuses on improving the efficiency of aircraft (the E2 family offers around a 25% improvement), achieving 100% SAF compatibility and developing electric/hybrid propulsion (Energia family concepts).[121]
- As a state-owned enterprise, COMAC's approach reflects the Chinese government's emphasis on balancing economic growth with environmental responsibility. The company is focused on developing more fuel-efficient aircraft and increasing the adoption of SAF. Additionally, COMAC is investing in research and development for next-generation technologies, in line with China's strategic focus on innovation and technological self-sufficiency.[122]

However, the primary climate impact of aircraft manufacturers lies not in their own operations (Scope 1 and 2 emissions) but in the emissions generated by the aircraft they sell, throughout their decades-long service lives (Scope 3 emissions). **Ensuring that all manufacturers accept their life-cycle responsibility and set ambitious targets covering the in-use emissions of the aircraft they sell is critical for driving progress. Airbus' adoption of a specific Scope 3 intensity reduction target reflects an important signal.**[123]

There are two main carbon market schemes in the aviation sector: the EU Emissions Trading System (ETS) and the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). To avoid double-claiming benefits under the different schemes, airlines must carefully account for SAF use.[124]

- The EU ETS' cap-and-trade system applies to flights within the European Economic Area.[125] It sets a declining cap on emissions, and operators must surrender allowances to cover their verified emissions. Recent revisions have strengthened the system, phasing out free allowances for aviation by 2027 to increase the sector's contribution to EU climate goals. The EU ETS is also expanding its scope to include monitoring and reporting of non-CO_2 climate effects, starting in 2025.[126] Revenues generated or allowances saved through SAF use can potentially support further decarbonisation.
- CORSIA is the ICAO's global market-based measure to address CO_2 emissions from international flights above a defined baseline, with the goal of achieving carbon-neutral growth.[127] Airlines operating international flights between participating states can offset any emissions exceeding this baseline by purchasing and cancelling CORSIA Eligible Emissions Units (EEUs) generated from approved carbon reduction projects elsewhere.[128]
- As of autumn 2024, global emissions had reportedly not yet reached the threshold triggering offsetting obligations under CORSIA.[129] From 2024 to 2035, the baseline is set at 85% of 2019 emission levels, and the scheme is expected to mitigate between 1.2 billion and 2 billion tonnes of CO_2 during this period.[130] Participating in CORSIA remains voluntary until 2027.[131]

This fragmentation of carbon reduction efforts for aviation, lacking a single, globally consistent carbon price signal, potentially leads to compliance complexities and competitive distortions. The EU ETS and CORSIA interact: the EU uses ETS rules to implement CORSIA obligations for extra-EEA flights operated by EU-based airlines. The EU ETS covers intra-EEA flights, whereas CORSIA targets the growth in international emissions (but has yet to require offsetting); various national taxes or levies add another layer.

The environmental integrity of CORSIA, as an offset-based mechanism, depends critically on the quality of the EEUs and the robust implementation of accounting rules under Article 6 of the Paris Agreement by host countries providing the offsets. This involves rigorous processes for authorisation, tracking, reporting and applying "corresponding adjustments" to national emission inventories to prevent double counting of emission reductions.[132] Ensuring this integrity across countries with varying capacities is an ongoing governance challenge for the ICAO and the international climate regime, also requiring co-ordination with the UN Framework Convention on Climate Change. With the progress made on Article 6 at the 2024 UN Climate Change Conference in Azerbaijan (COP 29) and the existence of stringent CORSIA Emissions Units Eligibility Criteria as approved by the ICAO Council, governments hosting activities that generate EEUs now have the guidelines they need to authorise the use of these units under CORSIA.[133]

Financial support mechanisms are crucial enablers of the SAF transition, given the high cost of the fuels and the significant investment risks associated with developing new technologies and production facilities.

- For risk mitigation, access to low-interest loans and loan guarantees from public finance institutions (such as the European Investment Bank or national development banks) and export credit agencies is seen as vital, particularly for first-of-a-kind projects.[134]
- To support market aggregation and facilitation, concepts such as Green Market Makers, potentially using blended finance (public/private capital), aim to bridge the price gap, provide liquidity, absorb risk and facilitate off-take agreements. Demand pooling instruments have also been proposed.[135]
- Efforts are under way to improve access to international climate finance, especially for low- and middle-income

countries. The ICAO Finvest Hub aims to improve access to international climate finance for aviation decarbonisation, particularly for low- and middle-income countries, by connecting countries and project developers with funding opportunities, whereas and proposals for Global Solidarity Levies target high-emitting sectors (e.g., aviation) for climate and development financing to other sectors.[136]

Although the primary focus of aviation decarbonisation is on avoiding and reducing emissions at the source, there is growing recognition of the potential role of carbon dioxide removal (CDR) in addressing the residual emissions that remain after maximising reduction efforts. CDR activities remove CO_2 from the atmosphere and durably store it in geological, terrestrial, or ocean reservoirs, or in products. It is distinct from carbon capture and storage (CCS) from fossil fuel point sources, and from carbon offsetting that typically involves funding emission reductions elsewhere. CDR is primarily considered a means to neutralise the residual emissions that might come from legacy aircraft still in operation or from specific flight operations where SAF or low-emission aircraft are not yet feasible, or that could persist if the deployment of primary mitigation measures falls short of expectations.

- The Destination 2050 roadmap for European aviation relies on CDR – specifically direct air carbon capture and storage (DACCS) – to achieve net zero emissions by 2050, modelling it to address the final 10% (around 29 million tonnes) of emissions.[137]
- The ICCT's carbon budget analysis suggests that without a rapid shift to zero-emission aircraft or 100% low-emission SAF, substantial amounts of CDR (potentially tens of billions of tonnes via direct air capture, or DAC) would be required to offset the committed emissions from conventional aircraft delivered in the coming decades.[138]
- The US Aviation Climate Action Plan acknowledges the potential need for robust out-of-sector measures, including CDR, to close any remaining emission gap, and mentions US government support for research and development of CDR (for example, through the Department of Energy's Carbon Negative Shot).[139]
- Airbus has indicated investment in DAC technology and agreements for purchasing carbon removal credits, positioning it as part of the company's broader decarbonisation toolkit.[140]

Decarbonising aviation is not an isolated challenge but requires unprecedented levels of collaboration across multiple stakeholder groups. This need for collaboration stems from the sheer complexity of the transition. Developing and scaling SAF involves agriculture, waste management, chemical processing, energy production and logistics. Developing new aircraft involves advanced materials, propulsion physics and complex systems integration. Optimising operations requires co-ordination among airlines, airports and air navigation service providers. Financing the transition requires alignment among project developers, governments, and public and private financial institutions. Furthermore, aviation's decarbonisation is inextricably linked to the broader global energy transition, particularly the scale-up of renewable electricity and green hydrogen needed for e-fuels, requiring integrated planning across sectors.

Collaboration also faces challenges, as different stakeholders have varying, sometimes conflicting, interests. Fuel producers may desire long-term off-take certainty, while airlines might prefer shorter-term flexibility. Competition for limited resources such as sustainable feedstocks or renewable energy can create tensions among companies or even sectors. Differing views on the optimal policy mix (e.g., mandates versus incentives) also exist. Successful collaboration requires not only a willingness to work together but also effective mechanisms for dialogue, negotiation, risk-sharing, and incentive alignment to bridge these differences and foster collective action towards the common goal. Initiatives such as the proposed Green Market Makers aim to provide such mediating structures.[141]

Building aviation's resilience requires a collaborative effort across the interconnected aviation network to ensure operational continuity and safety in a changing climate. There is a need for aviation stakeholders (airports, airlines, air navigation service providers) to conduct systematic climate risk assessments and develop adaptation plans. This involves understanding local climate projections, assessing vulnerabilities, prioritising risks and identifying adaptation measures. Potential infrastructure adaptation measures include enhancing drainage systems, reinforcing structures against higher wind loads, using heat-resistant materials for pavements, protecting critical equipment from flooding or heat, potentially relocating critical infrastructure and building sea defences for coastal airports. Measures to enhance aircraft systems and operations include improving weather forecasting and decision support tools to better manage disruptions, adapting operational procedures for extreme heat or storms, enhancing aircraft systems' resilience to turbulence or icing, and potentially adjusting network planning and schedules to account for increased weather variability.

