International Transport Forum

ITF North and Central Asia Transport Outlook

Case-Specific Policy Analysis

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The International Transport Forum

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Case-Specific Policy Analysis Reports

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Foreword

The project *ITF Transport Outlook – Special Issues for Asia: Policy Analysis and Implementation* was developed jointly by the International Transport Forum and the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP). Both organisations have long collaborated closely and grant each other reciprocal observer status. Funded by ESCAP and carried out by the ITF, this project marks a new high point in this productive partnership.

The reports of this joint project will help member countries of both organisations to understand Asia's transport future better. How will demand for passenger mobility and freight transport evolve in the coming decades? What does this mean for transport-related emissions? And what impact could potential disruptions have? The Covid-19 pandemic has underlined the case for much more resilient transport systems, which require new and different transport policies.

Enhancing governments' capacity to identify critical differences in demand projections for passenger and freight transport between countries in different sub-regions in Asia and the rest of the world will help create a sound basis for necessary policy shifts.

The sub-regions covered by the project are experiencing rapid changes in transport demand, the evolution of mobility services and the provision of transport infrastructure. A primary objective of the work is to provide policy insights that help address the specific challenges in each sub-region and notably improve the sustainability of transport systems.

To support the implementation of sustainable transport pathways, the project included capacity-building and training sessions for each sub-region. The analyses also serve as input to priority actions on connectivity in the next phase of the ESCAP Asia-Pacific Regional Action Programme on Sustainable Transport Connectivity.

I look forward to building further on this excellent example of results-oriented collaboration between two leading intergovernmental organisations in the service of their members.

Young Tae Kim
Secretary-General, International Transport Forum

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Executive summary

What we did

This report provides recommendations for transport policy makers to help them align economic development and growth with the decarbonisation commitments of North and Central Asian countries under the Paris Climate Agreement. The policy insights are based on three scenarios for future transport demand and associated carbon dioxide (CO_2) emissions in North and Central Asia to 2050. The baseline scenario (*Recover*) assumes that government policies return to business as usual after the Covid-19 pandemic. The other two scenarios (*Reshape*, *Reshape+*) assume governments adopt more ambitious policies. Under *Reshape+*, governments leverage the impacts of the pandemic recovery measure for transport decarbonisation. The scenarios are a regional drill-down of the forward-looking policy scenarios for global transport activity used in the ITF Transport Outlook project.

What we found

The Covid-19 pandemic has caused significant disruptions and restrictions in the flow of people and goods worldwide. Landlocked regions that rely heavily on transport across land borders were particularly impacted by measures to limit the spread of the virus. During this time, transport demand for non-urban freight, urban freight and non-urban passenger travel significantly reduced in North and Central Asia. However, these disruptions were short-lived; projections do not foresee a long-term impact on transport demand growth and associated emission trends in North and Central Asia.

In all three scenarios, urban and non-urban freight activity in the sub-region more than doubles by 2050 compared to 2015. By 2030, the total tonne-kilometres of freight will grow by 72% under the *Recover* scenario compared to 2015. Under *Reshape* and *Reshape+*, freight activity will increase less (+58%) by 2050. After 2030, however, the policies and trends included in the *Reshape* and *Reshape+* scenarios indicate much more substantial demand growth of 70% and 60%, while the *Recover* scenario projects only a 17% growth in freight from 2030.

North and Central Asia will incur environmental costs for this growth unless significant changes reduce freight transport's energy consumption. Non-urban freight's tank-to-wheel (TTW) CO_2 emissions in the sub-region will peak in 2040, translating into a 14% increase in TTW emissions by 2050 compared to 2015. However, the region can successfully decarbonise while continuing to grow. More ambitious policies can lead to emissions reductions of more than 50%, according to the projections under the *Reshape* and *Reshape+* scenarios.

The reduced passenger activity during the pandemic is projected to be followed by significant growth to 2030. Passenger kilometres increase by 36% compared to 2015 in the *Recover* scenario, 30% under *Reshape* and 25% under *Reshape+*. By 2050, passenger kilometres could be more than twice as high as in 2015 under all three scenarios. They would be highest under the least ambitious scenario (*Recover*).

Passenger transport's environmental impacts vary significantly between the different transport modes. Air travel has a larger share of the emissions than of the transport activity under all scenarios and for all years. Similarly, road transport always accounts for at least 35% of non-urban passenger emissions, despite having a relatively small modal share ranging between 16% and 22%. Rail has a significantly larger modal share of 35% to 44% but contributes not more than 6% of passenger transport emissions.

The North and Central Asia population will transform the way it travels in the coming years. Private vehicles have the largest modal share of urban passenger travel in the sub-region, accounting for 44% of passenger-kilometres in 2015. The modal share for public transport was 29%, while walking, cycling and micromobility reached 20%. Paratransit accounted for only 4% in 2015, shared trips for 2% and shared vehicles for 1%. Nevertheless, shared mobility will grow under all three scenarios and more than double by 2050 to reach 17% by 2050 under *Reshape* and *Reshape+.* The share of private vehicles will drop to 30%, and paratransit will decrease to 1% of all passenger kilometres. The other passenger modes such as active mobility and micromobility, and public transport are likely to maintain their modal share.

Emissions from private vehicles make up the lion's share of all urban emissions, despite a significant reduction in its share of the transport activity by 2050. In 2015, 77% of passenger transport emissions came from private vehicles. As public transport activity stalled in 2020 due to the Covid-19 pandemic, their share increased to 85%.

What we recommend

Improve connectivity without increasing carbon intensity

Historically, increased carbon intensity and its associated environmental costs underpinned connectivity improvements. Enhancing the well-being of citizens while meeting the challenges of decarbonisation will require a paradigm change in connectivity strategies. Future economic development must be achieved in sustainable ways to avoid the human and economic damage that would be caused by further global warming. Better connectivity must not come with unacceptable environmental costs.

Target regional linkages and sustainable growth in connectivity strategies

Decarbonisation policies that increase the distance-based costs of transport activity – such as carbon prices or taxes – will affect citizens and businesses in remote regions and less-connected markets more than those in well-connected regions. To minimise this impact, policies should focus on improving regional connectivity and fostering regional trade.

Complement connectivity improvements with initiatives to decarbonise fuel production and energy sources

Over the coming years, improvements in North and Central Asia's transport sector should be complemented with initiatives to make energy and fuel production greener and more sustainable. Advancements in vehicle technology and transport operations will decrease tailpipe emissions. As a result, the proportional impact of well-to-tank emissions on total transport emissions will increase. Regions with natural resources, including energy sources, can gain a competitive and strategic advantage by improving their energy sectors. Where carbon-based energy is available locally, well-to-wheel emissions and total energy consumption can be reduced.

