From Breakdowns to Breakthroughs:

Climate Resilience of Asia-Pacific's Transport Infrastructure

Asian Transport Observatory

An Asian Transport Observatory (ATO) and Life-Links Publication

From Breakdowns to Breakthroughs: Climate-Resilience of Asia-Pacific's Transport Infrastructure

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About ATO

The Asian Transport Observatory is supported by the Asian Development Bank (ADB) and Asian Infrastructure Investment Bank (AIIB) to strengthen the knowledge base on transport in the Asia-Pacific region. ATO platform provides comprehensive yet focused data towards enabling better informed investments, and policy decisions in the transport sector.

About Life-Links

A global non-profit organization dedicated to build resilient supply chains for good, with a focus on logistics. Life-Links brings industry and other actors together to co-invest and collaborate in making critical links in supply chains more resilient to disruptions exacerbated by climate change, while reducing GHG emissions and enhancing sustainability at the same time.

Executive Summary and Conclusions

The transport sector plays a vital role in economic development, facilitating the movement of people and goods essential for trade, progress, and social interaction. Yet, transport systems face significant risks from climate change, resulting in physical damage and operational disruptions with economic, social and environmental consequences. Therefore, the focus is shifting to making transport systems more climate-resilient, so they are better able to withstand, respond and recover from disruptions, and adapt to future hazards, especially climate change. This is crucial for addressing the developmental needs of the Asia-Pacific region in the forthcoming decades.

From Breakdowns to Breakthroughs: Climate Resilience in Asia's Transport Sector focuses specifically on transport infrastructure in the Asia-Pacific region and improving resilience to climate-related hazards. It draws from ATO's database of transport indicators and policy documents from across the region. The objective is to systematically build a case for enhancing climate resilience in the Asia-Pacific transport sector by explaining the context, outlining transport infrastructure challenges and growing threat from climate change, and then exploring the current policy landscape to identify policy directions and what policymakers can build on. The paper's four conclusions and supporting evidence are summarised below.

1. Asia-Pacific's transport infrastructure is challenged to meet economic development needs

Asia-Pacific's economy relies on the transport sector, which in 2023 contributed about 8% of gross value added and employed 150 million people representing 6% of the workforce. However, key challenges remain:

- Transport infrastructure lags significantly behind the OECD, especially for road networks. Surface transport infrastructure ranges between 3.8-11.7 kilometres per thousand population, compared to the OECD average of 17. Infrastructure density is 433 km per 1000 km2 compared to 680 km in the OECD. Infrastructure is heavily concentrated on roads, which account for 98%, leaving railways and urban rapid transit far behind.
- Transport infrastructure expansion is uneven across the region and insufficient to close the gap between lower and higher income countries as well as with the OECD. Between 2020 and 2035 the project expansions are 24% for roads, 19% for railways, 50% for urban rapid transit infrastructure, 35% for port areas, and 250% of airport.
- The quality or transport infrastructure is still poor in low and lower middle-income countries, most of which have a transport quality rating between 2 and 3 (out of 5) compared to ratings of 3 or higher for most high-income countries in the Asia-Pacific and for Europe and North America. This is despite improvements in ratings of up to 55% between 2007 and 2022.
- The investment needs and gap for infrastructure development and maintenance is growing. Current spending as percentage of GDP varies greatly across the region, with China in the lead at 3.5%. Annual investment of $750 billion between 2000-2020 will quadruple to $3 trillion between 2025-2035, 63% of which will be required for road infrastructure, followed by 17% for railways.

Transport systems to better able to withstand, respond and recover from disruptions, and adapt to future hazards

2. Climate change is a growing threat to transport infrastructure with direct and indirect impacts

- Warming trends are double the global average and a disproportionate high share of global disasters happen in the Asia-Pacific region that also impact transport infrastructure: 77% of floods, 94% of landslide, 85% of tropical cyclones, 72% of wildfires. Urban areas and low and lower middle-income countries bear most of these disaster events.
- Transport infrastructure is exposed and vulnerable. 11% of Asia-Pacific's urban population and 75% of urban area are exposed to 100-year floods, while 75% of road and rail assets are exposed to more frequent and extreme precipitation. Pacific Island states have unfavourable scores for road vulnerability due to limited redundancies in their networks.
- Impacts on infrastructure damages and failures result in substantial costs. Physical infrastructure damages cost the Asia-Pacific $8.5 billion per year, or 65% of global costs. Financial losses from disrupted transport flows to companies and communities are significant, while 70% of the $60 billion global trade under threat from climate events at ports falls on the Asia-Pacific. Indirect impacts on other sectors, and other socioeconomic and environmental impacts can be significant, although quantitative data is scarce.

3. Policies must be directed to strengthen climate-resilience of transport

Of the many solutions for policymakers to consider, the following policy directions are highlighted

- Reorient climate finance and increased transport budgets towards adaptation. While 36% of the $704 billion public climate finance in the Asia-Pacific is allocated for the transport sector, only 0.13% is earmarked for adaptation, and only 0.06% for combined mitigation and adaptation measures. The $31 trillion in investment needed from 2025 to 2035 does not yet account for climate proofing.
- Enhance infrastructure quality and design standards. Of analysed Asia-Pacific countries, 60% of the 45 road infrastructure design codes are older than 2015 and usually rely on outdated climate data. Updating standards to reflect future climate risks is essential for the design, construction and maintenance of road and other transport infrastructure.
- Introduce adaptation policy measures alongside GHG mitigation. Of the climate measures in transport policies from 37 Asia-Pacific countries, 73% cover GHG mitigation, and only 5% focus on adaptation. Notably, 27% of climate policy measures of countries in the Pacific region focus on adaptation, reflecting the greater existing climate impacts.
- Develop adaptation policy measures beyond road transport. Of adaptation policy measures, 50% relate to road, and the remaining is about equally divided among rail, shipping, and aviation.
- Diversify adaptation policy measures. An encouraging development is that in recent years, policies have increased and diversified to include disaster monitoring and risk assessments, climate-resilient design standards, advanced technologies for transport asset management, and innovative funding strategies


Saikiran Kesari

4. Policymakers can build on what exists and benefit from collaboration with other stakeholders

- Build on existing adaptation policies in the Asia-Pacific. Examples cited cover planning and design, integrated land use and transport resilience, infrastructure standards and codes, improving existing assets, nature-based solutions, emergency preparedness and response, digital strategies, and transport financing and investment planning.
- Make use of guidelines, tools and databases. Various guidelines and tools are available from development agencies, insurers, NGOs, and companies. Many of the analytical tools available make use of various databases and combine this with Artificial Intelligence.
- Collaborate with other stakeholders on building transport resilience. An opportunity for greater collaboration lies with private sector actors with a commercial interest in optimizing transport resilience. Collaboration could focus on data sharing, input to policy measures, and co-investment and implementation of concrete resilience measures.

Enhancing climate resilience in Asia's transport sector is urgent and vital for creating sustainable and climate-ready transport networks in the region.

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List of Acronyms

Acronym	Definition
ATO	Asian Transport Observatory
GDP	Gross Domestic Product
GVA	Gross Value Added
GHG	Greenhouse Gas
ITF	International Transport Forum
OECD	Organisation for Economic Co-operation and Development
HSR	High-Speed Rail
SIDS	Small Island Developing States
WMO	World Meteorological Organization
GHSL	Global Human Settlement Layer
LECZ	Low Elevation Coastal Zones
NC	National Communication (UNFCCC reporting format)
BUR	Biennial Update Report (under UNFCCC)
NBS	Nature-Based Solutions
NDC	Nationally Determined Contribution
CDRI	Coalition for Disaster Resilient Infrastructure
CPI	Climate Policy Initiative
PBC	Performance-Based Contract
RHD	Roads and Highways Department (Bangladesh context)
UNFCCC	United Nations Framework Convention on Climate Change
DFAT	Department of Foreign Affairs and Trade (Australia)
LPI	Logistics Performance Index
IPCC	Intergovernmental Panel on Climate Change

1. Introduction

Transport systems under threat

Transport systems are essential to our societies and economies, both domestically as well as internationally. People depend on transport to access work, healthcare, education, and supplies. Transport systems underpin domestic and international trade, which represents 59% of the world's GDP (World Bank, 2025a), as well as defence.

Transport is also associated with adverse impacts, such as congestion, traffic accidents, noise, air pollution, and greenhouse gas (GHG) emissions. Approximately 7% of global GHG emissions are estimated to be attributed to the transport sector in the Asia-Pacific region, primarily due to its dependence on fossil fuels for energy. In fact, emissions from transport are still increasing in many countries.

Sustainable transport policies and investments to date have centred on providing accessible, affordable, safe, and clean, and reliable transport for passengers and goods. Climate efforts are still concentrated on decarbonization of transport through avoid, shift and improve strategies. Insufficient attention has been given to the resilience of transport systems to hazards, which is crucial for the smooth operation of our societies and economies.

Climate-resilient transport systems

Transport systems are increasingly being disrupted by **hazards** ranging from conflicts, strikes, trade wars, and other human-made hazards, to natural hazards like earthquakes and climate-related hazards. All models indicate that disruptions from climate change will increase exponentially. Climate hazards can be acute, such as storms, floods, and wildfires, or chronic, such as sea level rise, rising temperatures and erosion. This can result in physical damage, operational disruptions and reduced connectivity of transport systems, with economic, social and environmental impacts affecting everyone.

A transport system's **risk of disruption** is influenced by a location's exposure to climate-related events and its vulnerability, shaped by the sensitivity of structural features (like road type and asset quality) and geographical aspects, as well as its adaptive capacity. Areas that are particularly prone to hazards include for example coastal regions, where assets may confront combined threats like rising sea levels, severe weather, and changing precipitation patterns.

Investing in **resilient transport systems** that can withstand, respond to and recover from disruptions, and increasingly adapt to the projected increase impacts from climate change is essential to meet developmental needs in the coming decades. Three traits of the transport system are important. First is robustness, which denotes the system's ability to withstand hazards and prevent disruptions through redundancy and alternative options. Second is the recovery speed, indicating the time required to respond to disruptions and return to near pre-disruption service levels. And third is adaptation, which relates to structural changes to the transport system's infrastructure, operations, and organization and workforce to minimize the impact of climate change.

Transport systems underpin domestic and international trade, which represents 59% of the world's GDP, as well as defence

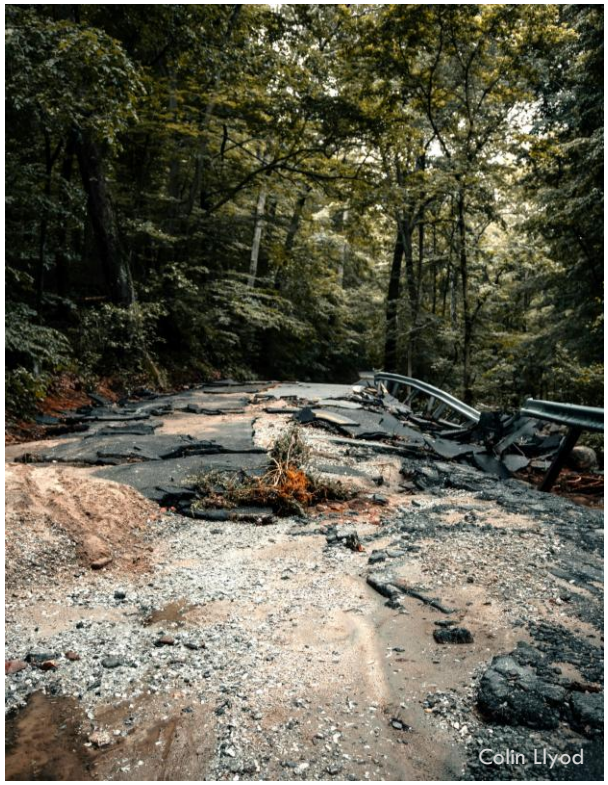
Background paper to support policy makers

This background paper was prepared by the Asian Transport Observatory (ATO) in partnership with Life-Links as a contribution to the International Transport Forum (ITF) Summit of May 2025 with the theme Transport Resilience to Global Shocks. It provides input to a side event at the ITF Forum 2025 titled "Transport System Resilience, Connectivity and Diversification in the Face of Climate Change and Other Global Shocks".

We recognise the multifaceted nature of building resilience. The impacts of climate change will be profoundly felt across essential infrastructure systems—including the transport sector, energy, water, healthcare, and communications. Building resilient transport systems encompasses physical, operational and organisational elements, the economic, social, environmental, and policy dimensions, and the decarbonisation imperative. It also requires the support of, and collaboration among all stakeholders: policy makers, private sector actors, financiers and insurers, development, research and civil society organizations, and others.

Within this context, this paper analyses and compiles key data from the ATO database and other sources focuses specifically on the transport infrastructure state of play and policy imperatives for developing more resilient transport networks in the Asia-Pacific region.

The paper details key transport infrastructure challenges in the Asia-Pacific and the growing threat from climate change to transport systems. Possible policy directions and emerging developments are highlighted, covering finance, infrastructure quality and design standards, and adaptation policy measures. Finally, existing practices from other countries, guidelines, tools and databases, and stakeholder collaboration are explored for policymakers to tap into.


Colin Llyod

2. Asia-Pacific's Transport Infrastructure is Challenged to meet Economic Development Needs

The Asia-Pacific region's transport system faces multiple challenges. With regards to transport infrastructure, five challenges are presented: the economy's dependence on the transport sector and its infrastructure, the infrastructure gap, uneven regional infrastructure expansion, poor quality infrastructure, and growing investment needs for infrastructure development and maintenance.

2.1 Economic dependence on the transport sector

Asia contributes to 47% of the global GDP (World Bank, 2023a) and is home to 58% of the world's population (United Nations Department of Economic and Social Affairs Population Division, 2022).

In the Asia-Pacific region, the transport sector's direct contribution to the economy is significant. In 2023, transport represented about 8% of gross value added (GVA) in the Asia-Pacific, which is comparable to other regions: 10% in Europe, 9% in North America, and 8% in Latin America and the Caribbean.

More than 240 million people globally, of which 150 million or 63% in Asia, were employed in transport and related fields in 2023, covering transport services, operations, and warehousing. In the Asia-Pacific, employment in transport accounted for 7% of the workforce, which is higher than in Sub-Saharan Africa at around 4%, but lower than in Europe at 9%, and notably lower than in North America at 11%. These statistics do not account for informal transport workers, who make up a significant share of the workforce, yet often go unrecorded.

The stronger the transport sector, including transport infrastructure, operations and workforce, the stronger the region's economy and socio-economic development.