National adaptation plans are also beginning to incorporate transport sector strategies. France's third National Climate Change Adaptation Plan (PNACC3) includes measures relevant to aviation resilience.[142]

Partnerships in action

- In 2025, the first **ICAO Aviation Climate Week** brought together 500 delegates to discuss global aviation's path to net zero carbon emissions by 2050; focal topics included SAF, the clean energy transition and implementation support.[143]
- The **ICAO Global Coalition for Sustainable Aviation**, with 58 members as of August 2025, brings together partners such as academia, aircraft manufacturers, airlines, SAF producers and other companies to facilitate new approaches and solutions for sustainable aviation.[144] In 2021, the coalition presented a report featuring a collection of innovations.[145]
- In 2024, the **International Transport Forum** and the **ICAO** released a joint agreement to advance sustainable aviation, with the ambition to deepen collaboration, data sharing and research.[146] The agreement enables research to address complex challenges: for example, the ITF report *Decarbonising Aviation: Exploring the Consequences* looks at connectivity, sustainable tourism, just transition and other impacts of moving towards net zero aviation.[147]

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Shipping

KEY FINDINGS

Demand, use and access

- Global maritime trade grew 2.4% in 2023 to 12.3 billion tonnes, after contracting 0.4% in 2022. Recent events have revealed how susceptible global trade and maritime transport are to distortions caused by geopolitical conflicts, climate change and economic slowdowns.
- Since 2022, the Russian Federation's invasion of Ukraine has had significant effects on global trade.
- Unrest in the Middle East and attacks on merchant ships in the Red Sea have greatly reduced vessel crossings of the Suez Canal, the shortest maritime route between Asia and Europe, through which around 15% of global maritime trade volume normally passes; most ships have since opted for a much longer route around the Cape of Good Hope in Africa. In the first two months of 2024, the volume of trade that passed through the Suez Canal dropped 50% from a year prior, while the volume of trade transiting around the Cape of Good Hope increased an estimated 74%.
- Climate change has affected one of the most important shipping routes – the Panama Canal – with the region's extreme drought resulting in a 50% reduction in crossings in the second half of 2023 and early 2024. This caused a significant slowdown in global trade and disruption to supply chains – including prolonged waiting times or re-routing around the Cape of Good Hope – leading to delays, increased operational costs and higher greenhouse gas emissions.
- The countries most affected by these disruptions have been small island developing states (SIDS) and least developed countries (LDCs). SIDS are highly dependent on maritime trade, even for essential consumer goods, and often face poor shipping connectivity. Countries that are located farther from major shipping routes can experience steep increases in consumer prices, especially for food.
- The global merchant fleet continues to grow steadily. For containerised cargo, trade flows have been mostly stable, with slight growth on the Trans-Pacific route and minor drops on the Europe-Asia-Europe and Transatlantic routes. In 2023, the largest container ports based on throughput were Shanghai (China) at 49.2 million twenty-foot equivalent (TEU), Singapore (39.0 million TEU) and Ningbo-Zhoushan (China; 35.05 million TEU). The cargo types that expanded most in 2023 were cars (15% growth), liquefied petroleum gas (LPG; 6%) and dry bulk (4.3%).
- As of mid-2025, the leading countries for ship registration were Liberia, with 424 million DWT, Panama (371 million DWT) and the Marshall Islands (305 million DWT). Out of a total of 112,495 ship registrations, SIDS accounted for 13.7% (15,462), and low- and middle-income countries (also including SIDS) represented 70.3% (79,098). By registering their vessels in SIDS, shipowners can benefit from less-costly registration fees, lower safety and worker welfare standards, and fewer restrictions overall.
- As of 2025, a total of 1.9 million seafarers were supporting USD 14 trillion worth of trade moving around the world. Working conditions are generally poor: in a 2022 survey, 25% of seafarers reported experiencing some kind of harassment and bullying (more than 50% for female seafarers) and 90% reporting having no weekly day off. Women accounted for 1.2% (24,000) of seafarers in 2020, up 46% from 2015.
- The global shipping fleet grew 3.2% in 2023 to 2.3 billion DWT, with most of this capacity represented by bulk carriers, followed by crude oil tankers and container ships. In 2024, oil tankers used to transport fossil fuels accounted for 28% of the world's shipping fleet. Although the total capacity of container ships fell in 2023, the fleet expanded 8% and the global shipyard output increased 10%, to 35 million compensated gross tonnage. In 2023, for the first time, China delivered half of the global shipbuilding output. Chinese shipyards controlled 65% of the world's vessel order books in 2024.
- As of 2024, the shipping sector was only partially on track to meet the IMO target for 5-10% zero-emission fuels by 2030. In 2023, just 0.44% of gross tonnage was capable of using scalable zero-emission fuels, up slightly from 0.32% in 2022.
- Around half of all new-build ship tonnage ordered in 2024 (62.2 million gross tonnage) was capable of using alternative fuels. The order book included vessels running on methanol (118 ships), ammonia (25), LPG (72), and hydrogen (12), in addition to LNG (820 total orders, including 390 LNG carriers).
- In addition to the shift to alternative fuels, 37% of the vessel tonnage as of 2024 was fitted with energy-saving technologies to improve the carbon intensity performance of ships.
- Global sales of marine fuel grew 1.8% in 2023 and 4% in 2024 – propelled by rerouting due to the Red Sea crisis –

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after falling sharply in 2020 and 2022 due to economic slowdowns. The demand for marine bunker fuels hit an all-time high in 2024, with total sales of 143.6 million tonnes.

- Digitalisation and automation have played a key role in transforming maritime logistics and operations. The use of new technologies has occurred across operations ranging from vessel control to port logistics to route planning.

Sustainability and climate trends

- Greenhouse gas emissions from shipping (domestic and international) totalled around 950 million tonnes of CO_2 equivalent in 2023. International shipping contributed more than three-quarters of the total, or 746 million tonnes (up 1.1% from 2022 and 11.2% from 2020), while domestic shipping (or waterborne navigation) contributed 205 million tonnes, up 26% from 2020.
- If shipping emissions were measured alongside countries, the sector would rank as the ninth-largest contributor of greenhouse gas emissions worldwide in 2023, comparable to major industrialised countries. In a single year, the emissions from shipping were nearly equivalent to the total transport emissions from all countries in Africa and Latin America and the Caribbean combined.
- As of 2025, the shipping sector was on a trajectory to completely exhaust its proportional share of the world's carbon budget – the amount of emissions it can release without surpassing global warming of 1.5 degrees Celsius (°C). At the current pace, shipping will exceed its budget for staying within 1.5°C of warming by 2030, its 1.7°C budget by 2037 and its 2°C budget by 2047.
- To fully contribute to the Paris Agreement goal of limiting global warming to 1.5°C, shipping's greenhouse gas emissions need to decline drastically to reach zero by 2050. Up to 90% of the reductions could be achieved by replacing fossil fuels with zero-emission fuels, and 10% through operational efficiency improvements.
- Emissions of sulphur dioxide (SO_2) from shipping have fallen since January 2020, when the IMO cap on sulphur came into force. Shipping's SO_2 emissions totalled 3.7 million tonnes in 2022, down two-thirds from 10.4 million tonnes in 2019.
- The most common ways to reduce a ship's energy intensity and fuel consumption are energy-saving technologies such as air lubrication, wind-assisted propulsion, and waste heat recovery, which can deliver energy savings of 5-20% or more (for example, with wind propulsion on favourable routes). Route optimisation can result in similar emission savings, and even higher cuts can be achieved through "slow steaming", or intentionally reducing the travel speed.
- Improving the energy efficiency of ships will be key to meeting the sector's climate targets set by the IMO, but also help the transition to sustainable zero-emission fuels.
- Climate change is likely to impact the shipping sector more frequently and severely in the future, with the greatest hazards being sea-level rise, severe tropical storms and extreme heat events. Weather was the main factor behind at least one-fifth of the roughly 400 vessel losses globally between 2015 and 2019.
- The impacts of climate change could bring an additional financial burden of USD 25 billion every year to the shipping industry by 2100. This includes estimates for port damages and disruptions, but not the wider impact on logistics and supply chains. These are extremely high costs compared to the industry's total operating profits of USD 20 billion annually between 2018 and 2020.