Prioritise service improvements and land-use development that encourages public-transport use

Inclusive public transport development would result in fairer outcomes in the cities of North and Central Asia. Projections highlight that it is possible to significantly improve the accessibility provided by public transport with negligible impacts to the accessibility provided by private vehicles. North and Central Asia's under-used road networks present an opportunity to focus investments on public transport development. On average, no more than 20% of the road network capacity is used; by 2050, the figure could be below 5%. Thus, congestion is not a significant problem in the sub-region.

Ensure urban mobility is affordable in North and Central Asia's largest cities

Estimates expect that costs of urban mobility, based on the projected transport modal mix, will become less affordable in the sub-region's largest cities over the coming decades. Under the business-as-usual Recover scenario, the affordability of travelling in the largest cities will be two times lower than in 2015. Urban mobility becoming less affordable in these cities is concerning given the projected increase in the urban population. Larger shares of the population will be living in the largest cities in the coming decades in North and Central Asia. Policies that keep transport accessible to all citizens, including the most disadvantaged segments of the population, will assist equitable outcomes.

Pathways to decarbonise transport in North and Central Asia by 2050

North and Central Asia includes many landlocked developing countries and is heavily reliant on in-land transport. The countries in the sub-region are highly motivated to increase their connectivity to the rest of the world to improve their economic and trade prospects. However, these connectivity ambitions, seeking to encourage trade and its associated transport activity, must be balanced with the environmental goals of the sub-region as part of the global challenge to decarbonise and minimise climate change.

Greenhouse gas (GHG) emissions are a key contributor to climate change on a global scale. It is therefore imperative for decarbonisation to become a policy priority globally. To decarbonise, national, regional, and global efforts will be needed. Without significant changes, it is estimated that the costs for maintenance and reconstruction of urban infrastructure will increase with global warming levels. It will also cause substantial functional disruptions in cities, particularly those located in permafrost, in cold regions, and on coasts. (IPCC, 2022). However, the social and economic impacts will be felt across national boundaries. The IPCC (2022) states with high confidence that through supply chains, markets and natural resources, there are projected to be increased transboundary risks across the water, energy, and food sectors.

This report highlights potential future directions of freight and passenger transport demand and transport-related emissions for North and Central Asia to 2050. This information can be helpful to policy makers in the sub-region as its countries strive to combat climate change by meeting their submitted Nationally Determined Contributions (NDCs) to the UNFCCC under the Paris Agreement. The United Nations ESCAP's definition of the North and Central Asia sub-region has been adopted for this report[1] [2]. All North and Central Asia countries are signatories to the Paris agreement, a legally binding international treaty on climate change. Table 1 lists some ambitious unconditional commitments to reduce GHG emissions over the next decade. Several countries have also made further conditional commitments contingent on international support.

Table 1. Climate action plans in selected North and Central Asia countries: Nationally determined contributions

North and Central Asia Country	Commitment to United Nations Nationally Determined Contribution (UNNDC)	Date pledged	Updated commitment to UNNDC contingent on international support	Date pledged
Armenia	-	23/03/2017	40% reduction in emissions by 2030 (base year 1990)	05/05/2021
Azerbaijan	35% reduction in emissions by 2030 (base year 1990)	09/01/2017	-	-
Georgia	15% reduction in emissions by 2030 (base year 1990)	08/05/2017	35% reduction in emissions by 2030 (base year 1990)	05/05/2021
Kazakhstan	15% reduction in emissions by 2030 (base year 1990)	06/12/2016	-	-
Kyrgyzstan	11.5-13.70% reduction in emissions by 2030	18/02/2020	16% reduction in emissions by 2030	09/10/2021
Tajikistan	10-20% reduction in emissions by 2030 (base year 1990)	22/03/2017	30-40% reduction in emissions by 2030 (base year 1990)	12/10/2021
Turkmenistan	Commitment to Reduction	21/10/2016	-	-
Uzbekistan	10% reduction in emissions per unit of GDP by 2030 (base year 2010)	09/11/2018	35% reduction in emissions per unit of GDP by 2030 (base year 2010)	30/10/2021

Notes: All reported commitments are unconditional reductions. Some North and Central Asia countries have also made larger conditional commitments subject to further conditions. Values for Kyrgyzstan have been rounded up for consistency with other country data.

Source: Data from country submitted Nationally Determined Contributions. NDC Registry (n.d.), "All NDCs", webpage, https://www4.unfccc.int/sites/NDCStaging/Pages/All.aspx (accessed 7 February 2022).

The scenarios used in this study assess potential impacts of future transport activity on climate change through detailed carbon dioxide (CO_2) emissions projections under different conditions. The ITF models used for the *ITF Transport Outlook* are demand-based models that show what could be possible under certain policy scenarios, using policies that are already committed as the baseline. These ITF models are global, and as such, there are limitations to how granular the results presented can be. Model outputs are therefore reported at the sub-regional level, except for the connectivity section, that reports results at the national level. For the most recent ITF Transport Outlook (ITF, 2021), three scenarios were considered, *Recover*, *Reshape* and *Reshape+*. These are described in detail in Annex A, with the specific policies for each of the transport models in Annexes B, C and D – all of which are extracted from the original Outlook 2021. Figure 1 gives a high-level summary of the three.

Figure 1. *ITF Transport Outlook 2021* scenario overview

Source: ITF (2022b).

The *Recover* scenario is the baseline in terms of policy measures. Under *Recover*, it is assumed that transport trends return to levels seen prior to the pandemic by 2025. It also assumes that only pre-existing planned or committed policies are implemented, so there are no additional policies that build on the pandemic experience. From a policy perspective, this could be considered the business-as-usual scenario.

Under *Reshape*, transport trends are again assumed to have returned to their pre-pandemic levels by 2025, and it is assumed that significantly more ambitious policies to decarbonise transport will be implemented. This scenario is considered "transformational". It assumes policy measures that "encourage changes in the behaviour of transport users, uptake of cleaner energy and vehicle technologies, digitalisation to improve transport efficiency, and infrastructure investment to help meet environmental and social development goals." (ITF, 2021). Measures such as carbon pricing or port fees would be assumed to be more stringent, while the attractiveness of more sustainable modes would be increased. The improved attractiveness would be due to assumed lower penalties for multimodal interchanges, greater investment in infrastructure and services, more efficient operations (through asset sharing in freight, for example) and broader uptake of innovative transport solutions and alternative fuels or power.