2.2 The transport infrastructure gap

Given Asia-Pacific's significant share of the global GDP and population, it comes as no surprise that **a significant share of global transport infrastructure is in the Asia-Pacific** (see Figure 1). Yet, the region's surface transport infrastructure appears relatively modest, accounting for only 38% of the global total (International Union of Railways, 2024; ITDP, n.d.; Nirandjan et al., 2021). The region is estimated to house 43% of primary roads - in terms of total length - 36% of secondary roads, 29% of tertiary roads, 40% of railways, and a quarter of the total airports (Nirandjan et al., 2021). Asia encompasses 61% of bridges and tunnels in the world (Wiedenhofer et al., 2024), 26% of the global aerodrome area (Nirandjan et al., 2021), and 49% of the worldwide port area (Hanson & Nicholls, 2020).

Asia – Pacific's surface transport infrastructure accounts for only 38% of the global total

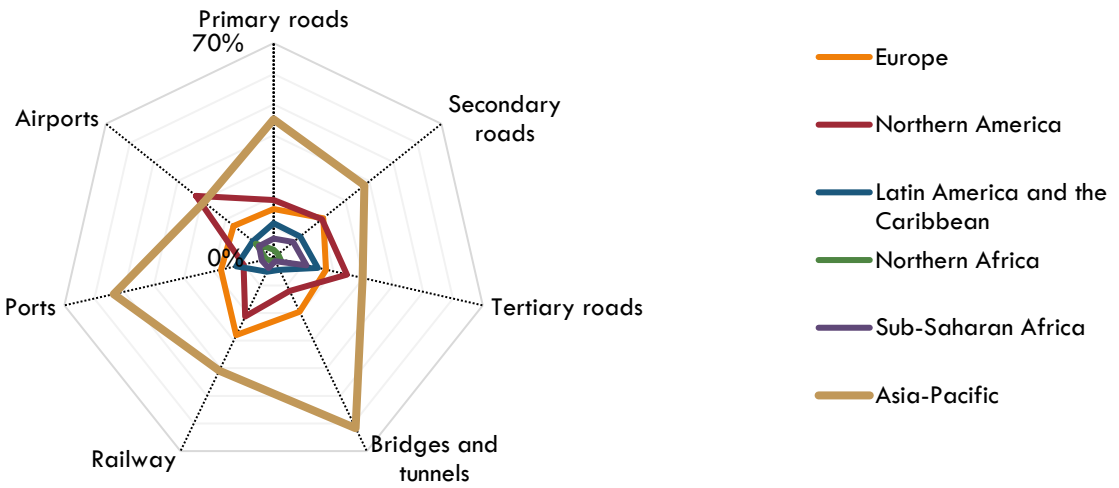


Figure 1. Regional Shares in Global Transport Infrastructure
Source: (Hanson & Nicholls, 2020; Nirandjan et al., 2022; Wiedenhofer et al., 2024)

Despite rapid progress over the past decade in infrastructure development, substantial disparities persist across the Asia-Pacific as of 2023, and most countries significantly lag OECD nations.

Surface transport infrastructure in relation to the population size. Specifically, low- and lower-middle-income economies average just 3.8 kilometres of surface transport infrastructure per thousand population, upper-middle-income economies have 4.6 kilometres, and higher-income economies stand at 11.7 kilometres - all markedly lower than the OECD average of 17 kilometres per thousand population.

Infrastructure density: The gap is further emphasised by the Asia-Pacific's overall density of 433 kilometres per thousand square kilometres, compared to the OECD average of 690 kilometres. The gap is particularly pronounced in road infrastructure, where Asia has only 309 kilometres per thousand square kilometres, less than half of the OECD's 680 kilometres. Regional variations are also significant, with Small Island Developing States (SIDS) notably trailing behind at an average density of just 109 kilometres per thousand square kilometres.

Type of surface infrastructure: In the Asia-Pacific region, most surface infrastructure is concentrated on roads, which account for 98% of the total. In contrast, heavy railways, including high-speed trains, make up only 2%, while urban rapid transit systems represent a mere 0.1%.

2.3 Uneven infrastructure expansion across the region

ATO's Outlook 2035 analysis (ATO, 2024) of current trends and projections for the transport infrastructure landscape in the Asia-Pacific region leading up to 2035 indicates significant expansion. However, this will be insufficient to close the big infrastructure gap.

Road infrastructure: The total road network within the Asia-Pacific region is anticipated to expand by 24% from 21 million kilometres in 2020 to 26 million kilometres by 2035. However, the availability of road infrastructure remains markedly uneven across the region, and most countries will continue to trail behind the OECD average. A substantial portion of this growth (57%) is projected to occur in upper-middle-income economies from 2025 to 2035, followed by low and lower-middle-income economies (40%). High-income economies contribute a mere 3%, which reflects the advanced stage of their transport systems. Regarding road classification, the percentage of primary roads is expected to increase to 14% by 2035—an addition of 1 million kilometres—while secondary roads are projected to see a modest rise from 12% to 13% (an increment of 800 thousand kilometres). In contrast, the share of tertiary roads is forecasted to decline, despite an increase of 2.8 million kilometres. On the positive side, the quality of road assets is expected to improve, with the proportion of paved roads expected to rise from 67% in 2020 to 79% by 2035 (see Figure 2 – also applicable for the subsequent points on infrastructure availability below).

Railway infrastructure: The heavy railway network in the Asia-Pacific region is expected to expand from 493 thousand kilometres in 2020 to 589 thousand kilometres by 2035, reflecting an increase of 96 thousand kilometres (19%). Notably, approximately 80% of this expansion is concentrated in three countries: the People's Republic of China (PRC), India, and the Russian Federation. This suggests that although railway infrastructure is advancing, its growth rate does not align with that of the road sector and remains insufficient to address the region's requirements. Like road infrastructure, most of the growth in railway infrastructure from 2020 to 2035 is anticipated in upper-middle-income economies (71%), followed by low- and lower-middle-income economies (27%), with high-income economies representing only 2%. This growth results in uneven improvements in railway availability per capita. Upper-middle-income economies are projected to see a significant rise from 180 to 226 kilometres per million population, whereas low- and lower-middle-income economies will experience a marginal increase from 46 to 49 kilometres per million population. These figures remain substantially lower than the current OECD average of 342 kilometres per million population. Additionally, the region is poised to experience considerable advancements in high-speed rail (HSR), with an anticipated network length of 91 thousand kilometres by 2035, reflecting an increase of approximately 49 thousand kilometres from 2020. By 2035, 15 Asia-Pacific countries are expected to operate HSR networks, indicating that about one-third of all railway expansion in the region between 2020 and 2035 will comprise high-speed rail.

Bornil Amin

Urban rapid transit: In 2020, the availability of rapid urban transit infrastructure was considerably lower in low and lower-middle-income economies (2 kilometres per million urban people) compared to their upper-middle-income (8 kilometres) and high-income (9 kilometres) counterparts. By 2035, this availability is projected to

increase to approximately 6, 17, and 18 kilometres per million urban people, respectively. The average availability of urban rapid transit across the Asia-Pacific region is expected to double from 6 kilometres per million people in 2020 to 12 kilometres by 2035.

Port infrastructure: The total port area in the Asia-Pacific region is projected to increase from 900 square kilometres in 2020 to 1,200 square kilometres by 2035, representing a significant growth of 35%, exceeding the anticipated growth in Europe and North America (28%). High-income economies are expected to contribute the largest share of this expansion (41%), followed by upper-middle-income economies (36%) and low and lower-middle-income economies (23%). By 2035, East Asia is projected to account for the largest portion of the region's port infrastructure area (approximately 640 square kilometres), with Southeast Asia following at 290 square kilometres.

Airport infrastructure: Projections indicate a considerable increase in aerodrome area within the Asia-Pacific region, expected to grow from 6,000 square kilometres in 2022 to an astonishing 21,000 square kilometres by 2035 (250% growth). Notably, 90% of this expansion is anticipated in low- to upper-middle-income economies, with the PRC and India expected to lead this growth with rates of 600% and 800%, respectively. In contrast, landlocked economies in the region are projected to experience a modest increase of 3% in aerodrome area during the same period, attributable to moderate socio-economic growth.

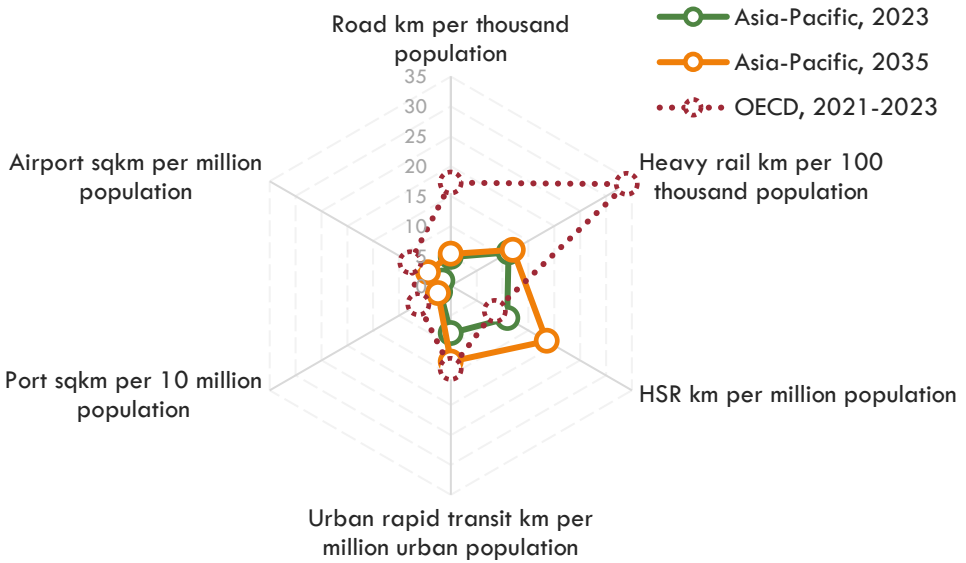


Figure 2. Asia-Pacific Transport Infrastructure Expansion

Source: ATO modelled estimates using (Hanson & Nicholls, 2020; Institute for Transportation and Development Policy, 2020; International Union of Railways, 2024; IRJ, n.d.; Nirandjan et al., 2022)

2.4 Poor quality of transport infrastructure in low and lower middle-income countries

Low and lower middle income countries encounter a dual challenge regarding infrastructure: they not only has less infrastructure per capita compared to upper middle- and high-income countries, but the quality of transport infrastructure is generally much lower (Figure 3). Lower-quality infrastructure with current and anticipated climate change can aggravate maintenance and repair costs, further depleting already scarce resources. Neglecting essential maintenance, crucial for transport assets' longevity, safety, and efficiency, is a historical trend that further undermines transport network resilience. [1] Figure 4 shows the relative position of the regions (on average) in terms of rated quality of transport infrastructure, with Asia lagging behind more advanced regions.

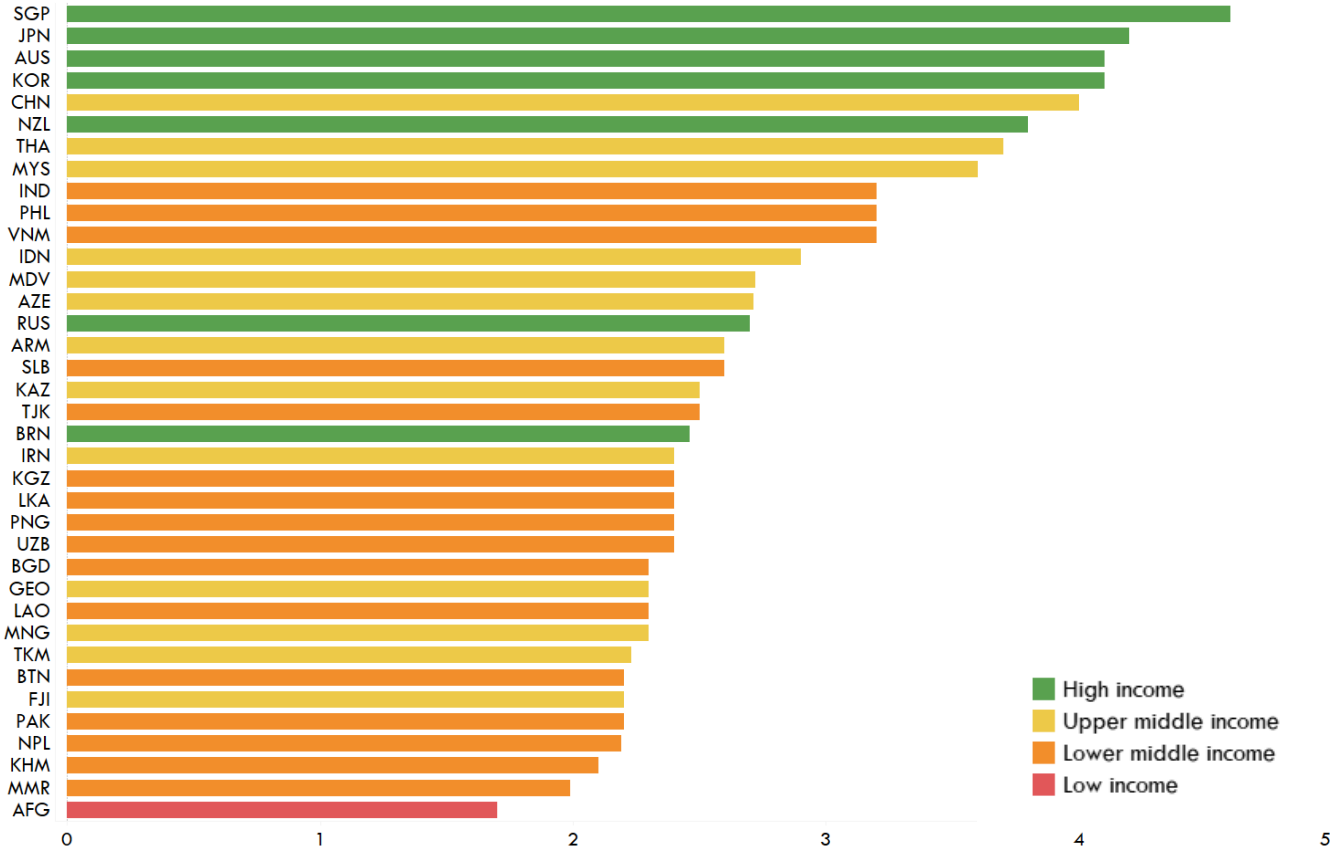


Figure 3. Ratings for the Quality of Transport Infrastructure in selected Asia-Pacific Countries (1=low, 5=high)
Source: Own analysis and visualization based on World Bank (2023)

[1] See Annex 1 for an Asia-Pacific country classification by regions and income levels.