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Policy and investment developments

- The 2023 IMO Strategy on Reduction of GHG Emissions from Ships, adopted in June 2023, raised the level of ambition set in the IMO's 2018 Initial Strategy on Reduction of GHG Emissions from ships. The 2023 Strategy features two new components: indicative checkpoints and a general understanding of the basic elements for the development of a basket of mid-term measures.
- The 2023 IMO Strategy's indicative checkpoints outline a clear emission reduction trajectory for international shipping: reduce the sector's total annual greenhouse gas emissions 20-30% by 2030 and 70-80% by 2040 (compared to 2008 levels), on a path to net zero emissions by or close to 2050. The Strategy is designed to place the sector within scenarios that keep global temperature rise well below 2°C, although it falls short of scenarios that keep temperature rise below 1.5°C.
- In April 2025, after extensive negotiations and external geopolitical pressures, the IMO agreed to the IMO Net-Zero Framework, a landmark regulatory package of mid-term measures that (if adopted in October 2025 and entered into force in 2027) would become the first legally binding carbon price across an entire industry sector.
- Under the Net-Zero Framework's emissions trading rules, compliant ships would be eligible to generate surplus emission units that can be sold to under-compliant ships (under specific conditions). The revenues would be allocated to the IMO Net-Zero Fund to support the adoption of zero- and near-zero emission fuels and technologies, as well as infrastructure development, capacity building, climate resilience in developing countries, and the mitigation of adverse impacts on vulnerable countries.
- In 2024, IMO Member States began a review of two short-term greenhouse gas reduction measures – the Energy Efficiency Ship Index (EEXI) and the Carbon Intensity Indicator (CII) – adopted in 2021 and effective as of January 2023.
- At the regional level, some regulators have moved much faster in addressing emissions from the shipping sector. As of 1 January 2024, under the EU's Emissions Trading System (EU ETS), all ships above 5,000 gigatonnes arriving to EU ports are subject to carbon prices. The FuelEU Maritime regulation, adopted in 2023 and in force as of January 2025, sets maximum limits on the annual average greenhouse gas intensity of the energy used by ships calling at EU ports.

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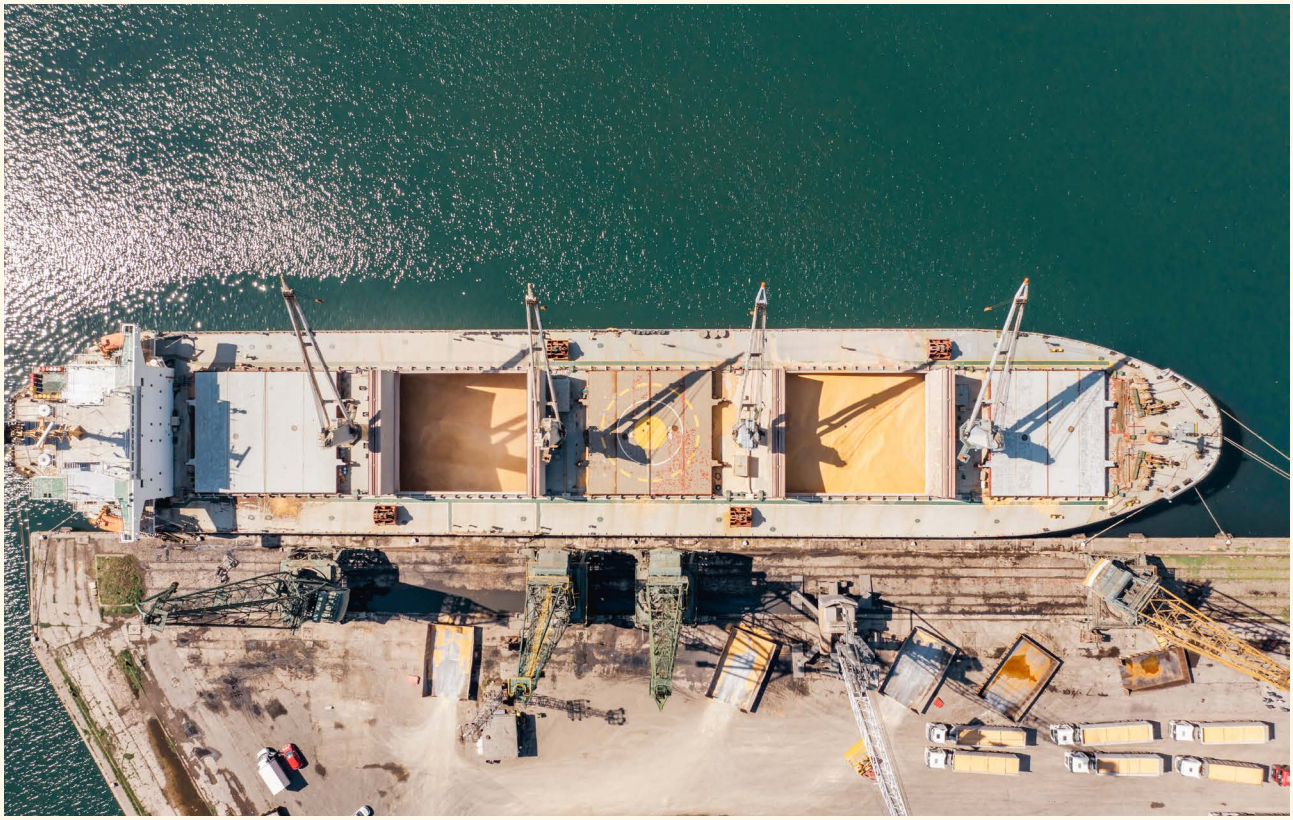
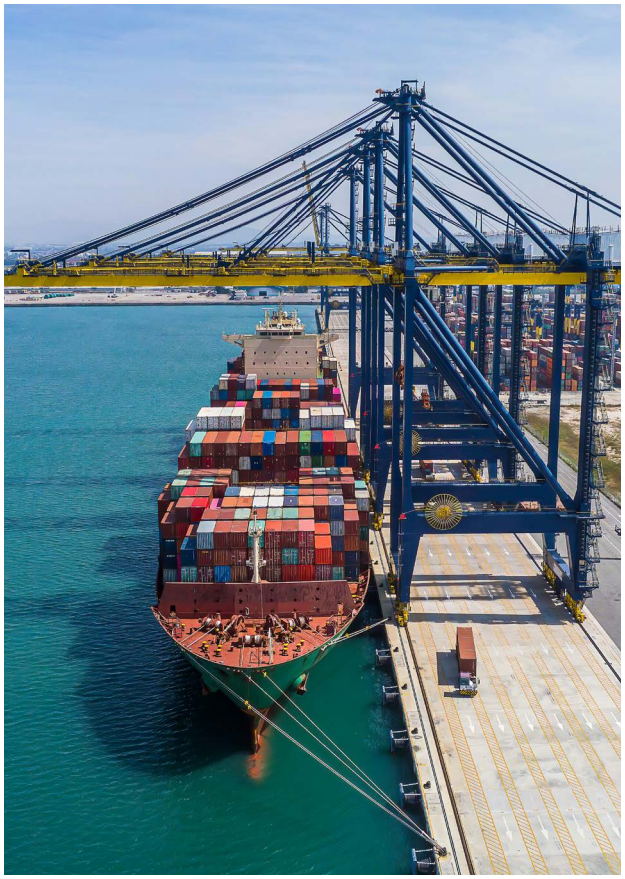
- As of mid-2025, Australia was in the process of developing a Maritime Emissions Reduction National Action Plan, following public consultations held in 2023 and 2024.
- China's Emissions Trading System (ETS), the world's largest by covered emissions, does not yet apply to international or domestic shipping. However, the sub-national carbon market in Shanghai covers ports and shipping companies that emit more than 50,000 tonnes of CO_2 from domestic shipping.
- The UK Emissions Trading Scheme will apply to domestic shipping emissions starting in 2026, and maritime sector emissions are approved for inclusion in the country's sixth carbon budget (2033-37).
- in the United States, the California Air Resources Board (CARB) expanded the coverage of its 2020 At-Berth Regulation, which requires operators of ocean-going vessels and marine terminals to report every visit made to a California terminal.
- Multiple voluntary initiatives for reducing shipping emissions have been established in recent years, covering various types and groups of maritime stakeholders.
- Only 7 of the 29 third-generation Nationally Determined Contributions (NDCs) submitted as of 1 August 2025 included shipping-focused actions towards reducing greenhouse gas emissions under the Paris Agreement.109 The seven submissions were from Belize, Canada, Marshall Islands, Monaco, Niue, the United Kingdom and the United States.
- A total of 62 green shipping corridor initiatives had been announced worldwide as of November 2024, 40% more than in 2023. One-third of this activity was in Europe, while the Asia Pacific and North Pacific regions each represented around one-fifth. With only six initiatives preparing for implementation, a key bottleneck has been the lack of national policy incentives to bridge fuel costs.
- Additional projects have focused on alternative fuel production and infrastructure development, green shipping innovation, resilience and climate mitigation in ports, and decarbonisation efforts in developing countries.