Reshape+ is the most ambitious of the three scenarios. It assumes that "governments seize decarbonisation opportunities created by the pandemic, which reinforce the policy efforts in *Reshape*." (ITF, 2021). Under *Reshape+*, any reductions in transport demand observed during the pandemic broadly continue, with a more ambitious policy package also being implemented.

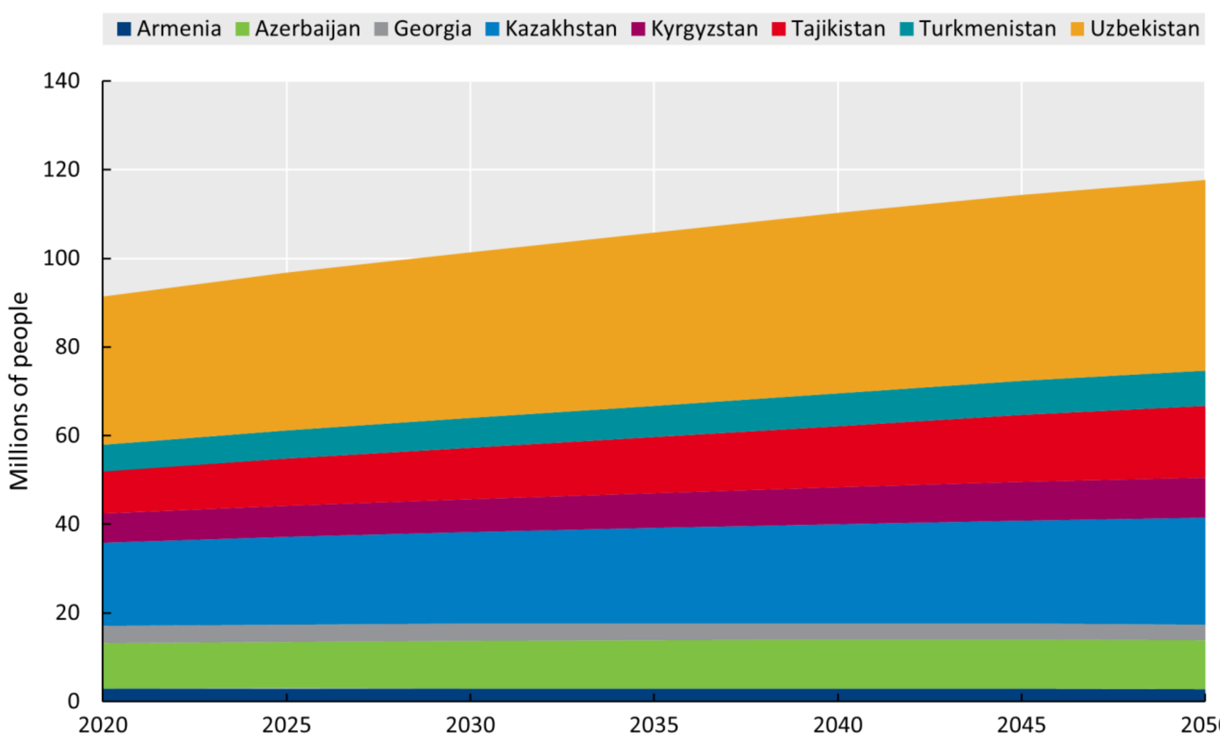
Reshaping transport as economies develop

North and Central Asia is an extremely diverse sub-region that spans vast distances and has differing urbanisation rates, economic outlooks and energy endowments. The majority of these countries are landlocked. The region's demographic, economic, and policy context informs the transport trends and priorities. This chapter highlights country-specific and sub-regional economic and demographic forecasts.

The human dimension: Considering uneven population growth

The population of North and Central Asia was estimated to be 237.4 million in 2020 and, on aggregate, is expected to grow by 7% by 2050, reaching 253.5 million inhabitants (UNDESA, 2019). However, individual countries show different trends.

Figure 2. Projected population growth of selected North and Central Asia countries to 2050



Note: Data are according to the medium-variant projections.

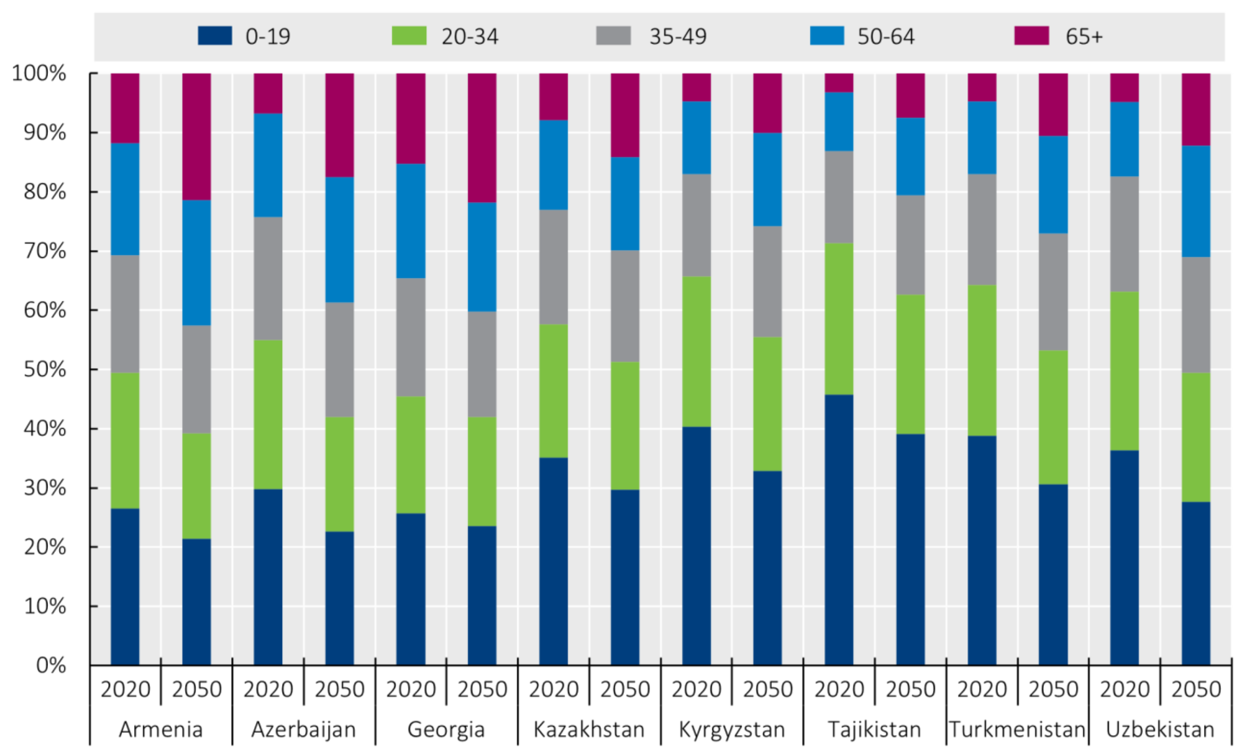
Source: Adapted from UNDESA (2019), Population Division World Population Prospects 2019 (database), https://population.un.org/wpp/.