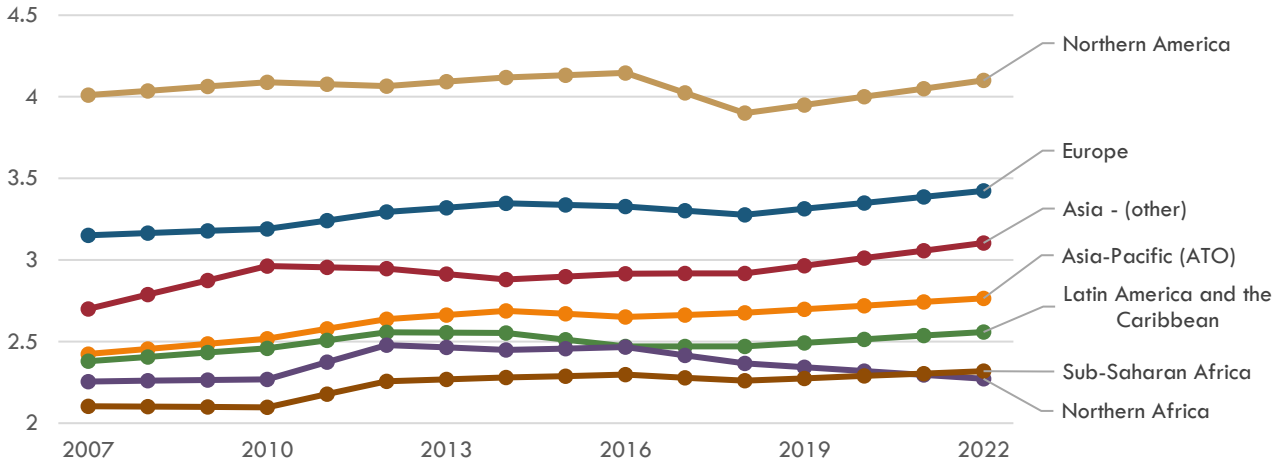


Figure 4. Average Ratings for the Quality of Transport Infrastructure (2007 to 2022) (1=low, 5=high)
Source: Own analysis and visualization based on World Bank (2023)

Primary roads are vital for economic and regional integration. However, they comprise a smaller portion of the road network in low- and lower-middle-income countries than their high-income Asian counterparts. Low-quality infrastructure entails more long-term maintenance and impacts road safety, as rutting and potholes are risk factors associated with safety incidents. While improvements have been made to the rated quality of transport infrastructure across the Asia-Pacific region, some countries exhibit worrying signs of degradation (Figure 5).

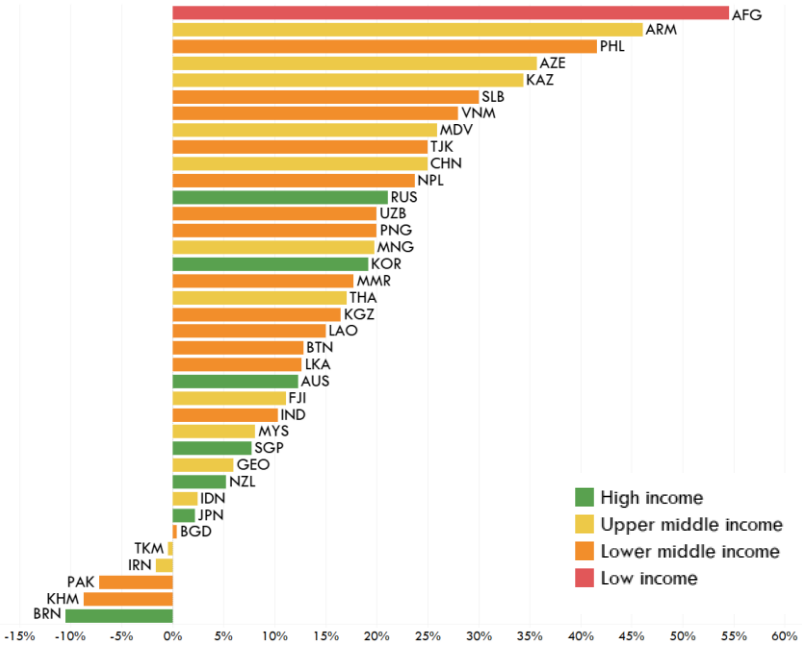


Figure 5. Percentage Change in the Ratings for the Quality of Transport Infrastructure (2022 vs 2007)
Source: Own analysis and visualization based on World Bank (2024)

2.5 Growing investments needs and gap for infrastructure development and maintenance

Finance for transport infrastructure development and maintenance are crucial for many reasons, among which to support economic growth, respond to the expected growth in vehicle ownership, improve access and connectivity, and continued and efficient operation of the transport system.

Figure 6 below reveals notable differences in transport infrastructure and maintenance spending across selected Asia-Pacific countries.

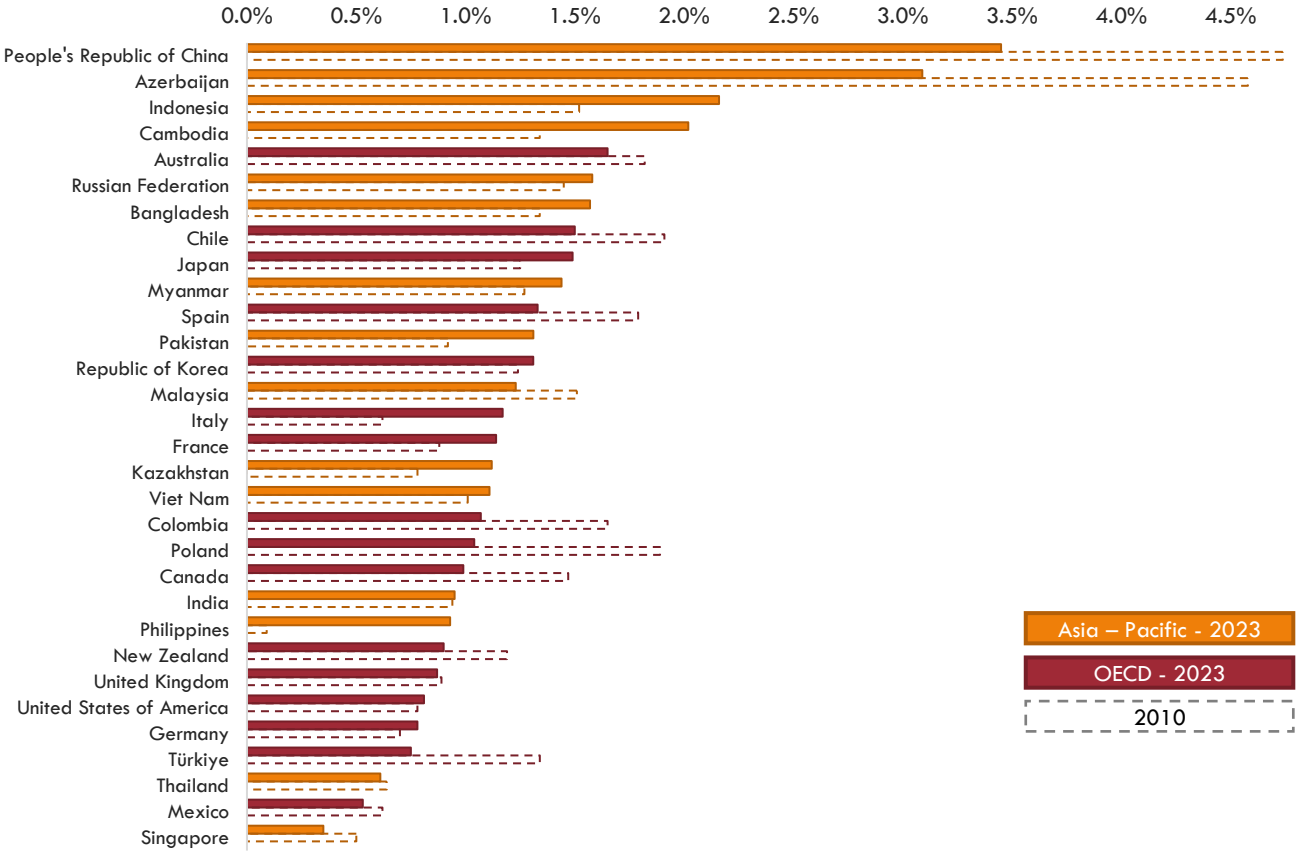
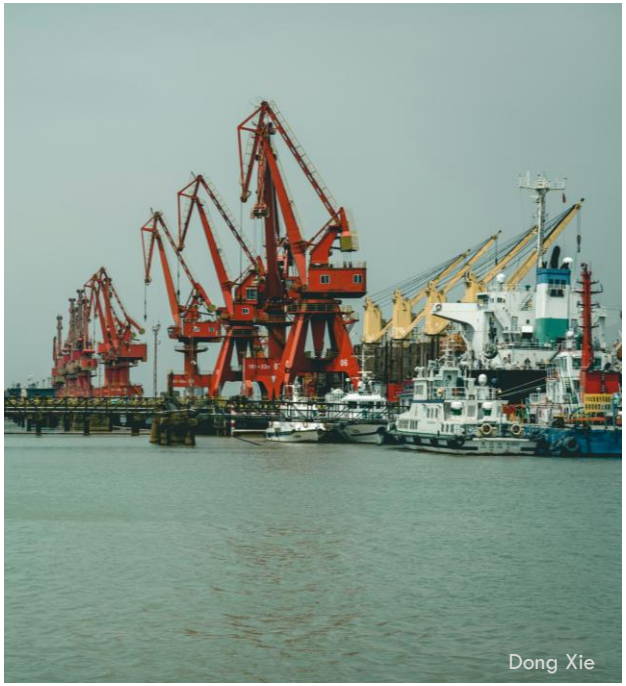


Figure 6. Transport Infrastructure Development and Maintenance Spending as % of GDP (2023)
Source: Own analysis and visualization based on (Global Infrastructure Hub, n.d.)

Estimates suggest that the Asia-Pacific region will need approximately $31 trillion (in current USD) from 2025 to 2035 to develop, maintain, and repair its transport infrastructure, roughly 1.9% of the region's GDP. The average annual investment demand is projected to rise from $750 billion between 2000 and 2020 to $3 trillion between 2025 and 2035. This quadrupling in transport investment needs demands urgent proactive planning and resource mobilisation. Between 2025 and 2035, road transport is expected to attract the largest share of investments, making up 63% of total investment (approximately 1.2% of GDP).

The remaining need for investment is allocated across various subsectors as follows: 17% for railways (including high-speed rail, about 0.3% of GDP), 10% for rapid urban transit (approximately 0.2% of GDP), 4% for ports (0.1% of GDP), and 6% for airports (0.1% of GDP).


Dong Xie

3. Growing Threat of Climate Change to Transport Infrastructure

3.1 Climate impacts already being felt and growing

In 2022, the region experienced 81 climatological, weather, and water-related disasters, 83% of which were storm and flood events. These resulted in more than 5,000 fatalities, affected over 50 million people, and caused an estimated $36 billion economic damage. The warming trend in Asia in the period 1991-2022 was almost double of the trend in 1961-1990 (WMO, 2023).

With its rapid urbanisation, dense populations, and infrastructure concentrated in climate-vulnerable areas, the Asia-Pacific is exposed to climate hazards. In recent years, typhoons damaged transport systems, landslides cut off critical road and rail connections, and extreme heat strained energy and mobility infrastructure. According to various studies, Asia will likely see an increase in floods, coastal erosion, and urban heat stress, all of which have profound implications for transport systems, economic resilience, and human well-being (Calvin et al., 2023; CDKN, 2014; Dong et al., 2024).

A disproportionate high share of global disasters happen in the Asia-Pacific region that also impact transport infrastructure:77% of flood events, 94% of landslides, 85% of tropical cyclones, , and 72% of wildfires This underscores the urgent need for focused disaster preparedness strategies within the region (Centre for Research on the Epidemiology of Disasters, 2025) (shown in Table 1, and Figure 7). [2]


Zain Raza

Table 1: Disaster Occurrences

	Asia-Pacific % of Occurrences	Total Global Occurrences
Floods	77%	4,038
Landslides	94%	259
Tropical Cyclones	85%	9,614
Wildfires	72%	142

Source: Own analysis and visualization based on Centre for Research on the Epidemiology of Disasters (2025)

[2] The EM-DAT International Disaster database globally records at the country level human and economic losses for disasters that meets one of the following: at least 10 fatalities; at least 100 people affected; a declaration of state of emergency; a call for international assistance.