Context, challenges and opportunities

Maritime shipping remains the backbone of global trade, responsible for transporting more than 80% of total goods by volume.[1] However, its centrality in the global economy also makes it vulnerable to geopolitical shocks, climate disruptions and increasing scrutiny for its growing greenhouse gas emissions. The sector has navigated profound challenges in recent years, including the COVID-19 pandemic in 2020 and 2021, armed conflict in Ukraine and the Red Sea region since 2022, and drought-related constraints in the Panama Canal in 2023. These events have reshaped trade routes, increased costs and reinforced the urgency of building a more resilient and sustainable maritime sector.

In 2023, global maritime trade rebounded 2.4% to reach 12.3 billion tonnes of goods transported, despite continued volatility.[2] These shifts also underscored the sector's exposure to climate risks and its role in shaping the economic vulnerability of small island developing states (SIDS) and least developed countries (LDCs), many of which depend almost entirely on maritime imports for basic goods. At the same time, the global fleet has continued to expand and modernise, with a growing share of new ships designed to use alternative fuels such as methanol, ammonia and biofuels. Even so, the transition to zero-emission fuels in the sector remains slow (and only partially on track) due to factors including limited infrastructure, high costs and the modest climate benefits of transitional fuels such as liquefied natural gas (LNG).

In 2023, the global shipping sector (domestic and international) was the ninth-largest emitter of greenhouse gases worldwide, when ranked alongside the economy-wide emissions of countries.[3] Considering only transport greenhouse gas emissions, it was the third-largest emitter after the United States and China.[4] In 2023, global shipping contributed 950 million tonnes of carbon dioxide (CO_2) equivalent; more than three-quarters of this (79% or 746 million tonnes) was from international shipping.[5]

Progress on shipping decarbonisation has been incremental, although the implementation of measures such as the International Maritime Organization's (IMO) cap on sulphur emissions has reduced pollutants such as sulphur dioxide (SO_2). Wind-assisted propulsion, route optimisation driven by artificial intelligence (AI), and slow steaming have helped improve energy efficiency, but the uptake of truly low- and zero-emission vessels and technologies remains limited. In 2024, sales of alternative marine fuels surpassed 1 million tonnes for the first time, yet they represented only a small share of total marine fuel consumption.[6]

Policy momentum has accelerated, particularly with the adoption of the 2023 IMO GHG Strategy, which sets emission reduction checkpoints for 2030 and 2040 and aims for net zero greenhouse gas emissions from international shipping by or around 2050. The April 2025 agreement on the IMO's Net-Zero Framework, a first-of-its-kind standard for global greenhouse gas pricing and lifecycle fuels, marks a potentially transformative step. If adopted in October 2025, it would provide a predictable regulatory pathway for the sector's decarbonisation. In parallel, the IMO is reviewing its short-term greenhouse gas reduction measures – including the Energy Efficiency Existing Ship Index (EEXI) and the Carbon Intensity Indicator (CII) – to strengthen their effectiveness and address implementation challenges.

At the regional level, some regulators have moved faster with their own mechanisms. The European Union's (EU) Emissions Trading System now includes maritime emissions, and the FuelEU Maritime regulation mandates steep reductions in greenhouse gas intensity through 2050. Similar initiatives have emerged in China, the United Kingdom and the United States at the sub-national level.

Beyond regulation, industry-led initiatives have expanded. As of November 2024, 62 green shipping corridor initiatives had been announced globally, with several moving towards implementation.[7] Voluntary frameworks such as the Poseidon

Principles and the Science Based Targets Maritime Guidance are also helping guide finance and freight actors towards climate-aligned practices. These developments reflect a growing recognition that innovation, investment and international co-operation are essential to enable a just and effective transition.

To reach net zero emissions by mid-century, the shipping sector must scale up its use of zero-emission fuels to achieve 5-10% by 2030, accelerate efficiency improvements and ensure that no country is left behind.[8] The interplay between regulation, market signals and technological innovation will determine whether the maritime transport sector can successfully navigate the path to a sustainable future.

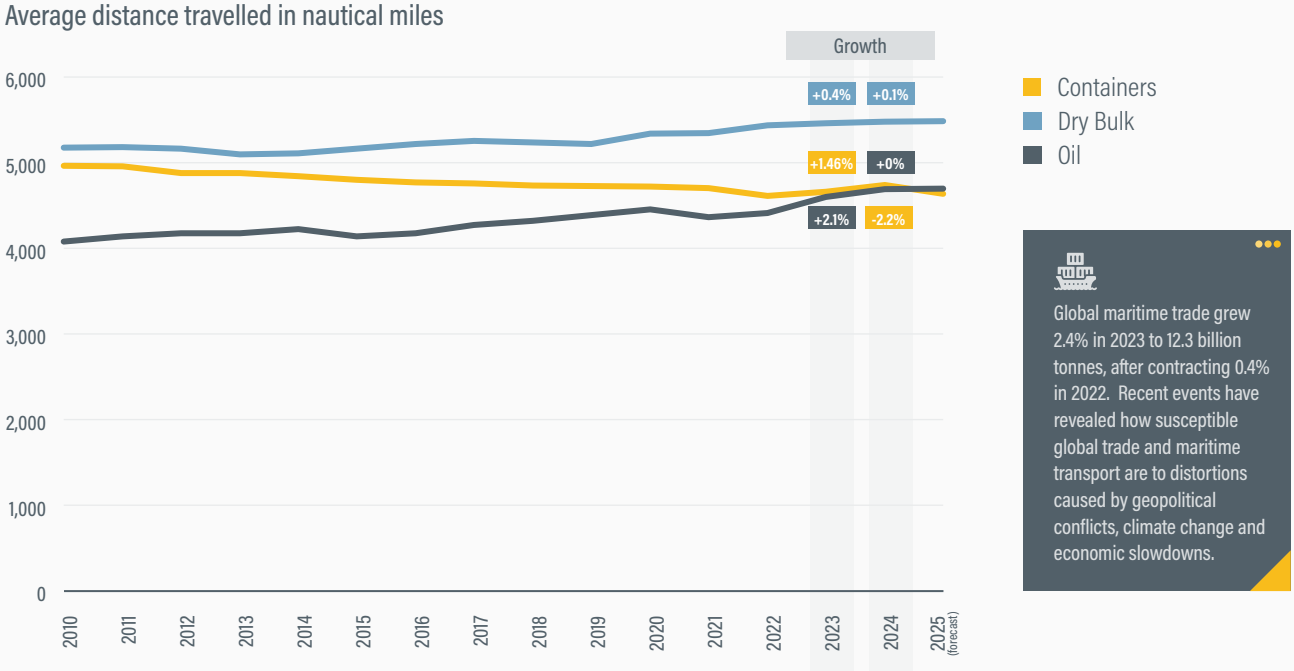
Demand, use and access

Global maritime trade grew 2.4% in 2023 to 12.3 billion tonnes, after contracting 0.4% in 2022.[9] Recent events have revealed how susceptible global trade and maritime transport are to distortions caused by geopolitical conflicts, climate change and economic slowdowns (Figure 1).[10] The shipping sector, and especially travel distances, have been impacted by disruptive events including the COVID-19 pandemic and related recession in 2020 and 2021, the Russian Federation's invasion of Ukraine in 2022, disruptions in the Panama Canal in 2023 and ongoing geopolitical tensions in the Red Sea region.[11]

Since 2022, the Russian Federation's invasion of Ukraine has had significant effects on global trade. Ukraine is a major global producer and exporter of grain (wheat, barley and corn) and sunflower oil, and these exports fell 90% during the first half of 2022.[12] Pre-war export levels of agricultural products from Ukraine were restored only in April 2024, and the operation of vessels in the Black Sea has remained a risky business.[13]