Some countries' populations are expected to decrease while others grow. Growth rates vary widely among the countries with projected population increases. Azerbaijan has the smallest growth of 9% and Tajikistan the highest at 70%. Kazakhstan, Kyrgyzstan, Turkmenistan and Uzbekistan are also expected to have high population growth rates: approximately 28% in Kazakhstan and Uzbekistan, 30% in Turkmenistan and 40% in Kyrgyzstan. Conversely, Armenia's population, for example, will decline by 5% and Georgia's by 12%.

These differences can be explained, in part, by the different demographic profiles of each of these countries. As shown in Figure 3, the countries with populations expected to decrease (Armenia and Georgia) are the only countries where the share of population under 20 years old is below 30% and the only countries with elderly rates above 10% (UNDESA, 2019). On the other extreme, almost 40% of Tajikistan's population is currently under 20 years old, while only 3% are over 65 years old. Kyrgyzstan, Turkmenistan and Uzbekistan also show low elderly shares of 5%.

The overall population growth in the sub-region and the expected significant growth rates in many countries are likely to increase transport demand for passenger and freight transport at national and sub-regional scales. This will have implications for network planning, and importantly, is also likely to have environmental consequences. National and regional policy makers should consider ways to minimise and mitigate the environmental impacts, including carbon dioxide (CO_2) emissions.

Figure 3. National population by age (%) in selected North and Central Asia countries, 2020 and 2050



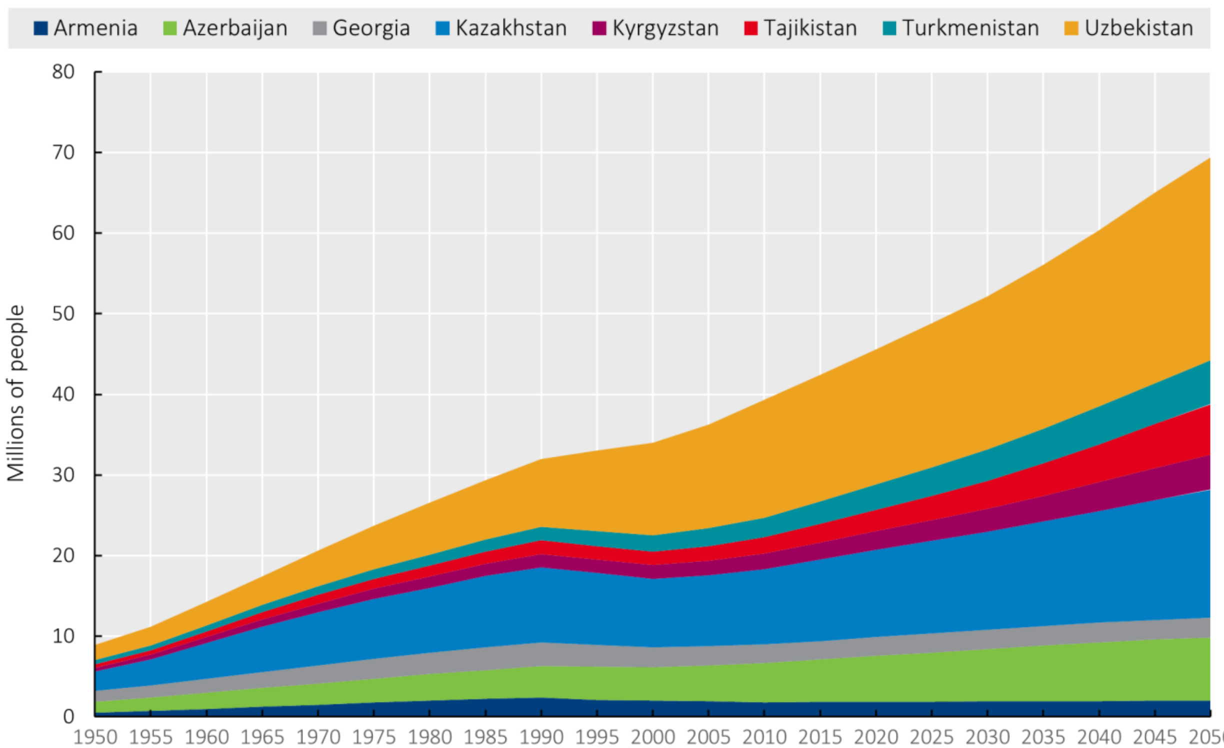
Note: Data are according to the medium-variant projections.

Source: Adapted from UNDESA (2019), *Population Division World Population Prospects 2019* (database), https://population.un.org/wpp/.

How and where the population of the sub-region lives is also expected to change. Its urban population has been continuously growing since the middle of the last century. This trend is expected to continue (see Figure 4). It is estimated that 64% of the North and Central Asia population, approximately 153 million people, currently live in cities (UNDESA, 2019). Most North and Central Asia countries already have urban population rates above 50%, e.g., 63% of the Armenian population is urban. Kyrgyzstan and Tajikistan are the only countries in North and Central Asia where less than 50% of the population reside in urban areas; 36% for Kyrgyzstan and 27% for Tajikistan. By 2050, the urban population of North and Central Asia is predicted to increase to over 180 million people, accounting for 71% of the expected total population of

253.5 million (UNDESA, 2019). Individually, the urban population rate is expected to increase in all North and Central Asia countries. Only Tajikistan and Kyrgyzstan are estimated to still have urban population rates below 50% by 2050, with 39% and 48%, respectively. In Armenia, Azerbaijan and Georgia, the rate is expected to be approximately 71% each.

Figure 4. Population living in urban areas in selected North and Central Asia countries, 1950-2050



Source: Adapted from UNDESA (2018), *World Urbanization Prospects: The 2018 Revision* (database), https://population.un.org/wup/.