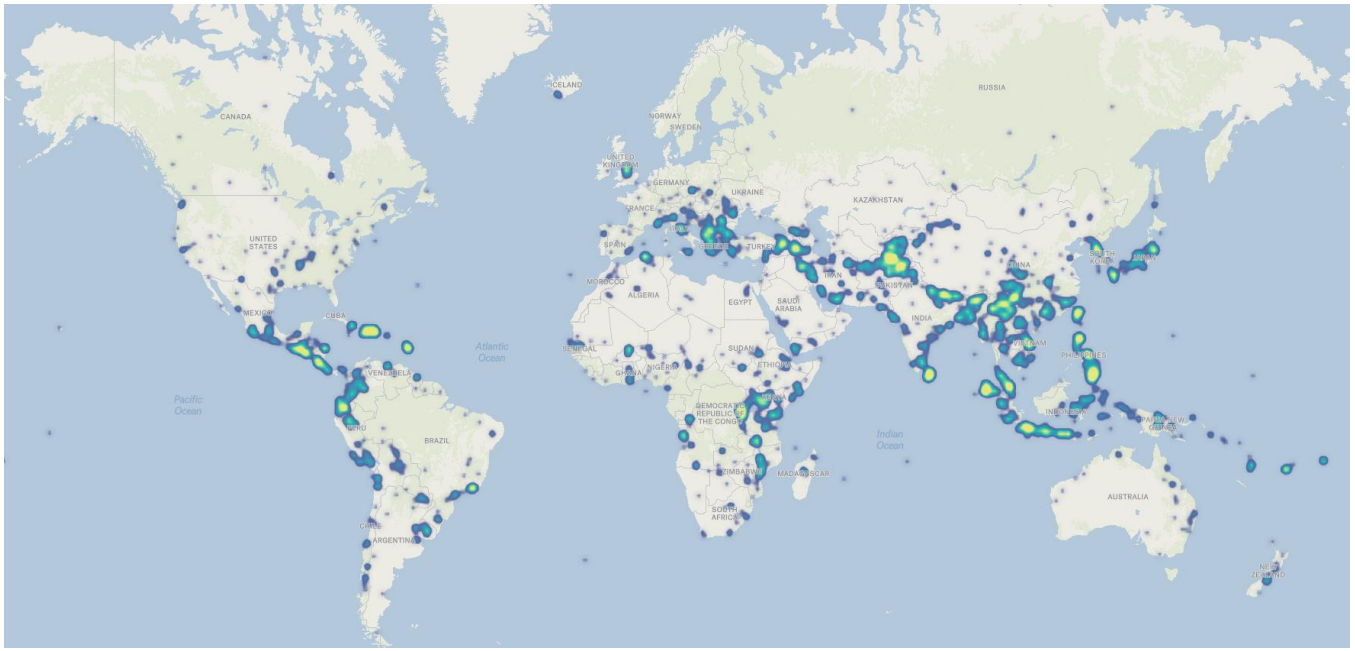


Figure 7. Distribution of Disaster Events Across the Globe (2000-2025)

Source: Own analysis and visualization based on Centre for Research on the Epidemiology of Disasters (2025)

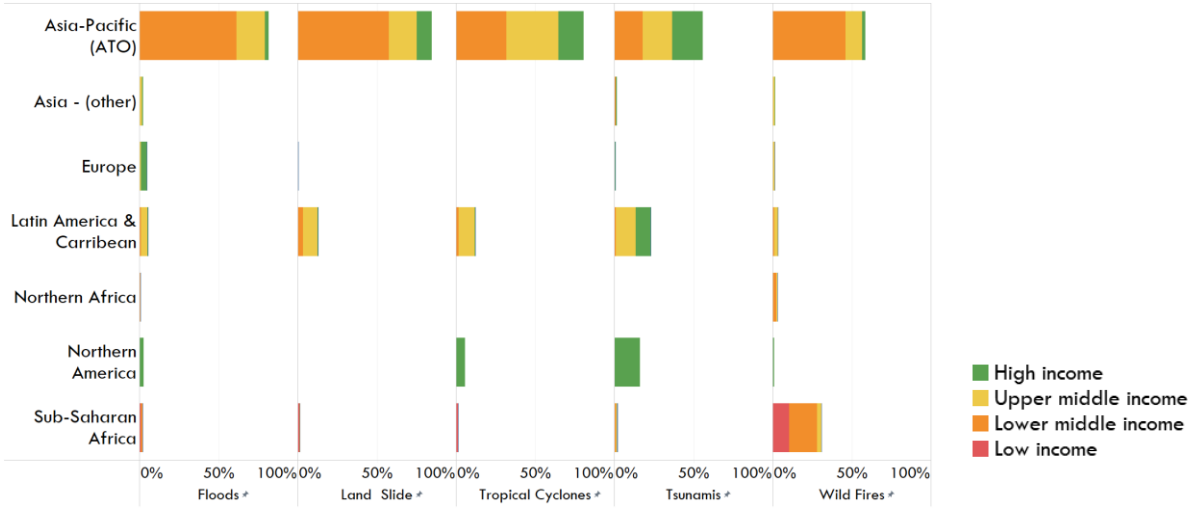


Figure 8. Share of Global Regions in the Total Occurrences of Hazard Events in Urban Areas

Source: Own analysis and visualization based on Melchiorri et al (2024)

Low and lower-middle income countries practically bear most of the disaster events in the Asia-Pacific, including those that occur in urban areas. In Asia, 82% of the documented flood-related disasters, 70% of land slide-related disasters, and 89% of wildfire-related disasters in Asia-Pacific (from 2000-2025) occurred in low and lower-middle income countries. For urban areas, more than 75% of the flood occurrences, 92% of the landslides, 65% of the tropical cyclones, and 70% of the wildfires globally happen in Asia-Pacific (Melchiorri et al., 2024) (Figure 8).

3.2 Exposure and vulnerability of urban and transport infrastructure

The growing threat of climate change also impacts the Asia-Pacific region's transport systems, which is explained through the exposure of built environment, transport infrastructure, and transport operations and services.

Exposure of urban built infrastructure to flooding

An analysis of the GHSL Urban Centre Database 2025 further reveals the exposure of the Asia-Pacific climate-related hazards, in particular the exposure of the urban built environment and urban populations to floods (Melchiorri et al., 2024). Globally, 8% (507 million) of the urban population is exposed to 100-year flooding, compared with 11% in the Asia-Pacific (75% of the total) (Figure 9). The Asia-Pacific also represents 75% and 70% of the urban built area, that is exposed to flooding and coastal flooding every 100-years. It is of great concern that the Asia-Pacific holds most of the newly built urban areas between 1975 and 2025 under threat: 80% exposed to 100-year floods; 89% exposed to coastal floods; and 77% in low-elevation coastal zones vulnerable to sea-level rise.

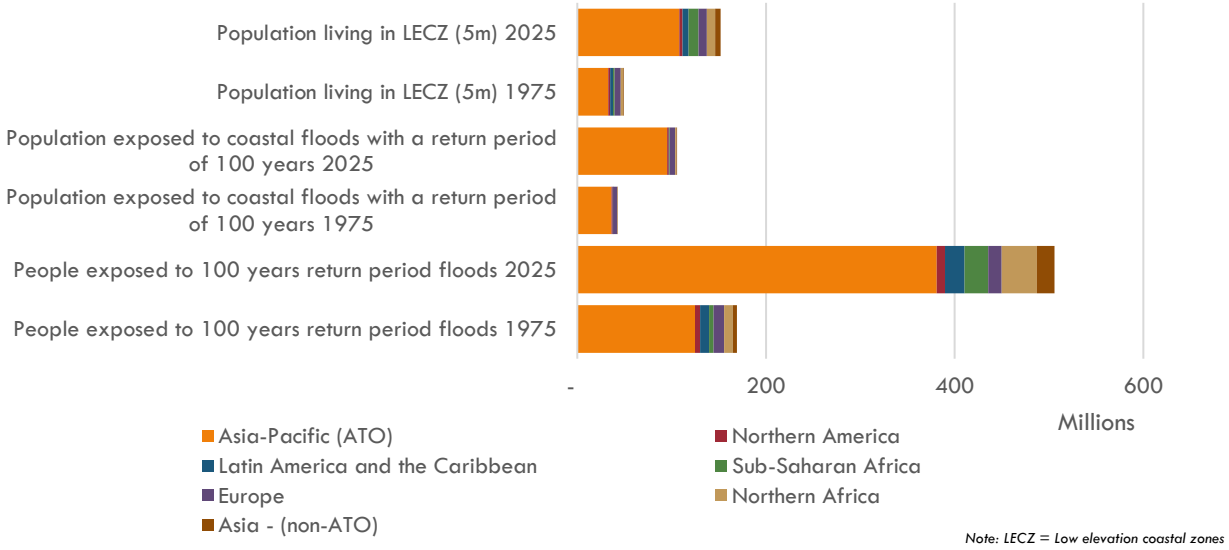


Figure 9. Urban Population Exposure [3]

Source: Own analysis and visualisation based on data from Melchiorri et al. (2024)

Asia-Pacific holds most of the newly built urban areas between 1975 and 2025 under threat: 80% exposed to 100-year floods; 89% exposed to coastal floods; and 77% in low-elevation coastal zones vulnerable to sea-level rise

[3] LECZ = low elevation coastal zones.

Exposure of rail and road infrastructure

Transport infrastructure follows built-up infrastructure. Thus, while the Asia-Pacific has limited infrastructure density, it is highly exposed. Under a 4.5-degree increase scenario, more than 75% of Asis-Pacific's road and rail assets are exposed to more frequent and extreme precipitation, representing an estimated 41% of the global total (Liu et al., 2023) (Figure 10).

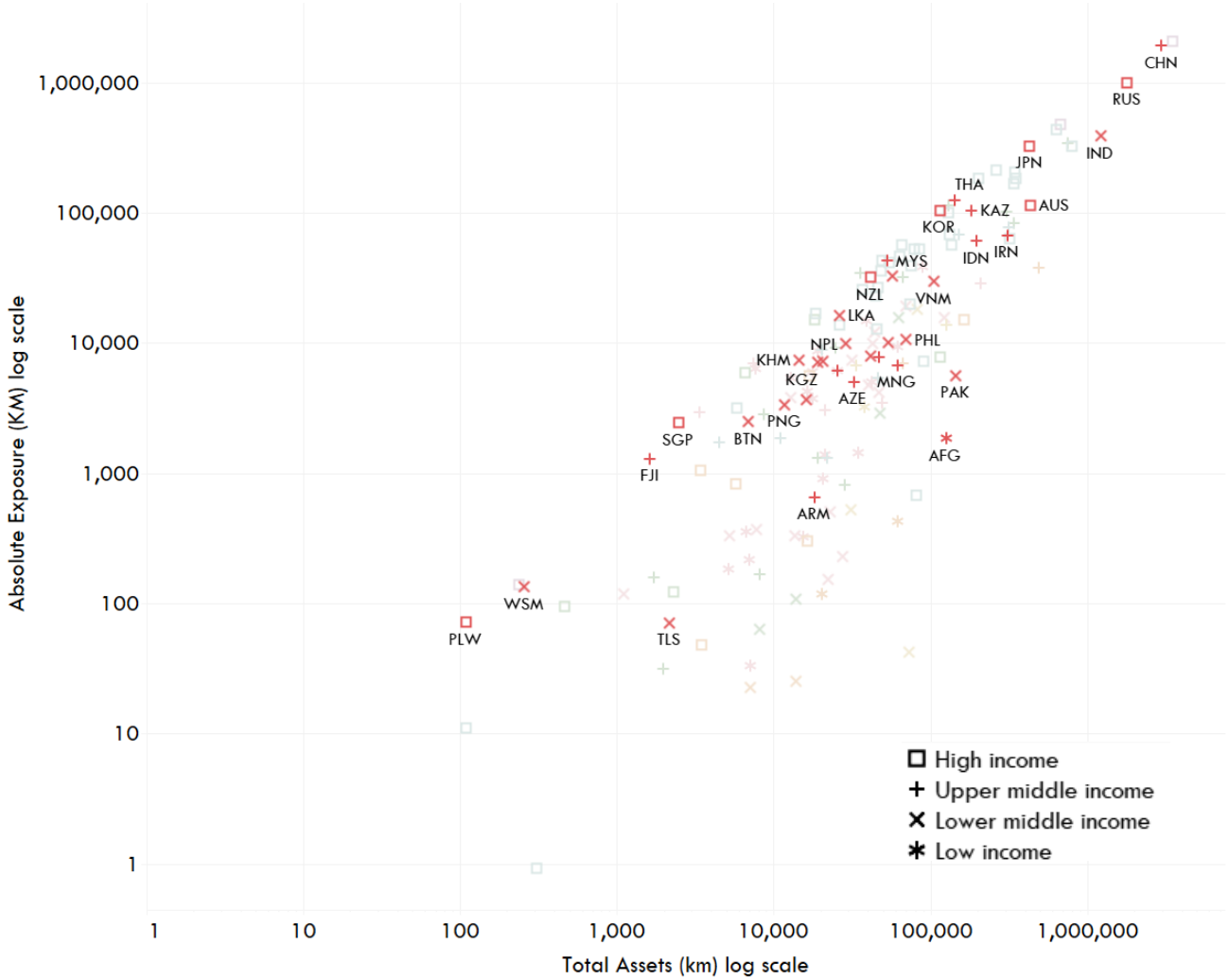


Figure 10. Total Asset Length (km) and Absolute Exposure (km) – Road and Rail
Source: Own analysis and visualisation based on data from Liu et al. (2023)

Delays and disruptions of transport movements: National Road Vulnerability Index

The National Road Vulnerability Index measures the number of trips that could be delayed or disrupted due to transport infrastructure damage caused by natural hazards (E. Koks et al., 2023). A higher ranking indicates lower vulnerability, meaning that these countries have significant redundancies in their road networks to absorb road traffic from disrupted. Countries with limited and inadequate networks are the most vulnerable to interruptions. For instance, Pacific Island countries have limited physical space to accommodate more road infrastructure, and countries with hilly terrain will have similar restrictions in adding roads (Figure 11).

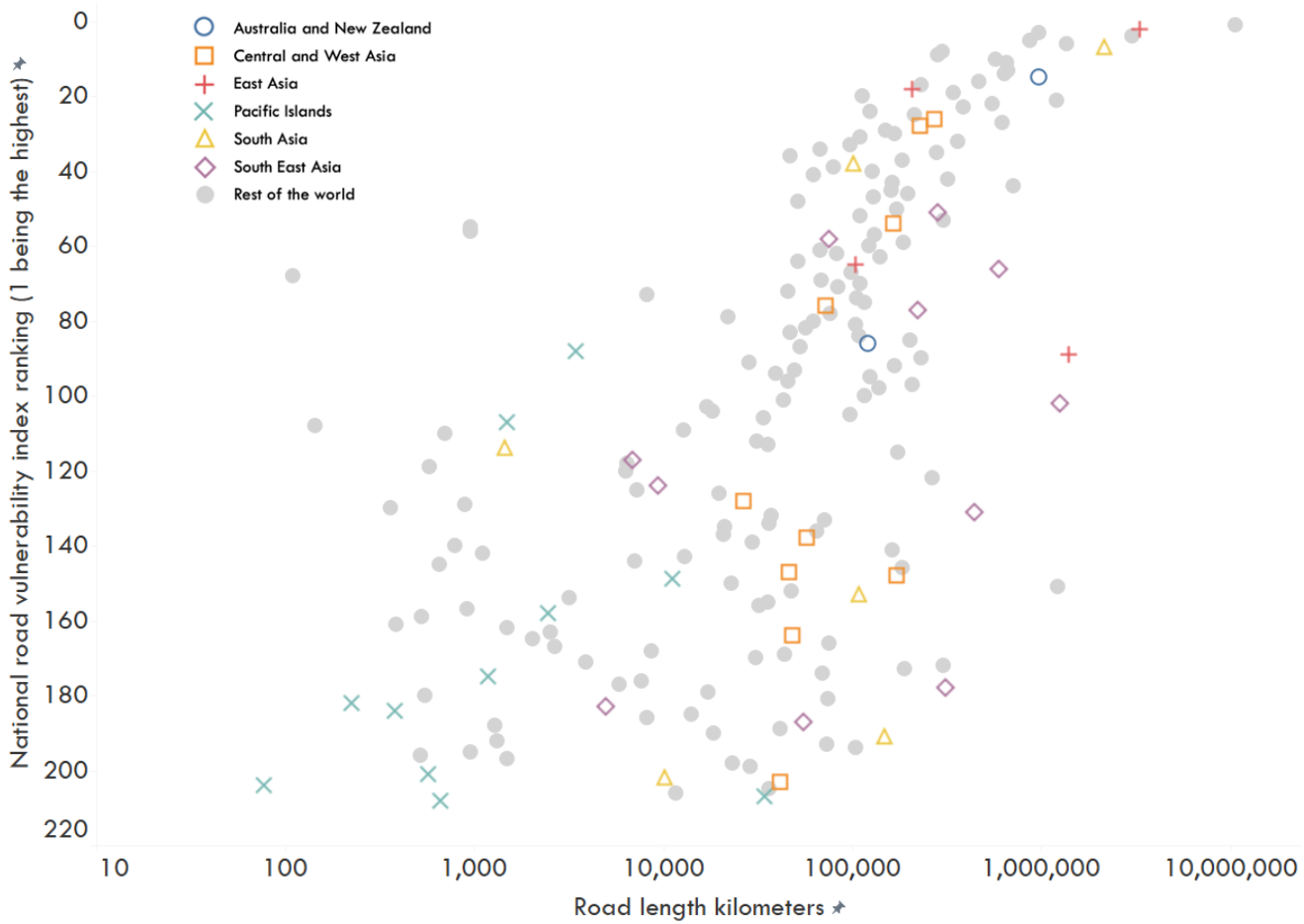


Figure 11. National Road Vulnerability Index ranking by Country [4]
Source: Koks et al. (2023)

[4] Note that the higher the ranking, the lower the vulnerability based on Koks et al. (2023).