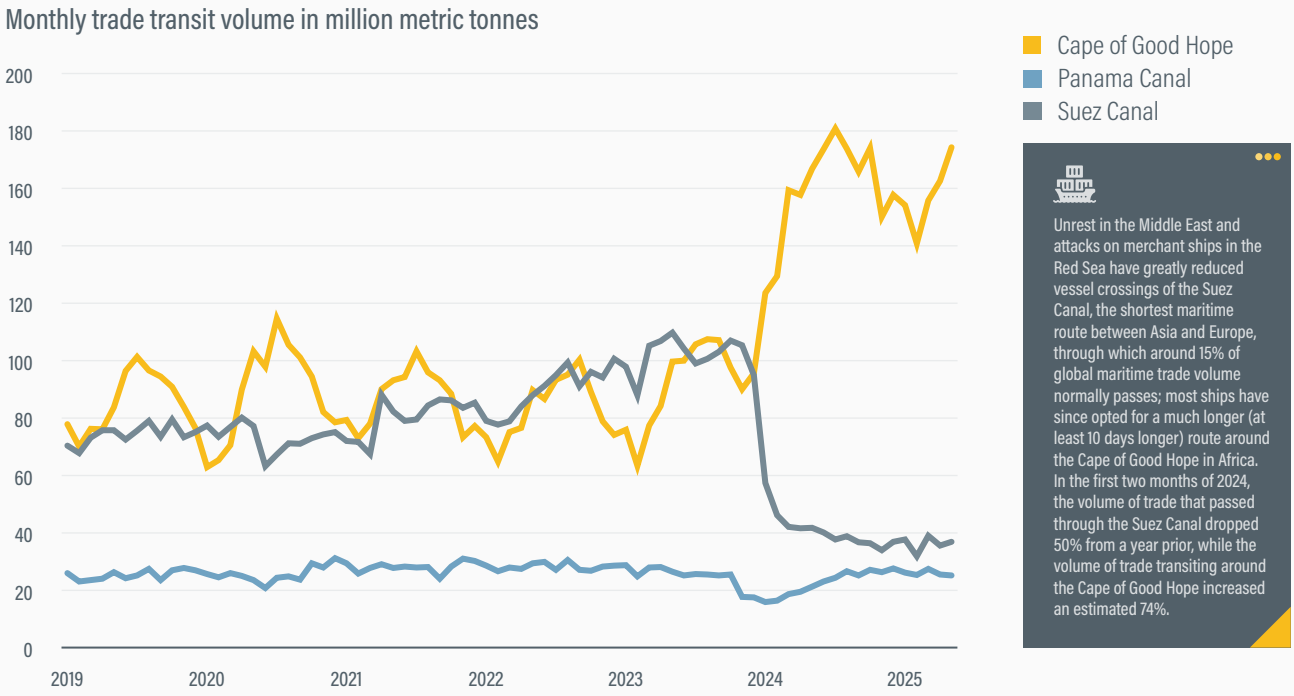
Unrest in the Middle East and attacks on merchant ships in the Red Sea have greatly reduced vessel crossings of the Suez Canal, the shortest maritime route between Asia and Europe, through which around 15% of global maritime trade volume normally passes; most ships have since opted for a much longer (at least 10 days longer) route around the Cape of Good Hope in Africa.[14] In the first two months of 2024, the volume of trade that passed through the Suez

FIGURE 1. World seaborne trade by type, 2010-2024 and forecast for 2025



Source: See endnote 10 for this section.

FIGURE 2. Monthly trade transit volume of major shipping routes



Source: See endnote 15 for this section.

Canal dropped 50% from a year prior, while the volume of trade transiting around the Cape of Good Hope increased an estimated 74% (Figure 2).[15]

Climate change has affected one of the most important shipping routes – the Panama Canal – with the region's extreme drought resulting in a 50% reduction in crossings in the second half of 2023 and early 2024.[16] This caused a significant slowdown in global trade and disruption to supply chains – including prolonged waiting times or re-routing around the Cape of Good Hope – leading to delays, increased operational costs and higher greenhouse gas emissions. Many ships had to look for alternative (and much longer) routes, and trade patterns shifted.[17]

The countries most affected by these disruptions have been small island developing states (SIDS) and least developed countries (LDCs). SIDS are highly dependent on maritime trade, even for essential consumer goods, and often face poor shipping connectivity.[18] Countries that are located farther from major shipping routes can experience steep increases in consumer prices, especially for food.[19]

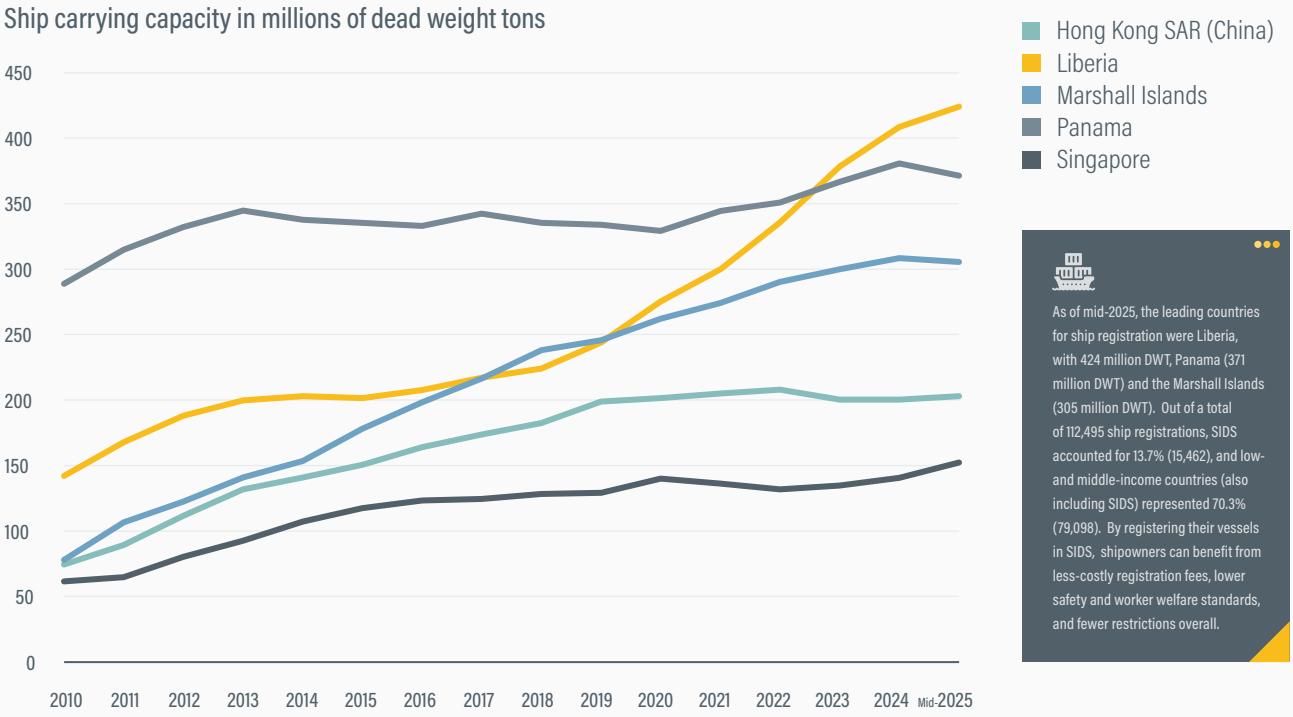
- The combination of the COVID-19 pandemic and the Russian invasion of Ukraine resulted in 46.8% of the global SIDS population experiencing moderate to severe food insecurity between 2020 and 2022.[20]
- In SIDS that are tourism-oriented, up to 90% of food is imported, compared to a global average of around 5%.[21]

The global merchant fleet continues to grow steadily.[22] For containerised cargo, trade flows have been mostly stable, with slight growth on the Trans-Pacific route and minor drops on the Europe-Asia-Europe and Transatlantic routes.[23] In 2023, the largest container ports based on throughput were Shanghai (China) at 49.2 million twenty-foot equivalent (TEU), Singapore (39.0 million TEU) and Ningbo-Zhoushan (China; 35.05 million TEU).[24] The cargo types that expanded most in 2023 were cars (15% growth), liquefied petroleum gas (LPG; 6%) and dry bulk (4.3%).[25]

As of mid-2025, the leading countries for ship registration were Liberia, with 424 million DWT[i], Panama (371 million DWT) and the Marshall Islands (305 million DWT) (Figure 3).[26] **Out of a total of 112,495 ship registrations, SIDS accounted**

i Deadweight tonnage (DWT) is a measure of how much weight a ship can carry, usually in metric tons; this includes cargo, bunker oil, fresh water, ballast water, provisions, passengers and crew.