The economic dimension: Pandemic impacts

The economic outlook of the sub-region is challenging. Even before the Covid-19 pandemic, there was a deceleration in emerging market and developing economy countries (Dieppe, 2021) and many existing structural issues were exacerbated by the pandemic. The falling demand for merchandise trade in 2020-22 has resulted in decreased fiscal revenue for landlocked countries (UNCTAD, 2021). This reduced trade is particularly affecting the many landlocked countries in the sub-region dependent on such exports. During 2020, the growth of merchandise exports decreased for all North and Central Asia countries, except Kyrgyzstan (UNCTADstad, 2022e) and Tajikistan (UNCTADstad, 2022f). The reduction in the growth of these exports was exceptionally high for Turkmenistan, Azerbaijan, and Kazakhstan (UNCTADstad, 2022b; UNCTADstad, 2022d; UNCTADstad, 2022g).

Many of the largest merchandise export partners for North and Central Asia countries are other countries within the sub-region. During 2020, this sub-regional trade was somewhat maintained despite the overall reduction in growth. Azerbaijan, Georgia, Kazakhstan and Uzbekistan were among the top five export purchasers of merchandise from other North and Central Asia countries. This reliable demand highlights the importance of increasing sub-regional trade. Sub-regional trade can be more sustainable than long-distance interregional trade since the distance component of the tonne-kilometre output is reduced. It is also often more resilient under challenging conditions.

On aggregate, Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan, suffered a 1.5% reduction in GDP in 2020. However, the countries of the South Caucasus region, Armenia, Azerbaijan and Georgia, were more severely impacted. In these countries, there was a 5.2% reduction in GDP (World Bank, 2021). More specifically, country estimates show reductions in GDP growth of 7.4% in Armenia (UNCTADstad, 2022a), 4.3% in Azerbaijan (UNCTADstad, 2022b), 6.2% in Georgia (UNCTADstad, 2022c), 2.6% in Kazakhstan (UNCTADstad 2022d), and 8.6% in Kyrgyzstan (UNCTADstad 2022e). Only the following three countries had positive gross domestic product growth rate in 2020 Tajikistan (3%), Turkmenistan (5.9%) and Uzbekistan (1.6%) (UNCTADstad, 2022f; UNCTADstad, 2022g; UNCTADstad, 2022h).

Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan's economies are expected to rebound in 2022 and grow by 4.3% after a 1.5% reduction in 2020 (World Bank, 2021). The South Caucasus region is expected to have similar growth of 4.2% in 2022. These projected growth increases are unlikely to be sufficient to reverse the damage from the Covid-19 pandemic. Such forecasted recovery numbers are well below historical averages (World Bank, 2021). Additionally, the reality of GDP per capita in 2022 falls far from pre-pandemic projections. For example, GDP per capita is 6.3% lower for Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan in 2022 than pre-pandemic projections and similarly 6.7% lower for the South Caucasus. Inflation in the sub-region also continues to be problematic, partially causing policy interest rates to rise in Armenia, Georgia, Kyrgyzstan and Tajikistan (World Bank, 2021).

Transport policy priorities for better sub-regional connectivity

The North and Central Asia sub-region is strategically important given its geographic location that connects Eastern Asia with the European continent. Despite this location, the access of this sub-region to the rest of the world remains low, and these countries face difficulties in accessing the global trade market (ITF, 2019). Furthermore, the cost of trading goods in the overall North and Central Asia sub-region is among the highest in the world. It is estimated that only developing economies in the Pacific Islands have a higher cost of trading than Central Asia countries (UNESCAP, 2021).

Transport has been one of the sectors hit the hardest by the Covid-19 pandemic. The landlocked developing countries of this sub-region face a very particular set of challenges. Border closures and disruptions to trade and transport have further isolated them from global markets (UNCTAD, 2021). As each of these countries strive to recover from the effects of the Covid-19 pandemic, challenges will arise to align their existing transport priorities, with the submitted Nationally Determined Contributions (NDCs) commitments as part of the Paris Agreement. In particular, better connectivity is a sub-regional transport priority that may not necessarily align with decarbonisation. Increasing connectivity has been associated with increased carbon intensity, in part because it induces demand and encourages longer distances to be travelled. As such, the environmental costs of increased transport activity needs to be considered and policies need to be implemented to minimise the potential negative impacts.

Connectivity can be understood as measuring the "economic space" available for trade for each country. That is, the ease with which their goods can reach potential global markets. In this sense, it contextualises the scale of freight transport activity. Because of the abstract nature of measuring connectivity, i.e., how many opportunities (defined as GDP) can be reached from each country, using a relative measure makes the results easier to interpret. The Netherlands is used as the reference point for the relative connectivity measure because it was estimated to have the highest connectivity. All other connectivity values are given as percentages of this maximum connectivity in the results presented below. Further details about the indicator can be found in Box 1.

The connectivity gap in North and Central Asia is substantial. The relative connectivity ranges from 53% to 75% of the connectivity achieved by the Netherlands, as seen in Figure 5. Tajikistan has the lowest relative connectivity (53%), followed closely by Kyrgyzstan, which reaches only 54% of the Dutch connectivity. Armenia is found to have the highest connectivity, albeit still only 75% of Dutch connectivity. Azerbaijan and Georgia have relative connectivity above 70%.

Much of the connectivity gap is due to geography. This calls into question the aim of increasing connectivity for the sake of connectivity. Figure 6 shows the distance gaps for North and Central Asia countries to reach world GDP compared to better-connected regions is significant. The figure includes the Netherlands, the reference country in the relative connectivity measure, and the United States. The latter is an example of a large, developed economy with significant international trade. The United States and the Netherlands can reach a significantly higher percentage of the global GDP within much shorter distances.