3.3 Impacts from transport infrastructure damage and disruptions

Climate and other hazards can cause damage to transport infrastructure and disruptions of transport flows, with direct and indirect impacts.

Direct costs of transport infrastructure damages: According to data from Koks et al. (2019), the Asia-Pacific accounts for 65% of the globally expected annual direct physical damages to transport infrastructure due to climate and various other hazards (Figure 12).[5] This amounts to an estimated $8.5 billion per year. Low- and middle-income countries account for three-quarters of the estimated damages (Coalition for Disaster Resilient Infrastructure, n.d.). Roads account for 61% of direct costs from transport infrastructure damage. Bridges and tunnels are particularly vulnerable, potentially reaching as high as 30% in Palau, 39% in the People's Republic of China, or 48% in Singapore as a share in total road damages (Coalition for Disaster Resilient Infrastructure, n.d.).

Direct costs of disrupted transport flows: Damaged or obstructed transport infrastructure can directly hinder connectivity, causing delays in transport and disrupting trade supply chains, with associated financial losses for transport operators, companies and communities that depend on these transport systems. While road infrastructure accounts for the bulk of the damages, it is essential to recognise that in some countries, the value of transport infrastructure may lie in other modes, which can be more vulnerable to hazards and disruptions. For example, in SIDS, ports contribute an average of 34% to total transport losses, reaching as high as 75% in Tuvalu. In countries with more advanced rail systems, the share of transport losses attributed to rail can be as high as 61% in Kazakhstan or fall within the range of 40-50% in the People's Republic of China, India, and the Republic of Korea (Coalition for Disaster Resilient Infrastructure, n.d.) (Figure 13).

Indirect costs of disrupted trade flows: According to Verschuur et al. (2023), global trade valued at approximately $60 billion is threatened by natural hazards– tropical cyclones, earthquakes, river flooding, pluvial flooding, and coastal flooding— at ports, with 70% of this risk focused in Asian countries. Such devastating disruptions may result in trade losses up to 100 times greater than the damages incurred at the ports, as seen in Sri Lanka's infrastructure.

Indirect impacts on other sectors: Failure in one or more transport link can trigger a chain reaction with indirect impacts on other sectors, such as energy or telecommunications, which creates wider economic repercussions beyond the original point of disruption. Since transport systems supports multiple economic sectors, their breakdown can significantly disrupt a regional economy.

Socio-economic and environmental impacts: Disruptions in transport links and supply chains can have significant percussions for people and the environment. For example, farmers may be unable to get their fresh produce to markets in time, drivers may have to travel double the distance after a main bridge collapses, people may not be able to go to work, school, or hospitals, and communities may be cut off from food and medicine supplies. The environment and natural resources that local communities depend on can also be hit by the same climate and other hazards that cause transport system disruptions.

Asia-Pacific accounts for 65% of the globally expected annual direct physical damages to transport infrastructure due to climate and various other hazards

[5] Based on Koks et al. (2019), the figures represent direct damages to road and rail assets, and do not include the costs from transport delays and disruption, or wider economic impacts.

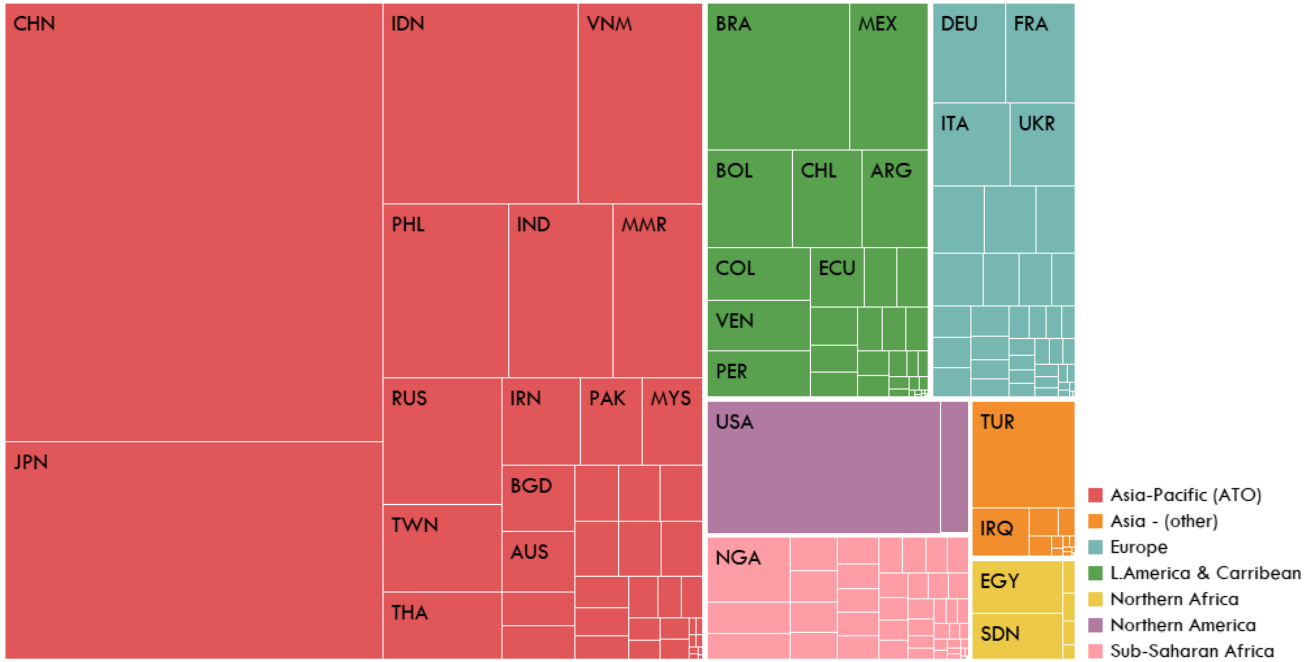


Figure 12. Multi-hazard Expected Annual Financial Damages to Transport Infrastructure by Region and Country
Source: Koks et al. (2019)

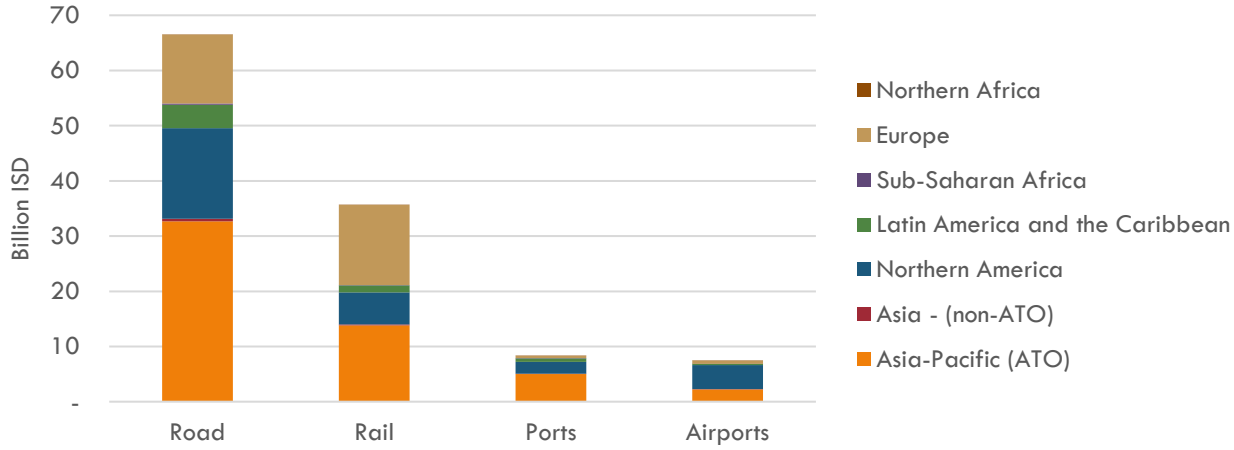


Figure 13. Average Annual Financial Losses due to Environmental Hazards (billion USD)
Source: Own analysis and visualisation based on data from the Coalition for Disaster Resilient Infrastructure (n.d.)

4. Policy Directions for Climate-Resilient — Transport

If left unaddressed, the threats posed by environmental and climate hazards will disrupt the movement of people and goods and undermine decades of developmental gains in the Asia-Pacific region. Strengthening transport resilience is not just an option; it is an urgent necessity to ensure that the region's growth remains inclusive, sustainable, and climate ready. Improving transport resilience is an ongoing process, not a one-time effort and never truly finished. This involves understanding the climate-related risks and vulnerabilities across the entire system, including the interconnections and consequences of cascading failures. Policymakers must engage in sustained, long-term planning and action to respond to climate risks effectively. Of the many solutions for policymakers to consider, important ones include finance, standards, and adaptation policy measures.

4.1 Reorientation of climate finance and increased transport budgets

A first solution is to reorient climate finance as well as increase transport budgets towards adaptation and resilience. The growing need for budget allocation towards the development and maintenance of transport infrastructure was discussed previously and should be expanded with consideration of current and future climate hazards.

The Climate Policy Initiative estimates that in 2022, $746 billion was earmarked for climate finance in the Asia-Pacific region ($50 billion in South Asia and $660 billion East Asia and the Pacific, $4.6 billion for Central Asia and Eastern Europe). Of this, 35% is allocated to the transport sector, recognizing both its exposure to climate change as well as its importance to the economy and trade (Figure 14).

However, it is alarming that only 0.13% of the committed funds for transport-related climate finance in the Asia-Pacific in 2022 is earmarked towards supporting adaptation, and only 0.06% are earmarked for actions with multiple objectives (including mitigation and adaptation) (Figure 15).[6] Furthermore, the $31 trillion in investment requirement between 2025 and 2035 does not yet account for climate proofing of the transport infrastructure.

The distribution becomes doubly alarming infrastructure and buildings, and energy systems together with transport have the lowest shares of climate finance that is allocated to adaptation (Buchner et al., 2023). Reasons are that the decarbonisation of the transport sector depends on decarbonisation of these other sectors, as well as that disruptions from climate hazards in any of these sectors have compounding impacts.

Only 0.13% of the committed funds for transport-related climate finance in the Asia-Pacific in 2022 is earmarked towards supporting adaptation

[6] The estimates are based on the Global Landscape of Climate Finance dataset which includes finance instruments both from private and public sector (commercial financial institutions, corporations, household-level entities and individuals, relevant funds, institutional investors, multilateral climate funds, multilateral development finance institutions, state-owned entities, state owned financial institutions). The instruments include balance sheet financing, grants, project-level equity, project-level market rate debt, and low-cost project debt).

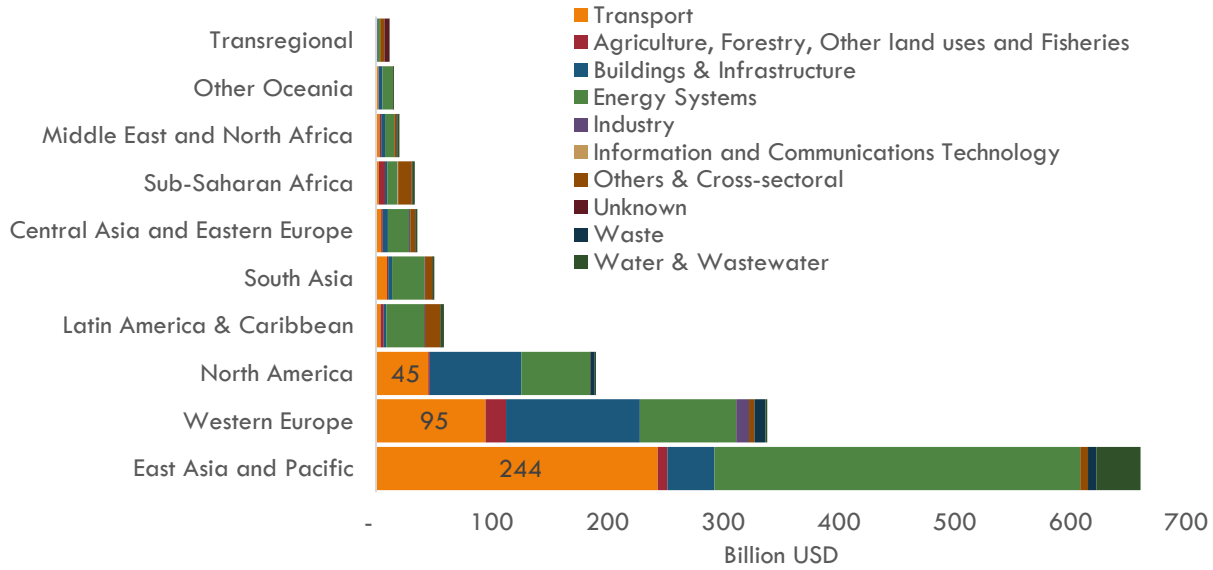


Figure 14. Climate Finance Flows (2022) by Sectors and Regions
Source: Own analysis and visualization based on (Buchner et al., 2023)