FIGURE 3. World's top five countries for ship registration, 2010-2025



Source: See endnote 26 for this section.

for 13.7% (15,462), and low- and middle-income countries (also including SIDS) represented 70.3% (79,098).[27] By registering their vessels in SIDS, shipowners can benefit from less-costly registration fees, lower safety and worker welfare standards, and fewer restrictions overall. The flag that a ship is registered under is often unrelated to the nationality of the owner.[28] The Marshall Islands alone had 4,254 registered ships as of mid-2025, or 3.8% of the total maritime fleet.[29]

As of 2025, a total of 1.9 million seafarers were supporting USD 14 trillion worth of trade moving around the world.[30] Working conditions are generally poor: in a 2022 survey, 25% of seafarers reported experiencing some kind of harassment and bullying (more than 50% for female seafarers) and 90% reporting having no weekly day off.[31] Women accounted for 1.2% (24,000) of seafarers in 2020, up 46% from 2015.[32] By 2026, a shortfall of 90,000 trained seafarers is projected, creating risks for global supply chains and safety at sea.[33] Significant efforts will be required in the coming decades to train seafarers on alternative fuels and new technologies.[34]

The global shipping fleet grew 3.2% in 2023 to 2.3 billion DWT, with most of this capacity represented by bulk carriers, followed by crude oil tankers and container ships.[35] In 2024, oil tankers used to transport fossil fuels accounted for 28% of the world's shipping fleet.[36] Although the total capacity of container ships fell in 2023, the fleet expanded 8% and the global shipyard output increased 10%, to 35 million compensated gross tonnage (CGT)[ii].[37] In 2023, for the first time, China delivered half of the global shipbuilding output.[38] Chinese shipyards controlled 65% of the world's vessel order books in 2024.[39]

As of 2024, the shipping sector was only partially on track to meet the IMO target for 5-10% zero-emission fuels by 2030.[40] In 2023, just 0.44% of gross tonnage was capable of using scalable zero-emission fuels, up slightly from 0.32% in 2022.[41] While the technologies to achieve this are readily available, the major bottlenecks are low supplies (i.e., low production volumes of zero-emission fuels), low demand from vessel operators and low investment levels. An estimated USD 6-10 billion in public finance is needed by 2030 for scalable zero-emission fuels; as of 2023, around USD 1 billion was

ii Compensated gross tonnage (CGT) reflects the shipbuilding output based on the amount of work required to build a ship relative to a vessel's gross registered tonnage.

secured and available for use, and USD 2 billion was committed by governments.[42]

Around half of all new-build ship tonnage ordered in 2024 (62.2 million gross tonnage) was capable of using alternative fuels.[43] **The order book included vessels running on methanol (118 ships), ammonia (25), LPG (72), and hydrogen (12), in addition to LNG (820 total orders, including 390 LNG carriers)**.[44] Although LNG is listed as an alternative fuel for ships, research has shown that it does not provide any substantial climate or environmental benefits compared to conventional fuels.[45] Its use is also not compatible with the climate objectives of the 2023 IMO GHG Strategy to reduce emissions from ships.[46]

In addition to the shift to alternative fuels, 37% of the vessel tonnage as of 2024 was fitted with energy-saving technologies to improve the carbon intensity performance of ships.[47] There were 145 retrofits and new orders for vessels with wind assistance, and 49 with onboard carbon capture.[48]

Global sales of marine fuel grew 1.8% in 2023 and 4% in 2024 – propelled by rerouting due to the Red Sea crisis – after falling sharply in 2020 and 2022 due to economic slowdowns.[49] **The demand for marine bunker fuels hit an all-time high in 2024, with total sales of 143.6 million tonnes.**[50] In Singapore, the Maritime and Port Authority revealed that bunker sales reached a new high of 54.9 million tonnes in 2024, with alternative fuel sales exceeding 1 million tonnes for the first time (1.34 million tonnes).[51] Most of these alternatives were biofuel blends (0.88 million tonnes) and LNG (0.46 million tonnes), followed by a small share of methanol (1,626 tonnes) and a first-ever trial of bunkering of ammonia (9.7 tonnes).[52]

Digitalisation and automation have played a key role in transforming maritime logistics and operations. The use of new technologies has occurred across operations ranging from vessel control to port logistics to route planning. Artificial intelligence (AI) has been increasingly applied in areas such as port management, cargo tracking, planning for maintenance and servicing, fuel and energy efficiency improvement, and route planning and voyage optimisation.[53] Digitalisation and automation can improve the shipping sector's sustainability and efficiency, helping to reach decarbonisation targets while reducing costs. Future technologies include autonomous ships and technicians, port automation, and AI-based data analysis, among many other applications.[54]

- Major ports in China and Singapore have invested in automation and digitalisation since 2018 to handle increased trade volumes.[55]
- In 2021, a Norwegian company launched the world's first autonomous and fully electric container ship, the *Yara Birkeland*.[56]
- The Global Fishing Watch platform is using big data, machine learning and other advanced technologies to monitor fishing vessels globally and to enable co-operation against illegal fishing.[57]

Sustainability and climate trends

Greenhouse gas emissions from shipping (domestic and international) totalled around 950 million tonnes of CO_2 equivalent in 2023.[58] International shipping contributed more than three-quarters of the total, or 746 million tonnes (up 1.1% from 2022 and 11.2% from 2020), while domestic shipping (or waterborne navigation) contributed 205 million tonnes, up 26% from 2020 (Figure 4).[59]

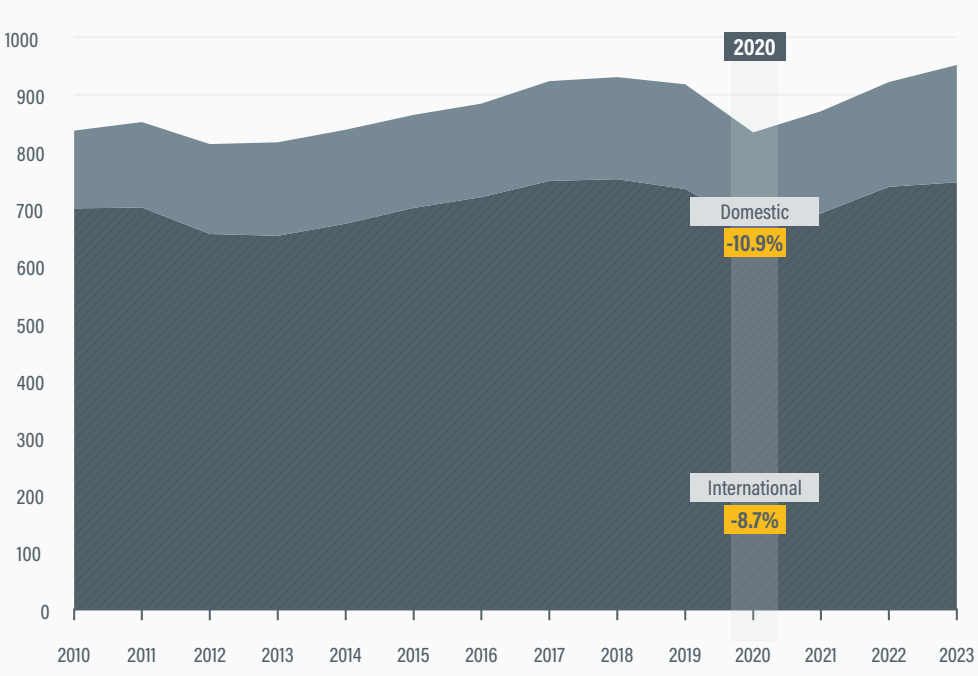
If shipping emissions were measured alongside countries, the sector would rank as the ninth-largest contributor of greenhouse gas emissions worldwide in 2023, comparable to major industrialised countries.[60] In a single year, the emissions from shipping were nearly equivalent to the total transport emissions from all countries in Africa and Latin America and the Caribbean combined.[61] Shipping's carbon emissions have nearly doubled since 1990, with periodic declines in the last two decades related to economic recessions and other developments that negatively affected trade.[62] Emissions have continued to increase despite global ambitions to limit global temperature rise under the Paris Agreement.