Figure 5. Connectivity gap for selected North and Central Asia countries compared with the Netherlands

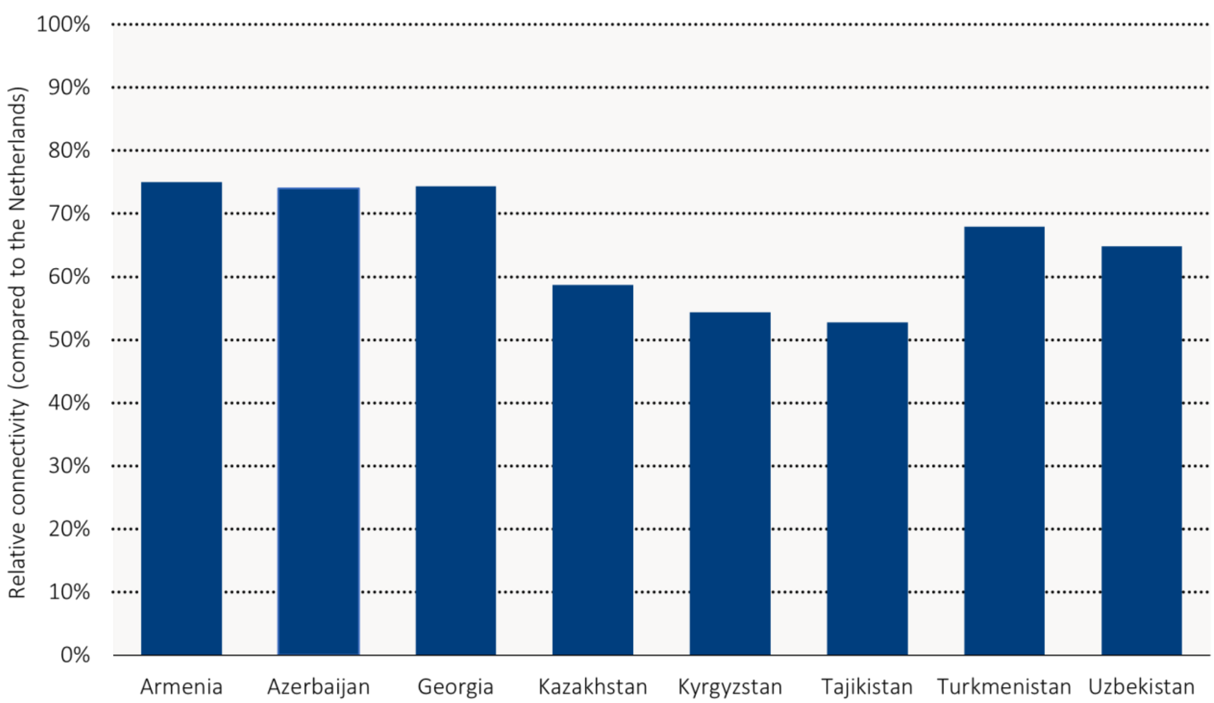
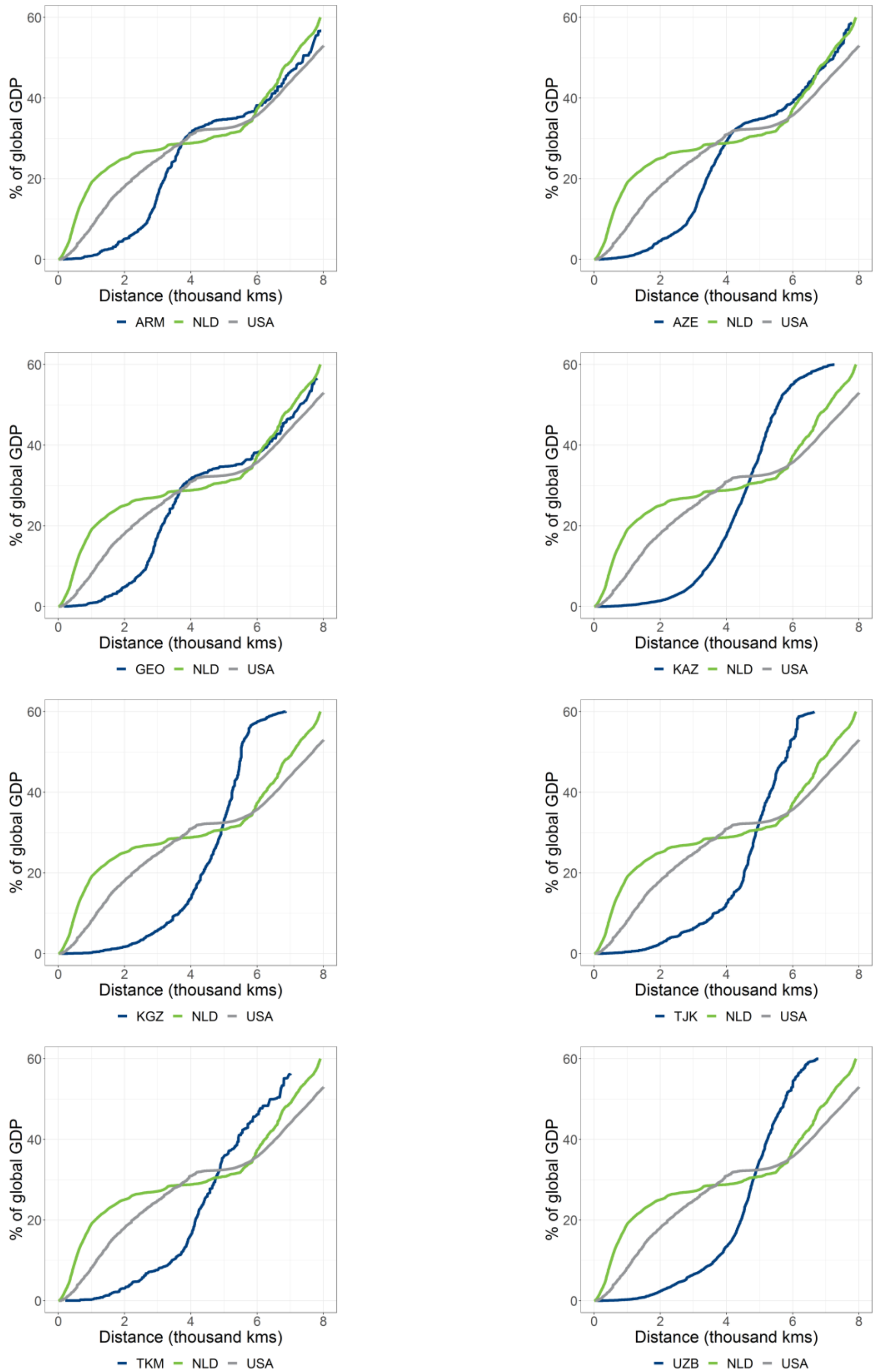


Figure 6. Impact of distances on each reaching global centres of production and consumption for selected North and Central Asia countries



Box 1. Measuring the connectivity gap between countries

The methodological approach for measuring connectivity in this report is a gravity-based model which measures how many opportunities (defined as GDP) can be reached from each country relative to other countries. The explanatory components are calculated for road, rail and maritime transport modes and include distance, transport cost (including border crossing and handling cost), travel time (speed) and border crossing time.