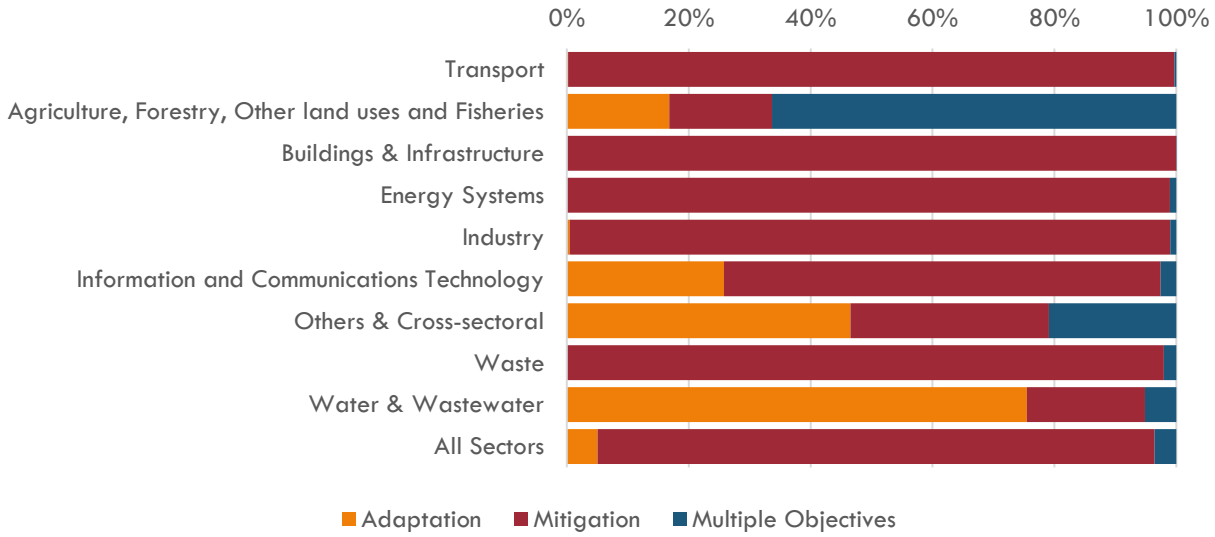


Figure 15. Climate Finance Flows (Global, 2022) by Sector - % Breakdown between Mitigation and Adaptation
Source: Own analysis and visualization based on(Buchner et al., 2023)

4.2 Enhanced infrastructure quality and design standards

A second solution is to improve transport infrastructure quality and design standards. The poor quality of transport infrastructure, particularly in low and lower middle-income countries as explained earlier, emphasises the pressing need for targeted investment in transport infrastructure quality and resilience.

Roads, bridges, railways, ports, and airports are generally intended to remain functional for several decades. However, these infrastructures have been designed and constructed based on historical climate data and standards that overlook future conditions. This misalignment between time periods renders a substantial portion of existing transport infrastructure inherently vulnerable, potentially shortening its expected useful life without proper adaptation measures.

Standards, construction codes, and regulations are vital for bolstering disaster and climate resilience in infrastructure projects, primarily through explicitly revising existing design standards to tackle climate change concerns. These standards deliver critical criteria and guidance for assessing a project's resilience, adaptation strategies, and climate risks throughout its life cycle, supporting advancements towards more robust infrastructure systems and enabling financial mobilisation.

The ATO holds an extensive collection of road infrastructure design codes for the Asia-Pacific region; however, a significant portion of these documents (60%) are older than 2015, highlighting an urgent need for updates. Updating these codes is crucial to incorporate resilient infrastructure planning, climate-responsive construction standards, and the latest technological innovations, ensuring that road infrastructure meets current and future climate challenges for Asia's sustainable urban and regional development (Figure 16).

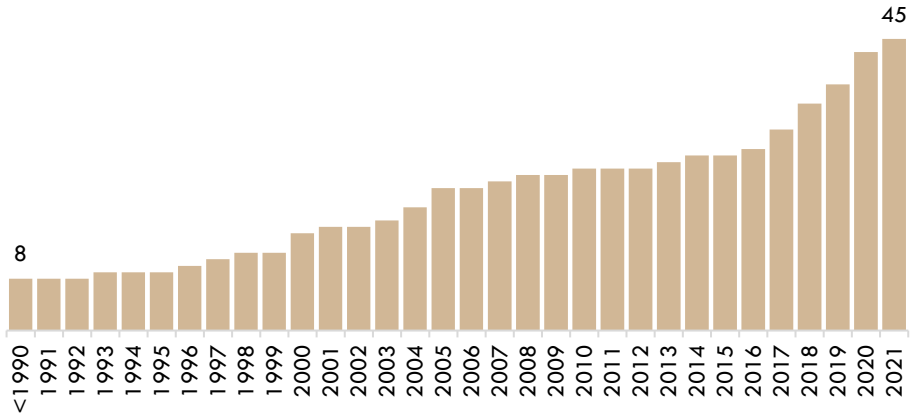


Figure 16. Cumulative Number of Road Infrastructure Design Code Documents in the ATO Database
Source: ATO repository of road infrastructure design codes

4.3 Urgent need for resilience and adaptation policy measures alongside mitigation

Policymakers can ensure that adaptation policy measures are introduced alongside greenhouse gas (GHG) mitigation measures.

A review of transport policies from 37 Asia-Pacific countries shows an increasing recognition of the importance of resilient and adaptable transport systems, including infrastructure, operations, and organisations/workforce While there is a rising trend in implementing 'mitigation-only' measures, this often comes at the cost of dedicated 'adaptation-only' or combined 'adaptation + mitigation' strategies (Figure 17) . The policy documents analysed reveal a significant imbalance: climate mitigation measures capture most of the attention (1845 measures or 73%), with adaptation and resilience making up a mere 5% (99) of the proposed actions, and combined measures 22% (382). This gap is particularly pronounced in low and lower middle-income nations, where adaptation and resilience are mentioned in only 4% of transport policy initiatives. Additionally, Nationally Determined Contributions (NDCs) from these same Asia-Pacific countries exhibit limited ambition, with a mere 3% of targets addressing the adaptation of the transport sector.

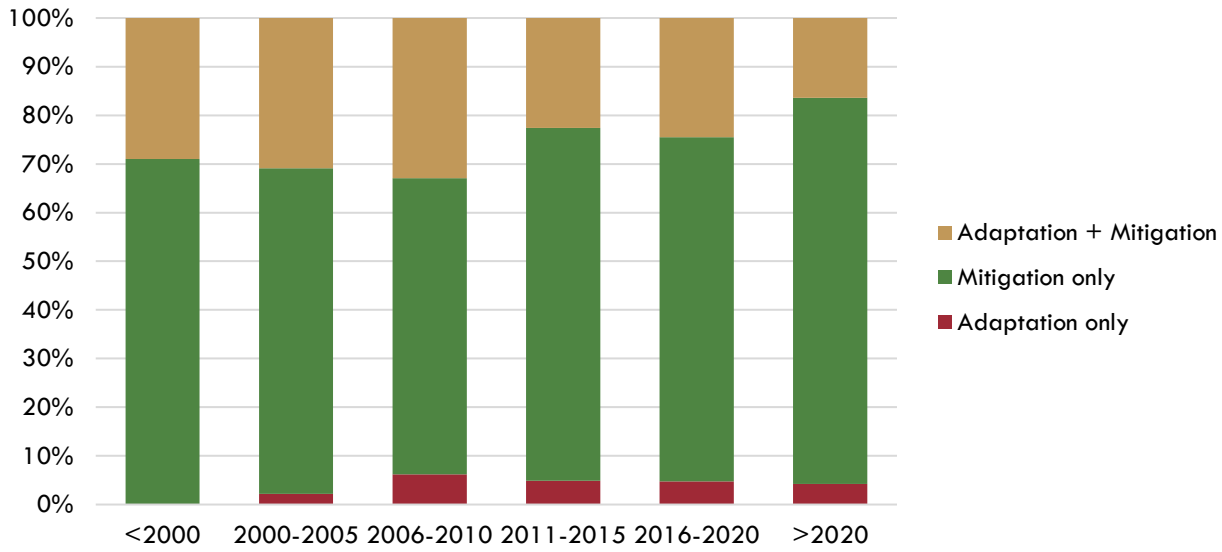


Figure 17. Share of Transport-relevant Policy Measures in 37 Asia-Pacific countries - Climate Mitigation, Adaptation, Combined
Source: ATO Policy Database

The analysis further highlights subregional differences in adopting transport climate resilience measures. On average, the Pacific subregion emphasises adaptation more, with approximately 27% of total measures addressing this theme (Figure 18).

In contrast, in Central and West Asia, as well as South Asia, around 22% of transport-related policies are related to adaptation. Southeast Asia records the lowest share at 20%, though with significant variation—ranging from Myanmar at 31% to Singapore at just 10%. Similarly, Central and West Asian countries exhibit notable disparities between the region's highest and lowest adaptation-focused nations.

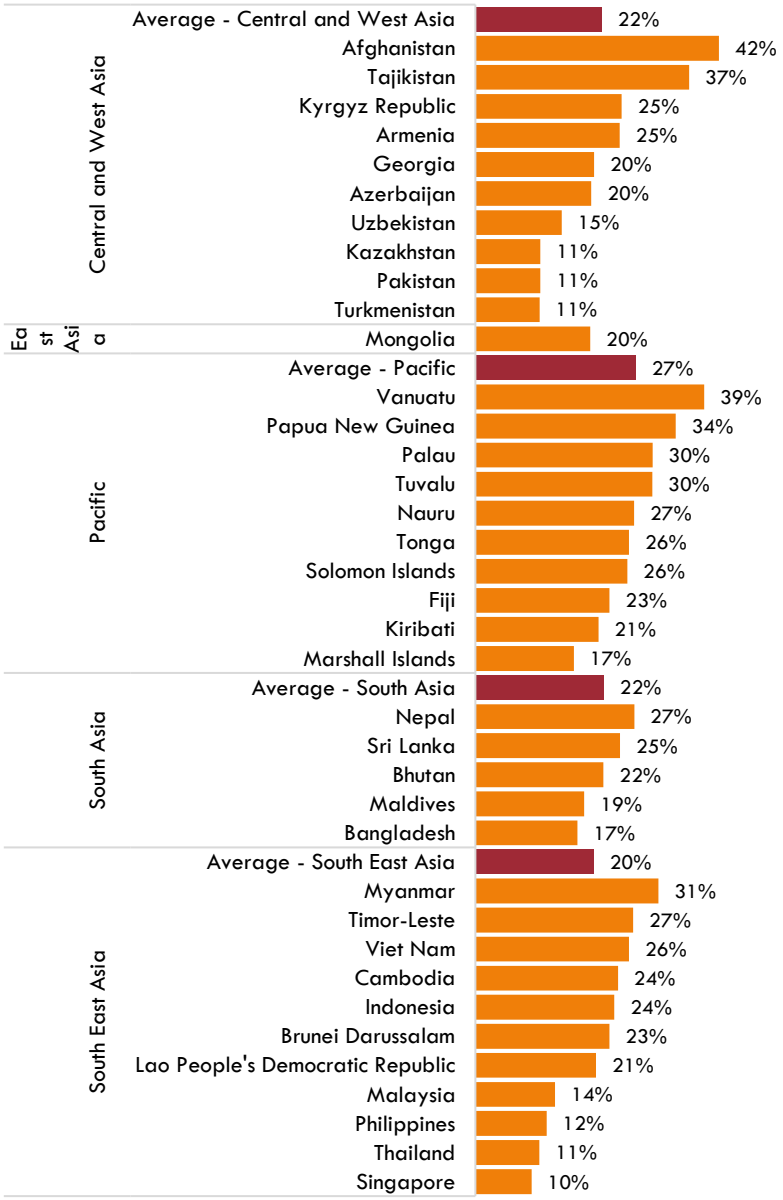


Figure 18. Share of Climate-related Policy Measures in Asia-Pacific Counties related to Adaptation
Source: ATO Policy Database

4.4 Resilience and Adaptation policy measures beyond road transport

The analysis of policy measures (i.e., resilience and adaptation) reveals limited variation in the distribution of policy measures across transport modes. Roads consistently receive the highest share, averaging around 50% of all measures, while the remaining 50% is almost equally divided among rail, shipping, and aviation. Additionally, the typological diversity of policy measures is more pronounced in the road transport subsector, where policies tend to be more detailed and target-specific than those in other modes (Figure 19).

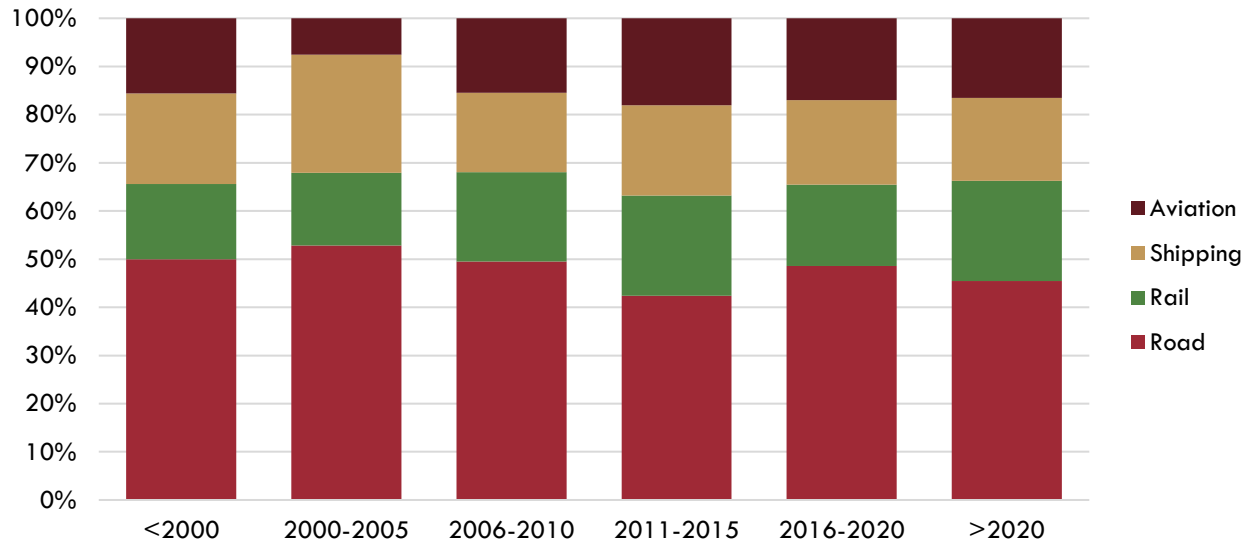


Figure 19. Distribution of Adaptation Measures by Mode
Source: ATO Policy Database

4.5 Diversification of resilience and adaptation policy measures

Over the years, transport adaptation measures have become more diverse and detailed. In the pre-2005 period, most measures focused primarily on general transport asset management and financing (Figure 20). However, in recent years, policies have expanded to include disaster monitoring and risk assessments, climate-resilient design standards, advanced technologies for transport asset management, and innovative funding strategies. Reviewed policies include those—national level— from different government departments, suggesting that adaptation policies will likely be better coordinated and aligned with each other.