As of 2025, the shipping sector was on a trajectory to completely exhaust its proportional share of the world's carbon budget – the amount of emissions it can release without surpassing global warming of 1.5 degrees Celsius (°C).[63] At the current pace, shipping will exceed its budget for staying within 1.5°C of warming by 2030, its 1.7°C budget by 2037 and its 2°C budget by 2047.[64]

To fully contribute to the Paris Agreement goal of limiting global warming to 1.5°C, shipping's greenhouse gas emissions need to decline drastically to reach zero by 2050 (Figure 5).[65] **Up to 90% of the reductions could be achieved by replacing fossil fuels with zero-emission fuels, and 10% through operational efficiency improvements.[66]**

Emissions of sulphur dioxide (SO_2) from shipping have fallen since January 2020, when the IMO cap on sulphur came into force.[67] Shipping's SO_2 emissions totalled 3.7 million tonnes in 2022, down two-thirds from 10.4 million tonnes in 2019.[68] The IMO regulation reduced the maximum allowed sulphur content in marine fuel oil used outside Emission Control Areas (ECAs) to 0.5% (down from 3.5%).[69]

FIGURE 4. Greenhouse gas emissions from shipping (international and domestic), 2010-2023



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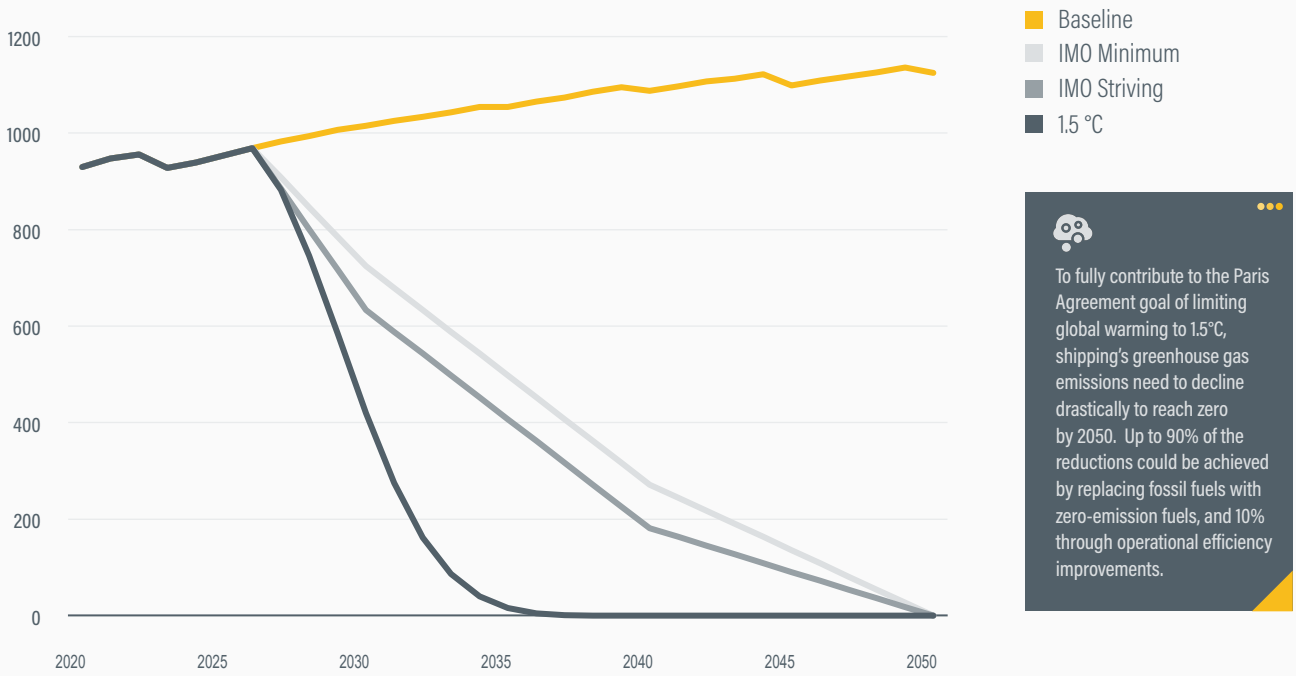
Source: See endnote 59 for this section.

FIGURE 5. Potential emission trajectories for shipping, 2020-2050

GHG emissions trajectories for global shipping in million tonnes CO_2 equivalent



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Source: See endnote 65 for this section.

The most common ways to reduce a ship's energy intensity and fuel consumption are energy-saving technologies such as air lubrication, wind-assisted propulsion, and waste heat recovery, which can deliver energy savings of 5-20% or more (for example, with wind propulsion on favourable routes).[70] **Route optimisation can result in similar emission savings, and even higher cuts can be achieved through "slow steaming", or intentionally reducing the travel speed.**

- Depending on the speed, slowing down can reduce vessel emissions by 20-40% in general, but up to 60% in the case of extremely slow steaming.[71] Wind propulsion can reduce energy demand by up to 30% in specific scenarios and also greatly reduce the need for stored energy.[72]
- Through efficiency measures, retrofits for alternative fuels, and the use of zero-emission vessels, greenhouse gas emissions from ocean-based shipping could be reduced by an estimated 0.59 gigatonnes annually by 2030 and 2 gigatonnes annually by 2050.[73]

Improving the energy efficiency of ships will be key to meeting the sector's climate targets set by the IMO, but also help the transition to sustainable zero-emission fuels. Most fuels being considered as near-zero carbon alternatives (such as methanol, hydrogen and ammonia) are likely to be much more expensive, at least during the transition period.[74] Some (such as hydrogen) also have a much lower energy intensity, which in practice means that a greater volume of fuel is needed to travel the same cargo-kilometres.[75]

Climate change is likely to impact the shipping sector more frequently and severely in the future, with the greatest hazards being sea-level rise, severe tropical storms and extreme heat events.[76] **Weather was the main factor behind at least one-fifth of the roughly 400 vessel losses globally between 2015 and 2019.**[77] Potential impacts include damage to port infrastructure as well as damage and disruptions to port and shipping operations. Inland flooding and droughts impact supply chains, while extreme heat can damage vessels and infrastructure as well as affect workers.[78]

The impacts of climate change could bring an additional financial burden of USD 25 billion every year to the shipping industry by 2100.[79] **This includes estimates for port damages and disruptions but not the wider impact on logistics and supply chains. These are extremely high costs compared to the industry's total operating profits of USD 20 billion annually between 2018 and 2020.**[80]

Policy and investment developments

The 2023 IMO Strategy on Reduction of GHG Emissions from Ships, adopted in June 2023, raised the level of ambition set in the IMO's 2018 Initial Strategy on Reduction of GHG Emissions from Ships.[81] The 2023 Strategy features two new components: indicative checkpoints and a general understanding of the basic elements for the development of a basket of mid-term measures. The Strategy aims to:

- review the energy efficiency design requirements for new ships, with the aim of strengthening them;
- reduce CO_2 emissions per transport work at least 40% by 2030 compared to 2008 levels, across international shipping;
- supply at least 5% (striving for 10%) of the energy demand in international shipping by 2030 through zero or near-zero greenhouse gas emission technologies, fuels and/or energy sources; and
- peak greenhouse gas emissions from international shipping as soon as possible, and reach net zero emissions by or close to 2050.[82]

The 2023 IMO Strategy's indicative checkpoints outline a clear emission reduction trajectory for international shipping: reduce the sector's total annual greenhouse gas emissions 20-30% by 2030 and 70-80% by 2040 (compared to 2008 levels), on a path to net zero emissions by or close to 2050.[83] The Strategy is designed to place the sector within scenarios that keep global temperature rise well below 2°C, although it falls short of scenarios that keep temperature rise below 1.5°C.[84]

In April 2025, after extensive negotiations and external geopolitical pressures, the IMO agreed to the IMO Net-Zero Framework, a landmark regulatory package of mid-term measures that (if adopted in October 2025 and entered into force in 2027) would become the first legally binding carbon price across an entire industry sector.[85] The measure would combine: 1) a mandatory global fuel standard targeting ships over 5,000 gross tonnage, requiring progressive reductions in the life-cycle greenhouse gas intensity of ships; and 2) a carbon price on vessel emissions that exceed set thresholds, with compliant ships that use zero or near-zero fuels and technologies being eligible for financial rewards.[86]

Under the Net-Zero Framework's emissions trading rules, compliant ships would be eligible to generate surplus emission units that can be sold to under-compliant ships (under specific conditions).[87] The revenues would be allocated to the IMO Net-Zero Fund to support the adoption of zero- and near-zero emission fuels and technologies, as well as infrastructure development, capacity building, climate resilience in developing countries, and the mitigation of adverse impacts on vulnerable countries.[88]

In 2024, IMO Member States began a review of two short-term greenhouse gas reduction measures – the Energy Efficiency Ship Index (EEXI) and the Carbon Intensity Indicator (CII) – adopted in 2021 and effective as of January 2023.[89] The review process is focused on: 1) the effectiveness of measures to reduce the carbon intensity of international shipping; 2) experiences with enforcing the measures; 3) data needs and the need to enhance the IMO Data Collection System (DCS); 4) impacts on Member States; 5) revising the emission reduction factors; 6) possible changes to the CII metric; 7) possible correction factors and voyage adjustments to the CII, 8) application of the IMO Lifecycle Assessment Guidelines; and 9) any related amendments to existing IMO instruments.[90] In April 2025, Member States completed the first phase of the review, agreeing to CII reduction factors through 2030, finalising a work plan through 2028 to address challenges or gaps in the CII regulatory framework, and approving draft amendments to the DCS that intend to provide greater access and transparency to vessel fuel consumption data.[91]

At the regional level, some regulators have moved much faster in addressing emissions from the shipping sector. These include initiatives in Australia, the EU, the United Kingdom, and parts of China and the United States.