The following formula represents the indicator structure:

$$I = \sum_{c \text{ in countries}} \frac{GDP_c}{\left({g_c}/{\beta}\right)^{\alpha}}$$

where g is the generalised cost, including all the explanatory factors; α is the elasticity of the index to the generalised cost and is set to equal 0.4 (a commonly used value for trade patterns elasticities); β is arbitrarily set so that the ratio gc/β is always below one and close to 1 for adjacent countries.

The index measures the "economic space" available to trade by country, given the explanatory factors.

Source: extract from ITF (2019), "Enhancing Connectivity and Freight in Central Asia", International Transport Forum Policy Papers, No. 71, OECD Publishing, Paris., p.45.

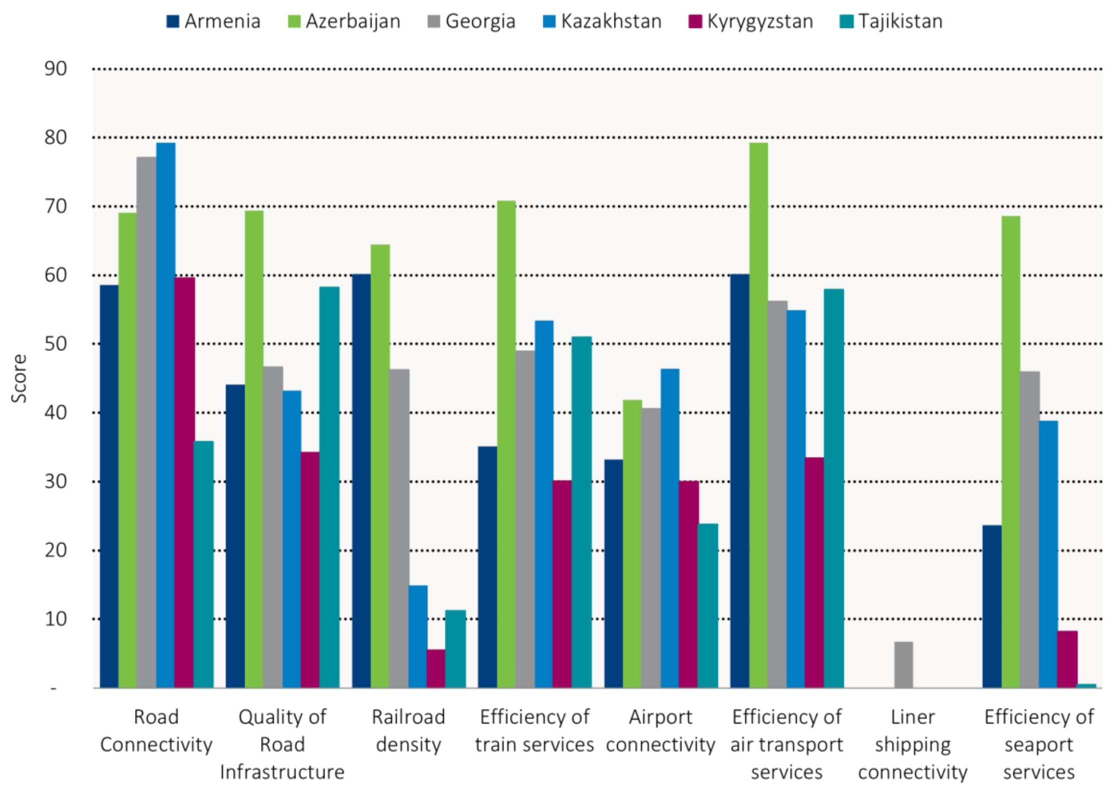
Transport infrastructure and operations

The North and Central Asia sub-region plays an essential role in the Eurasian transport system. The condition of the infrastructure and the landlocked position of many of the countries frame the freight and passenger transport situation in the region. The sub-region has an extensive road and rail network largely inherited from the Soviet period. The transport systems of the countries have high basic interoperability but now require technical and environmental upgrades. Additionally, the long average distances and the predominant role of inland transport has resulted in a corridor-based approach to transport system development of interconnected networks that are meant to serve as a link between outlying regions.

The sub-region faces significant transport infrastructure and operational hurdles to improve the quality of its transport networks. According to the World Economic Forum (WEF) global competitiveness report (WEF, 2019), Azerbaijan ranks 31st in the transport infrastructure score component of the index. The remaining countries in the sub-region included in the report (it excludes Turkmenistan and Uzbekistan) rank in the bottom half of 141 countries ranked. Kyrgyzstan and Tajikistan fare particularly poorly in this score at 129th and 111th, respectively. The WEF transport infrastructure score includes eight road, rail, sea, and air transport infrastructure sub-indicators. These are road connectivity, quality of road infrastructure, railroad density, the efficiency of train services, airport connectivity, the efficiency of air transport services, liner shipping connectivity and efficiency of seaport services (Figure 7).

The maritime shipping indicators are particularly low or non-existent, given the landlocked and limited maritime nature of many of the countries. Of the highlighted countries in Figure 7. Exceptionally, Georgia, has access to the Black Sea and Azerbaijan, Kazakhstan and Turkmenistan have access to the Caspian, a large inland body of water, but these three countries are still considered landlocked (UNCTAD, n.d.).

Figure 7. World Economic Forum transport infrastructure scores for six North and Central Asia countries



Note: The World Economic Forum database does not include Turkmenistan and Uzbekistan.

Source: Adapted from World Economic Forum (2019) The Global Competitiveness Report 2019.

The WEF transport indicator also highlights the different geographic scales in the region. Kazakhstan has a relatively higher efficiency of rail but the density of the rail system is low due to, in part, the size of the country. On the other hand, Armenia and Azerbaijan have higher rail density but lower efficiency, highlighting the different challenges faced by North and Central Asia countries.

Stable growth in air transport services has been observed for the sub-region. The annual growth rate in passengers is 7.7%, excluding the countries with incomplete data (Armenia, Turkmenistan, and Uzbekistan) (World Bank, n.d.). Even with this passenger traffic volume growth, the air connectivity of this sub-region remains relatively low. This is due in part to the lack of adequate infrastructure and services. It is common for passengers to transfer at an airport outside the sub-region to reach a destination in neighbouring countries.

Sustainability of freight operations in the context of the Covid-19 pandemic

Local greenhouse gas emissions by North and Central Asia countries correspond to the modal structure of transport. More than 80% of total transport-related CO_2 emissions are related to road transport (Crippa et al., 2021).