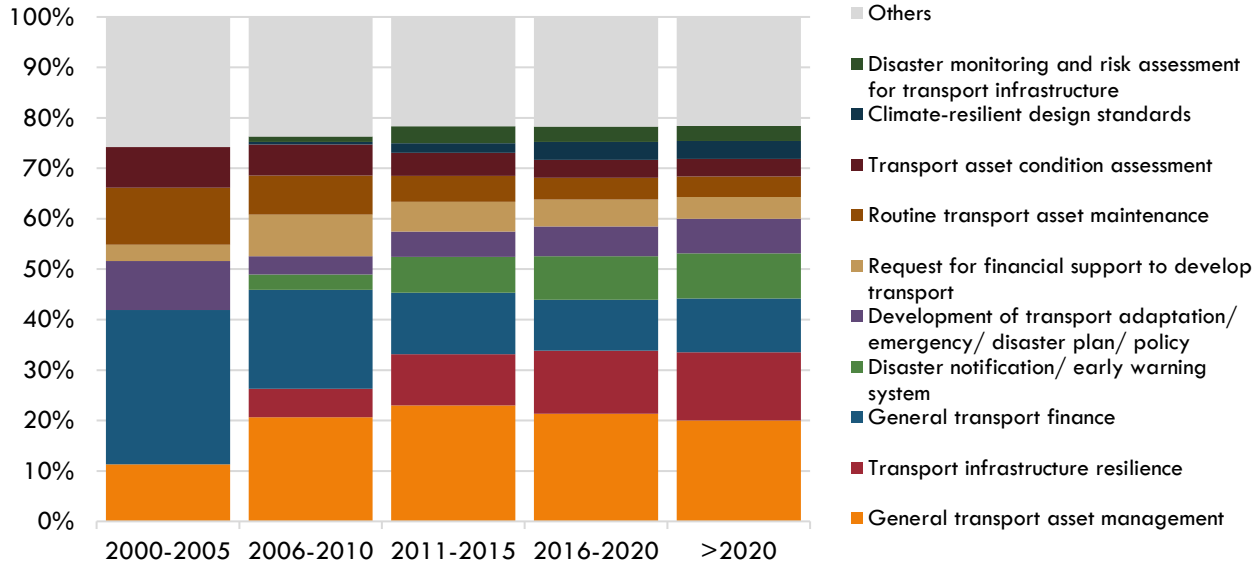


Figure 20. Distribution of Adaptation Policy Measures in Asia-Pacific Countries by Type
Source: ATO Policy Database

Another encouraging trend is the steady rise in the average number of adaptation measures per policy document, increasing from approximately 0.7 before 2005 to about 1.6 in the post-2015 period (Figure 21). This shift signals a growing recognition of the importance of adaptation in transport policies and a more structured approach to climate resilience.

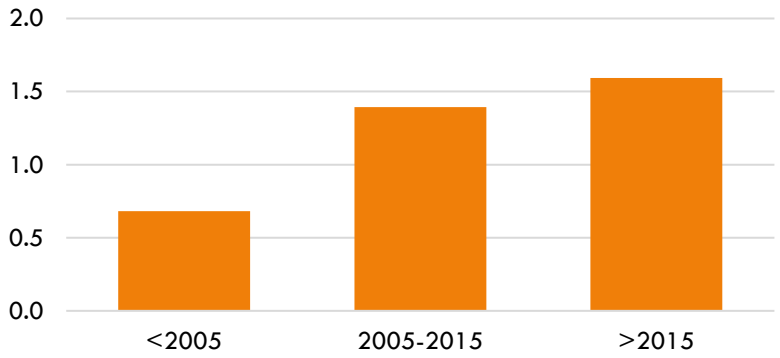
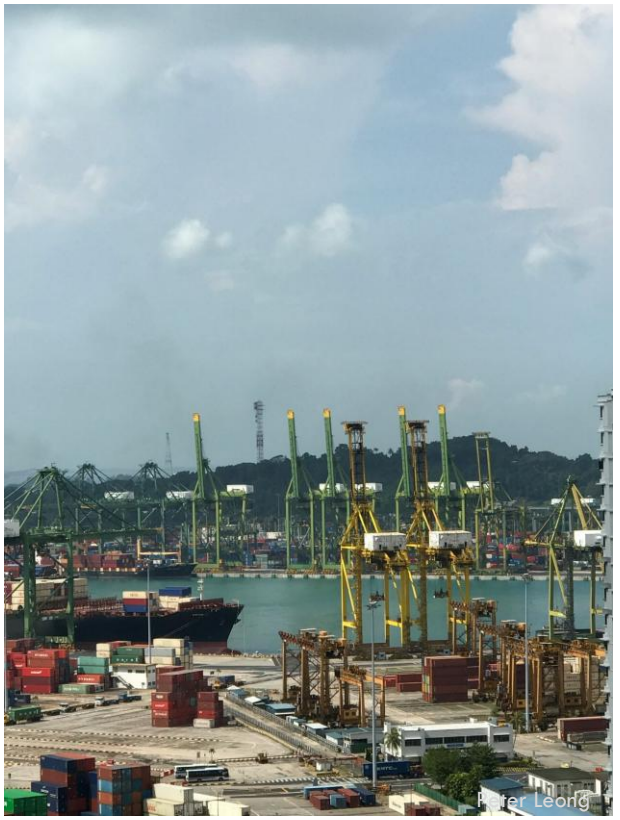


Figure 21. Number of Adaptation Measures per Policy Document in Asia-Pacific Countries
Source: ATO Policy Database

5. Building on What Exists and Collaboration

As there is no time to lose, policymakers should grasp the opportunity to learn from and build on practices from other countries, maximize the use of available guidelines, tools and databases, and seek collaboration with the private sector.



5.1 Examples of adaptation policies in Asia-Pacific countries

The good news is that several Asia-Pacific countries have already introduced adaptation policies and measures relevant to the transport sector. Policymakers can learn from these practices and tailor them to their own countries' circumstances, rather than designing policies from scratch. Annex 2 includes a table with examples of adaptation policies for different countries included in the ATO database, several of which are described below. Similarly, countries can learn from adaptation and resilience policies from countries elsewhere in the world.

1. Climate-informed transport planning and design

Several countries in the Asia-Pacific are integrating climate projections directly into transport planning and design processes. **Armenia** is preparing a national climate risk management plan tailored to its transport sector (Government of Republic of Armenia, 2021). **Bangladesh** has embedded climate resilience into long-term planning through its National Adaptation Plan (Government of the People's Republic of Bangladesh, 2022) and Bangladesh Delta Plan 2100 (Bangladesh Planning Commission, 2018), ensuring transport infrastructure is aligned with projected climate scenarios. **Sri Lanka** (Ministry of Mahaweli Development and Environment, 2016), **Thailand** (Office of Natural Resources and Environmental Policy and Planning, 2015), and **Timor-Leste** (Government of Timor-Leste, 2022a) are mainstreaming climate risk assessments into policy frameworks to enhance resilience across systems, while **Singapore** is future-proofing infrastructure by elevating critical assets above anticipated sea-level rise (Singapore - National Environment Agency, 2022). Through its National Adaptation Programme of Action (National Environment Commission, 2008), **Bhutan** identifies potential areas for resettlement of vulnerable communities, highlighting the intersection of climate risk, equity, mobility, and spatial planning in future infrastructure strategies.

2. Integrating land use and transport resilience

Resilient transport systems are increasingly being planned in tandem with broader land use strategies. **Timor-Leste**'s focus on rural roads in agricultural zones reflects this alignment (Government of Timor-Leste, 2018), while **Lao PDR**'s upgrades to regional corridors enhance cross-border accessibility and resilience (Laos - Ministry of Planning and Investment, 2016). Countries are recognising that embedding transport resilience into spatial planning - particularly through integrated national and subnational strategies - can safeguard mobility, support economic activities, and reduce economic damages.

3. Updating infrastructure standards and codes

Countries are updating their infrastructure design standards to better align with future climate risks. **Papua New Guinea** has committed over $1.2 billion to transport infrastructure that meets updated climate-resilient codes and standards by 2030 (PNG - Climate Change and Development Authority, 2022). **Timor-Leste** is improving rural connectivity by upgrading roads in agricultural areas to climate-resilient specifications (Government of Timor-Leste, 2018). **Myanmar** is embedding climate-focused design across its national strategy for rural roads (Government of the Republic of the Union of Myanmar, 2017), while **Lao PDR** is aligning 2,800 km of transport corridors with ASEAN technical standards to strengthen regional connectivity and resilience (Laos - Ministry of Planning and Investment, 2021).


Zoshua Colah

4. Maintenance, retrofitting, and upgrading existing assets

Countries increasingly recognise the value of adaptive asset management to protect transport investments. **Papua New Guinea** has set a structured roadmap for road maintenance, aiming for all core and priority roads to be in fair or good condition by 2028 (PNG - Department of Works and Implementation, 2018). **Bangladesh** is extending the lifespan of rural transport infrastructure through full asphalt conversion of village roads by 2041 (Bangladesh - General Economics Division (GED), 2020). **Armenia** is improving its road quality indicators across categories (Government of the Republic of Armenia & The 2021-2026 Action Plan of the Government of the Republic of Armenia, 2021). **Nepal** (Nepal - National Planning Commission, 2020) and **Indonesia** (Ministry of National Development Planning (Bappenas), 2020) are linking sustained maintenance and retrofitting to economic growth strategies. Performance-based contracts (PBCs), such as those proposed in **Sri Lanka**'s Public Investment Program, are gaining traction to ensure long-term quality and sustainability in road maintenance (Sri Lanka - Department of National Planning, 2021).

5. Nature-based solutions (NBS) in infrastructure resilience

Nature-based solutions are being used to complement physical infrastructure and mitigate disaster risk. **Bhutan** (Bhutan - National Environment Commission, 2020), **Malaysia** (Malaysia - Economic Planning Unit, 2021), and **Papua New Guinea** (PNG - National Disaster Centre, 2017) are integrating community-based disaster preparedness with structural and ecosystem-based interventions. **Fiji** (Government of Fiji, 2023) focuses on climate-resilient infrastructure like seawalls and natural buffer zones to protect coastlines and transport routes. These approaches reflect a broader shift toward solutions delivering resilience and environmental co-benefits.

6. Emergency preparedness and response planning

Strengthening early warning systems and emergency planning is a priority across multiple countries. **Bhutan** (National Environment Commission, 2008), **Cambodia** (Cambodia - Ministry of Environment (MoE), 2022), **Fiji** (Government of Fiji, 2020), and the **Philippines** (PHL - National Economic and Development Authority, 2023), among others are expanding early warning systems for floods, landslides, and extreme weather events. **Nauru** (Government of Nauru, 2022) and the **Solomon Islands** (Solomon Islands - Ministry of Environment, Climate Change, Disaster Management and Meteorology (MECDM), 2023) are advancing relocation strategies for high-risk communities. **Myanmar** (Myanmar - Ministry of Natural Resources and Environmental Conservation, 2019) is combining simulations, institutional coordination, and funding to improve its emergency preparedness. These efforts support rapid, coordinated responses to climate-related disruptions in transport systems.

7. Leveraging digital strategies for smarter road infrastructure

Many countries that recognise digital strategies have immense potential to revolutionise road infrastructure and management. Countries are trying to transform roads into safer, more efficient, and sustainable road networks by initiating intelligent transport systems, data analytics, and smart sensors. For example, the **Vanuatu** Roads for Development Program (Vanuatu, Department of Foreign Affairs and Trade, 2017) recommends developing and implementing a fit-for-purpose digitalisation strategy to improve information management and automate key business and work processes in systems such as the Road Asset Management System.

8. Integrating climate resilience and adaptation into transport financing and investment planning

Across the Asia-Pacific, countries are integrating financing strategies into transport resilience planning through long-term investment frameworks, targeted programmes, and international cooperation. **Bangladesh**'s Delta Plan 2100 (Bangladesh Planning Commission, 2018) sets out a phased investment roadmap to address climate and disaster risks through adaptive and integrated infrastructure strategies, while its Disaster Risk Reduction Strategy (Government of Bangladesh, 2021) aligns spending with the Sendai Framework. **Bhutan** has committed over $320 million to enhance the climate resilience of road networks and transport sector overall, supported by performance-based maintenance contracts (Bhutan, National Environment Commission, 2021). **Lao PDR** emphasises climate-informed long-range transport investment planning (Government of the Lao People's Democratic Republic, 2010), and **Timor-Leste** leverages the Green Climate Fund to strengthen climate information services and proactive risk management (Government of Timor-Leste, 2022b). **Tuvalu** (Government of Tuvalu, 2021) and **Uzbekistan** (Government of Uzbekistan, 2016) are embedding adaptation criteria into national budgets and public infrastructure investments, underscoring the growing trend of mainstreaming climate resilience into transport finance.

Countries are trying to transform roads into safer, more efficient, and sustainable road networks by initiating intelligent transport systems, data analytics, and smart sensors.

5.2 Guidelines, tools and databases

The lack of data and information makes it harder for policymakers and other stakeholders to build climate-resilience of its transport systems. There is a growing suite of guidelines and (commercial) tools available that can help governments to better predict and prepare for climate-related hazards affecting transport systems, respond and recover from disruptions, as well as build adaptive capacity to reduce future exposure and vulnerability.