- **As of 1 January 2024, under the EU's Emissions Trading System (EU ETS), all ships above 5,000 gigatonnes arriving to EU ports are subject to carbon prices.**[92] The system covers 100% of CO_2 emissions from voyages between EU ports and 50% of emissions from voyages that either start or end outside the EU.[93] Starting in 2026, the system will also account for methane and nitrous oxide (N_2O) emissions.[94]
- **The FuelEU Maritime regulation, adopted in 2023 and in force as of January 2025, sets maximum limits on the annual average greenhouse gas intensity of the energy used by ships calling at EU ports;** the aim is to encourage the adoption of renewable, lowcarbon fuels and clean energy technologies.[95] The limits apply to CO_2, N_2O and methane emissions on a well-to-wake basis (covering the entire environmental impact of the fuel production process, delivery and use onboard the vessel) and grow from a 2% reduction in intensity by 2025 to an 80% reduction by 2050.[96]
- **As of mid-2025, Australia was in the process of developing a Maritime Emissions Reduction National Action Plan, following public consultations held in 2023 and 2024.**[97] The plan will outline Australia's commitments to maritime decarbonisation.[98]
- **China's Emissions Trading System (ETS), the world's largest by covered emissions, does not yet apply to**

international or domestic shipping.[99] **However, the sub-national carbon market in Shanghai covers ports and shipping companies that emit more than 100,000 tonnes of CO_2 from domestic shipping.**[100]

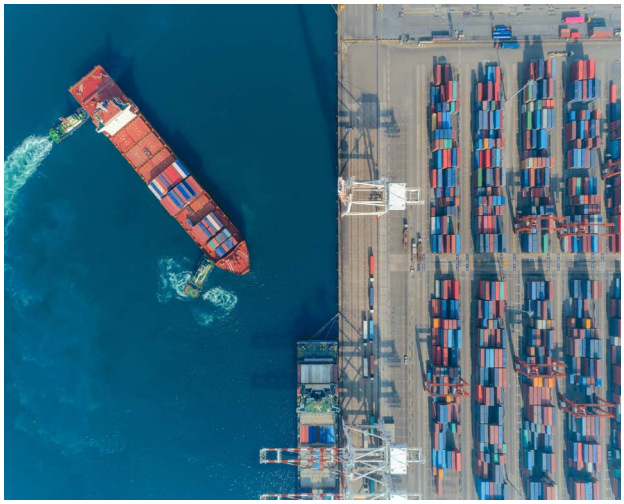
- **The UK Emissions Trading Scheme will apply to domestic shipping emissions starting in 2026, and maritime sector emissions are approved for inclusion in the country's sixth carbon budget (2033-37).**[101]
- **In the United States, the California Air Resources Board (CARB) expanded the coverage of its 2020 At-Berth Regulation, which requires operators of ocean-going vessels and marine terminals to report every visit made to a California terminal.**[102] Starting in 2025, the regulation requires not only containers, refrigerated cargo and cruise vessels – but also roll-on roll-off and tanker vessels – to use a CARB Approved Emission Control Strategy to control emissions for the duration of each visit.[103]

Multiple voluntary initiatives for reducing shipping emissions have been established in recent years, covering various types and groups of maritime stakeholders. (See also Partnerships in action.)

- The Green Shipping Challenge (2022) brings together stakeholders across the maritime ecosystem to reduce shipping's greenhouse gas emissions.[104]
- The Poseidon Principles for responsible ship finance (2019) and responsible marine insurance (2021) are aimed at aligning portfolios with climate objectives.[105]
- The Science-Based Targets for the Maritime Sector (2022) support companies to set climate targets aligned with the 1.5°C decarbonisation pathway.[106]
- The 2020 Sea Cargo Charter provides a global framework for aligning chartering activities with responsible environmental behaviour to promote the decarbonisation of international shipping. As of mid-2025, the charter had 37 signatories, and 34 of them (accounting for around 18% of the total bulk cargo transported by sea in 2024) had disclosed the climate alignment of their chartering activities.[107]
- The Zero Emission Maritime Buyers Alliance (ZEMBA), launched in 2023, brings together freight buyers to accelerate commercial deployment of the most scalable clean energy shipping solutions.[108]

Only 5 of the 27 third-generation Nationally Determined Contributions (NDCs) submitted as of 8 July 2025 included shipping-focused actions towards reducing greenhouse gas emissions under the Paris Agreement.[109] **The five submissions were from Belize, Canada, Marshall Islands, the United Kingdom and the United States.**[110]

- Belize's third-generation NDC highlights the importance of maritime transport for the economy and notes that a project to improve vessel fuel efficiency and reduce port infrastructure emissions will be piloted by 2035.[111]
- Marshall Islands' NDC sets a target to reduce domestic shipping emissions 40% below 2010 levels by 2030, with full decarbonisation by 2050.[112] It highlights pilot projects on low-emission vessels, wind-assisted propulsion, fuel-efficient engines and the use of solar power.[113]



A total of 62 green shipping corridor initiatives had been announced worldwide as of November 2024, 40% more than in 2023.[114] **One-third of this activity was in Europe, while the Asia Pacific and North Pacific regions each represented around one-fifth.**[115] **With only six initiatives preparing for implementation, a key bottleneck has been the lack of national policy incentives to bridge fuel costs.**[116] Green shipping corridors are specific routes where public and private actors have catalysed the feasibility of zero- and near-zero emission shipping; they were first introduced under the Clydebank Declaration, launched at the UN Climate Change Conference in Glasgow, Scotland (COP 26).[117] As of 2024, 17 of the corridors (40%) had progressed to a new stage of development, and 6 had successfully completed the Advanced Exploration phase and moved to the Preparation stage (completing feasibility studies, cost assessments, and establishing workstreams tackling specific barriers to realisation).[118]

Additional projects have focused on alternative fuel production and infrastructure development, green shipping innovation, resilience and climate mitigation in ports, and decarbonisation efforts in developing countries. In 2025, a tender by the Zero Emission Maritime Buyers Alliance (ZEMBA) kicked off the first-ever commercial deployment of e-fuels in the maritime sector, with the aim of aggregating 86 billion tonne-nautical miles of demand for e-fuel-powered shipping from 2027 onwards (equal to transporting around 1.5 million TEU from Shanghai to Los Angeles).[119]

Partnerships in action

- The **Getting to Zero Coalition**, launched in 2019, boasts more than 200 members working towards the operation of commercially viable zero-emission vessels by 2030.[120] The coalition's 2025 Action Framework documents the actions and progress towards decarbonising shipping.[121]
- In July 2025, the **Global Alliance for Maritime Electrification** (**GAME**) was jointly launched by the International Electric Marine Association, the Zero Emission Ship Technology Association, the Maritime Battery Forum, and the European Onshore Power Supply Association – which collectively represent more than 250 member organisations globally.[122] The primary aim is to accelerate the electrification of maritime transport, with a focus on inland, near-shore and commercial vessels.[123]
- At the United Nations (UN) Climate Change Conference (COP 28) in 2023, key public and private actors launched the **Green Maritime Africa Coalition** (**GMAC**) with the aim of building a zero-emission, resilient maritime sector in the region.[124] The GMAC was formed to address the lack of unified sustainability efforts in the sector and is focused on promoting the supply and use of zero-emission fuels.[125]
- The **Green Shipping Challenge**, launched by Norway and the United States at the 2022 UN Climate Change Conference (COP 27), has spurred increased action: two years later, at COP 29 in 2024, stakeholders made more than 40 announcements and updates showcasing concrete progress by countries, companies, ports and other actors in the shipping value chain.[126]
- Launched at COP 28 in 2023, **Resilience4Ports** is a multi-stakeholder whole-system approach seeking to enhance the resilience of ports and the communities that rely on them. At COP 29 in 2024, the initiative issued a call to action to accelerate the resilience and adaptation of port systems, and released a strategic plan for 2025-2027.[127]
- At COP 29 in 2024, a coalition led by the Regional Maritime University, the South African International Maritime Institute and the Climate Champions Team issued a **call to action to ensure a just transition for African seafarers**, building on the Maritime Just Transition Task Force's 10-point action plan.[128]

4.1
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S1
SECOND-HAND VEHICLES

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4.9 AVIATION

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