Box 1. Examples of supply chain guidelines relevant to transport

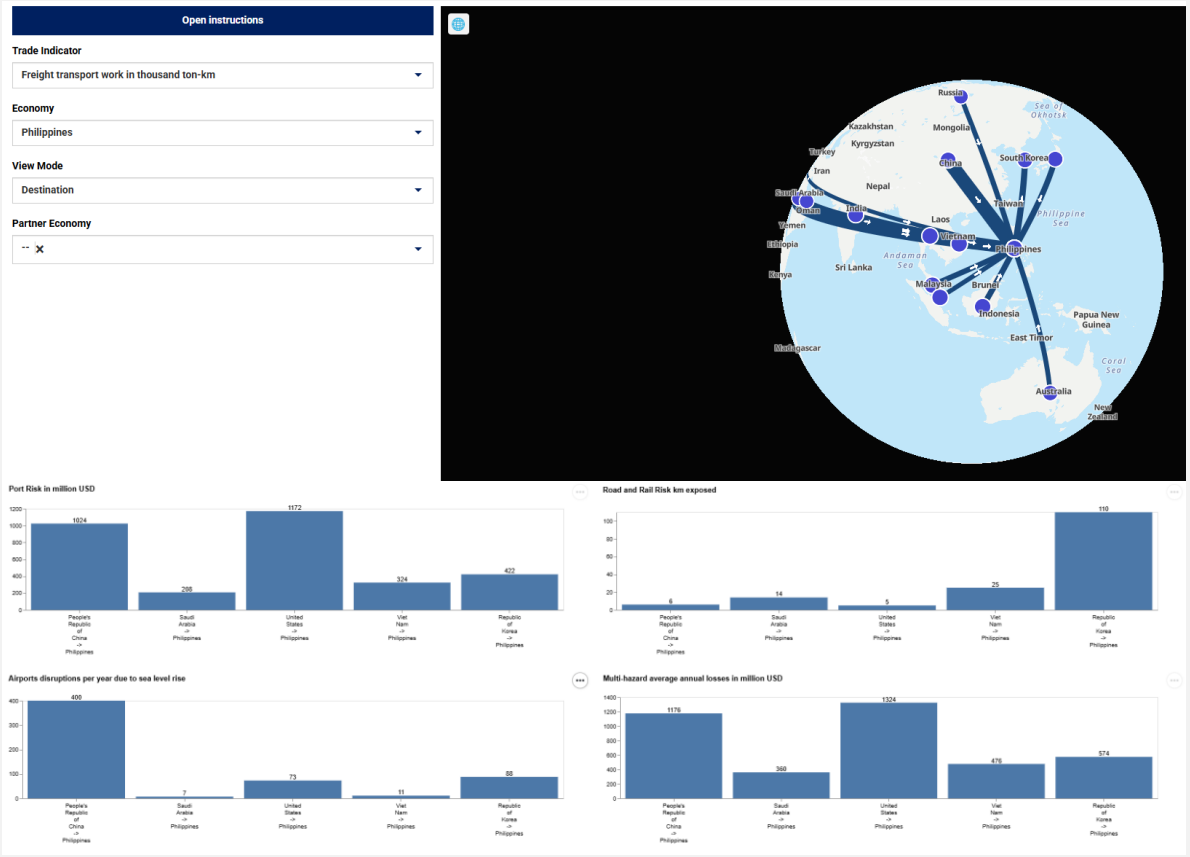
Source: www.life-links.org

- UNDRR - Framework for comprehensive risk assessment and planning in the context of climate change
- UNCTAD – Guidebook for Ports
- GIZ - Climate Risk Management (CRM) framework and a 6-step climate risk assessment (CRA) methodology
- World Bank - Climate Toolkits for Infrastructure PPP
- IDB - Disaster and Climate Change Risk Assessment Methodology
- UNEP's Adaptation and Resilience Investor Collaborative's Measurement Framework for Investors
- Global Center on Adaptation – Climate-Resilient Infrastructure Officer Handbook
- ICSI – Port Resilience Framework for Action
- MCII Integrating Insurance into Climate Risk Management
- ORIS Materials Intelligence platform on infrastructure materials sourcing, climate projections, socio-economic assessments, adaptation and mitigation measures
- CelsiusPro and the NCCS-Impact cross-sectoral assessment of climate change impacts on economic performance

Many of the analytical tools available make use of various databases and combine this with Artificial Intelligence. One such database is the ATO National Database that collects national-level indicators on the transport sector in 51 economies in the Asia Pacific region using about 400 indicators. The database also includes relevant information on policy frameworks for transport in these economies. .

Box 2. Beyond Borders: Mapping Trade Flows and Multi-Hazard Risks to Transport Systems

A recent tool was released by the ATO that enables the visualization ¬—by country pairs— of trade related data and data related to risks brought about by climate change and other environmental events to transport systems and components. By combining trade cost data from UNCTAD and the World Bank with risk and resilience indicators from various sources, as collated and organized by the Asian Transport Observatory, this tool gives a clearer picture of which routes are vulnerable—and what's at stake. It shows not just how goods move, but also what risks are faced by the transportation systems. The tool is available through: https://asiantransportobservatory.org/vis/trade-001/



5.3 Collaboration with other stakeholders

Governments cannot build resilient transport networks and infrastructure all by themselves. Already they work together with development banks, engineering firms, research institutes and NGOs to design, finance and implement solutions.

An opportunity for greater collaboration lies with private sector actors with a commercial interest in optimizing transport resilience. Transport operators and logistics service providers will be hit with additional costs and loss of income if transport networks are disrupted. Similarly, producing companies and retailers rely on functioning transport and logistics systems to get materials and products to factories and markets around the world on time. Insurers are faced with payouts when their customers at hit by climate disasters, including those along the transport network.

Policy makers can look for private sector partners to identify critical transport links – road segments, bridges, ports – that are important to them and vulnerable to climate hazards. Their own or commercial tools they use to predict and respond to hazards can help with this. Policymakers could also seek private sector to give feedback on proposed policy measures, test emergency response systems, and explore if they can co-invest and help implement concrete resilience measures for transport links. This could mean, for example, flood protection of ports, better road infrastructure, or setting up emergency alert systems for drivers or warehouse operators.

Ideally, these are combined with opportunities to reduce GHG emissions and deliver sustainability benefits for local communities. This integration of adaptation/resilience, GHG mitigation, and finance also helps to deliver on the Paris Agreement goals.

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Annex 1. Asia-Pacific Country Classification by Region and Income Level

Name	ISO Code	Sub-region	Income Group
Afghanistan	AFG	Central and West Asia	Low income
Armenia	ARM	Central and West Asia	Upper middle income
Australia	AUS	Pacific	High income
Azerbaijan	AZE	Central and West Asia	Upper middle income
Bangladesh	BGD	South Asia	Lower middle income
Bhutan	BTN	South Asia	Lower middle income
Brunei Darussalam	BRN	Southeast Asia	High income
Cambodia	KHM	Southeast Asia	Lower middle income
People's Republic of China	CHN	East Asia	Upper middle income
Cook Islands	COK	Pacific	Upper middle income
Fiji	FJI	Pacific	Upper middle income
Georgia	GEO	Central and West Asia	Upper middle income
India	IND	South Asia	Lower middle income
Indonesia	IDN	Southeast Asia	Lower middle income
Japan	JPN	East Asia	High income
Kazakhstan	KAZ	Central and West Asia	Upper middle income
Kiribati	KIR	Pacific	Lower middle income
Kyrgyz Republic	KGZ	Central and West Asia	Lower middle income
Lao People's Democratic Republic	LAO	Southeast Asia	Lower middle income
Malaysia	MYS	Southeast Asia	Upper middle income
Maldives	MDV	South Asia	Upper middle income
Marshall Islands	MHL	Pacific	Upper middle income
Micronesia (Federated States of)	FSM	Pacific	Lower middle income
Mongolia	MNG	East Asia	Lower middle income
Myanmar	MMR	Southeast Asia	Lower middle income
Niue	NIU	Pacific	Upper middle income
Nauru	NRU	Pacific	High income
Nepal	NPL	South Asia	Lower middle income
New Zealand	NZL	Pacific	High income
Pakistan	PAK	Central and West Asia	Lower middle income
Palau	PLW	Pacific	High income
Papua New Guinea	PNG	Pacific	Lower middle income
Philippines	PHL	Southeast Asia	Lower middle income
Republic of Korea	KOR	East Asia	High income

Notes: The sub-regions are based on sub-regional groupings by the Asian Development Bank. The following countries are included in the policy analysis that has been integrated in this report: Afghanistan, Armenia, Azerbaijan, Bangladesh, Bhutan, Brunei Darussalam, Cambodia, Cook Islands, Fiji, Georgia, Indonesia, Kazakhstan, Kiribati, Kyrgyz Republic, Lao People's Democratic Republic, Malaysia, Maldives, Marshall Islands, Micronesia (Federated States of), Mongolia, Myanmar, Niue, Nauru, Nepal, Pakistan, Palau, Papua New Guinea, Philippines, Samoa, Singapore, Solomon Islands, Sri Lanka, Tajikistan, Thailand, Timor-Leste, Tonga, Turkmenistan, Tuvalu, Uzbekistan, Vanuatu, Viet Nam.

Name	ISO Code	Sub-region	Income Group
Samoa	WSM	Pacific	Lower middle income
Singapore	SGP	Southeast Asia	High income
Solomon Islands	SLB	Pacific	Lower middle income
Sri Lanka	LKA	South Asia	Upper middle income
Tajikistan	TJK	Central and West Asia	Lower middle income
Thailand	THA	Southeast Asia	Upper middle income
Timor-Leste	TLS	Southeast Asia	Lower middle income
Tonga	TON	Pacific	Upper middle income
Turkmenistan	TKM	Central and West Asia	Upper middle income
Tuvalu	TUV	Pacific	Upper middle income
Uzbekistan	UZB	Central and West Asia	Lower middle income
Vanuatu	VUT	Pacific	Lower middle income
Viet Nam	VNM	Southeast Asia	Lower middle income
Hong Kong, China	HKG	East Asia	High income
Taipei,China	TWN	East Asia	High income
Iran (Islamic Republic of)	IRN	Others	Lower middle income
Russian Federation	RUS	Others	Upper middle income

Annex 2. Examples of transport adaptation policy measures

The table below lists selected adaptation policy measures of Asia-Pacific countries included in the ATO database.

Country	Transport Sector Adaptation Measure Description	Document Name	Year Published	Target year
Papua New Guinea	6 million people (70% of the population) benefit from improved early warning systems/information to respond to extreme climate events	Updated NDC	2020	2030
Bangladesh	At least 50% of railway infrastructure made climate-resilient and energy efficient.	Mujib Climate Prosperity Plan	2021	2030
Papua New Guinea	US$1.2b (PGK 4.2b) value of transport (air, sea, and land) infrastructure and assets built/rehabilitated according to climate-resilient codes and standards.	Updated NDC	2020	2030
Papua New Guinea	USD 1.3 billion value of transport (air, sea, and land) infrastructure and assets built/ rehabilitated according to climate-resilient codes and standards;	Second Biennial Update Report	2022	2030
Afghanistan	By 2020: 150 km of major roads improved and 180 km of roads maintained; by 2025, additional 150 km improved and 180 km maintained	Afghanistan Transport Sector Master Plan Update (2017–2036)	2017	2025
Armenia	Ratio of length of roads and segments in at least satisfactory condition to the overall length of roads of the same category, % = 65 Interstate = 100 State = 60 Local = 45 (Baseline %, 2012 = 39, 85, 34, 10)	Armenia Development Strategy for 2014-2025	2014	2025
Bangladesh	All village roads would be converted to asphalt standard with at least one lane to facilitate rural mobility of passengers and products.	Perspective Plan of Bangladesh 2021-2041	2012	2041
Bangladesh	Targets 2025: · Rehabilitate/ Upgrade 846 km existing rail line. Target 2025: Transport Infrastructure quality Country ranking = 80 Score = 47 Baseline 2019: Transport Infrastructure quality Country ranking = 100 Score = 42 share of Fair to Good road surfaces will be increased from 81% to 90% for overall RHD Road Network	Eighth Five Year Plan	2020	2025
Bangladesh	Retrofit 13,000 km (approx.) of zilla and upazila (farm to market) roads	Mujib Climate Prosperity Plan	2021	2030
Brunei Darussalam	25 km of upgraded road	Review to Formulate a Roadmap and Draft National Masterplan for a Sustainable Land Transportation System for Brunei Darussalam	2014	2035

Country	Transport Sector Adaptation Measure Description	Document Name	Year Published	Target year
Indonesia	Percentage of roads in good condition at the national/provincial/regency/city level (%) = 97/75/65 (Baseline 2019 = 92/68/57) Railroad conditions according to the Track Quality Index (TQI) categories 1 and 2 (%) = 94 (Baseline 2019 = 81.5)	National Medium Term Development Plan 2020-2024	2020	2024
Lao People's Democratic Republic	Build, upgrade, rehabilitate and maintain 2,800 km of land transport infrastructure, including roads, bridges and express ways as part of the network along the economic corridors connecting the countries in the region in accordance with ASEAN technical standards.	9TH FIVE-YEAR NATIONAL SOCIOECONOMIC DEVELOPMENT PLAN (2021-2025)	2021	2025
Papua New Guinea	Maintain 100% of roads	Development Strategic Plan 2010-2030	2010	2030
Papua New Guinea	All sealed/unsealed priority non-core and core roads in fair to good condition are provided routine and periodic maintenance. Twenty percent of sealed and unsealed roads in fair and good condition are resealed/re-gravelled annually. All sealed priority non-core roads in poor condition are in fair or good condition by 2028. All unsealed priority non-core roads in poor condition are in fair or good condition by 2028. All core and priority non-core sealed roads will be in fair or good condition by 2028. All core and priority non-core unsealed roads will be in fair or good condition by 2028. All routine maintenance costs for non-priority roads are included in phase 2 budget requirements	National Roads Network Strategy 2036	2018	2028
Papua New Guinea	All sealed non-priority roads in poor condition are brought to fair or good condition by 2037. All unsealed non-priority roads in poor condition are brought to fair or good condition by 2037. All routine and periodic maintenance costs for the core and priority non-core roads are included in the phase 3 budget requirement. All NRN sealed roads will be in fair or good condition by 2037. All NRN unsealed roads will be in fair or good condition by 2037	National Roads Network Strategy 2036	2018	2037
Timor-Leste	Upgrade to climate-resilient roads: Core Rural Roads in Coffee producing areas (D) Non-Core Rural Roads Low traffic (E1 Roads)	Transport Sector Master Plan	2018	2025
Timor-Leste	Upgrade to climate-resilient roads: Other non-coffee linked rural roads (D)	Transport Sector Master Plan	2018	2030
Timor-Leste	Non-Core Rural Roads low Traffic (E2 Roads)	Transport Sector Master Plan	2018	2022
Myanmar	by 2030, Myanmar has achieved climate-resilience and pursued a low-carbon growth pathway to support inclusive and sustainable development.	Climate Change Strategy 2018-2030	2018	2030
Nepal	Transportation, storage and communication Gross Domestic Product and sector-wise value addition target (In 10 million rupees) = 37,122 (baseline 2018/19 = 22,135) Economic growth rate and sector-wise value addition target = 10.8% (baseline 2018/19 = 5.9%) Sector-wise contribution to the gross domestic product = 7.7% (baseline 2018/19 = 7.2%) Incremental capital-output ratio and total investment (At the constant prices of FY 2018/19) (In 10 million rupees) = 45740	The Fifteenth Plan (Fiscal Year 2019/20 – 2023/24)	2020	2024