Box 2. Supporting regional co-operation on sustainable freight in Asia Pacific

The United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) is working on a regional strategy to deepen sustainability in freight transport and give further momentum and coherence to initiatives being undertaken at the region-wide level for Asia-Pacific. The outline of the proposed strategy addresses common challenges and offers a guiding vision, objectives, linkages to SDGs directly supported, enablers, priority areas and implementation arrangements. This policy document could bring a range of stakeholders onto a common platform to plan and implement sustainable freight-transport policies that contribute to achieving SDGs in the decade of action for sustainable development.

Regional strategy to deepen sustainable freight transport in Asia and the Pacific

Guiding vision	Efficient, connected, safe and clean regional freight transport system to support the realisation of Sustainable Development Goals (SDGs)
Objectives	Providing coherence to the sustainable freight initiatives Creating synergies through partnerships Ensuring high-level political affirmation Sharpening the links between freight transport policies and SDGs
SDGs supported directly	SDG Targets 9.1, 9.a, 3.6, 12.3, 9.4, 7.3, 13.1
Enablers or cross-cutting issues	Strengthening governance for sustainable freight transport at a national level Enhancing co-ordination for sustainable freight transport at sub-regional level Building the capacity of transport officials Promoting use of digital transport technologies Encouraging private sector engagement for sustainable freight transport policies Diversifying sources of financing for sustainable freight transport
Priority areas	Decarbonising freight transport Building resilience of freight transport to effectively deal with climate challenges and pandemics Strengthening cross-border and transit-transport connectivity Enhancing rural freight transport linkages Improving urban freight logistics Reducing freight-transport-related accidents Increasing share of rail freight and other sustainable transport modes
Implementing arrangements	Establishing a sustainable freight co-ordinating platform Developing a sub-regional action plan on sustainable freight transport Monitoring and evaluating through a results framework

Source: ITF (2022b).

Supply chain shortages caused by disruptions from the Covid-19 pandemic in 2020 and 2021 resulted in meaningful changes in the transport mix. There has been a significant shift to rail from maritime transport for international freight flows (containerised goods). In 2020, for the first time, rail transport was not only faster than sea transport, but for some destinations the cost of transportation was even lower than on any other alternative routes. In 2020 and 2021, specific measures to facilitate international transportation, mainly rail, were applied in several North and Central Asia countries. Rail was one of the few transport sectors that benefited from the pandemic period in the global container market. This growth in rail freight transport, along with the momentum gained by digitalisation initiatives, shows significant potential for improving the sustainability of the sub-region’s freight transport operations through national initiatives and regional co-operation.

Selected transport developments in North and Central Asia

Several transport initiatives have attempted to develop multimodal pathways in North and Central Asia to link Europe and Asia effectively. These projects include the International North-South Transport Corridor (INSTC), Central Asia Regional Economic Cooperation (CAREC) Program, Belt and Road Initiative (BRI), Transport Corridor Europe Caucasus-Asia (TRACECA), Trans-Asian Railway (TAR), Trans-Caspian International Transport Route (TITR) middle Corridor, Caspian Sea – Black Sea International Transport Corridor (ITC-CSBS), Baku-Tbilisi-Kars railway, and the Lapis Lazuli corridor.

The People’s Republic of China's National Transport Plan focuses on developing interconnected international physical networks (e.g., railways, waterways, pipelines) as part of the six economic corridors of the Silk Road Economic Belt. It is highly focused on intercontinental rail, although it also targets aviation and maritime shipping. A major goal is to better integrate transport and industrial infrastructure outside China. (Kenderdine and Bucsky, 2021) The Central Asia Regional Economic Cooperation Program (CAREC) program, which encompasses 11 countries, has financed over 200 projects totalling more than USD 40 billion in investments and has developed and financed transport corridors in the region. Since 2000, CAREC has directed 75% of the investment (more than USD 30 billion) at transport projects. An additional 22% has focused on energy (CAREC, 2021).

Sub-regionally, the Trans-Asian Railways traverses some North and Central Asia countries, including the Northern Corridor (e.g., Kazakhstan) and the North-South Corridor (e.g. Armenia, Azerbaijan, Kazakhstan, and Turkmenistan). Prompted by growing transport demand from international trade, the railway freight volumes along the Northern Corridor continue to grow. Meanwhile, the Baku-Tbilisi-Kars (BTK) railway line opened a new railway transit route in October 2017 to connect the North and Central Asia countries with Turkey and European countries. The BTK route is the shortest link between the Caspian Sea and Europe, prompting plans by Kazakhstan and Turkmenistan to start regular ferry services across the Caspian Sea (UNESCAP, 2019).

The Asian Highway Network is the backbone of the road networks in North and Central Asia. Since its inception, it has been included in the national plans of many countries of the sub-region. However, the planned network is still incomplete and the quality of the existing infrastructure remains a great concern for many of the countries. Primary and Class-I roads account for only 13% of the existing infrastructure. Roads of Class-III or below account for more than 30% of the existing road infrastructure in the sub-region. Significantly, in the cases of Kyrgyzstan and Turkmenistan, the large majority of their road infrastructure (more than 80%) is classed Class-III or below (UNESCAP, 2019).

In addition to necessary infrastructure improvements, there is a significant need to address non-physical barriers in the sub-region (UNESCAP, 2020a; UNESCAP, 2020b). Operational connectivity, including border crossings and transit facilitation, is crucial for road transport along the Asian Highways. To this end, there have been other developments to encourage transport within the sub-region. One example is the Common Economic Space and the formation of the Customs Union (also known as the Eurasian Economic Union). This Union is similar to the European Union (EU) but focuses on economic components to avoid political, military, cultural and ideological divisions (Mostafa and Mahmood, 2018). This single economic zone has removed inspections and other administrative barriers at the internal borders, transferring these to the external borders only (Faskhiev, 2018). Other lesser agreements, treaties, and statements have also promoted transport integration. The Eurasian Central Corridor, the most relevant to the North and Central Asia sub-region among three identified corridors, is almost entirely covered by applicable agreements or arrangements. Among the 16 border crossing points along the corridor, transshipment is only required between Afghanistan and Pakistan. The most common permit system along this corridor is the "single round trip permit," and permit-free bilateral transport arrangements have been made for the cases of Turkmenistan – the Islamic Republic of Iran, Kyrgyzstan – Tajikistan, and Uzbekistan – Kazakhstan round-trip connections.

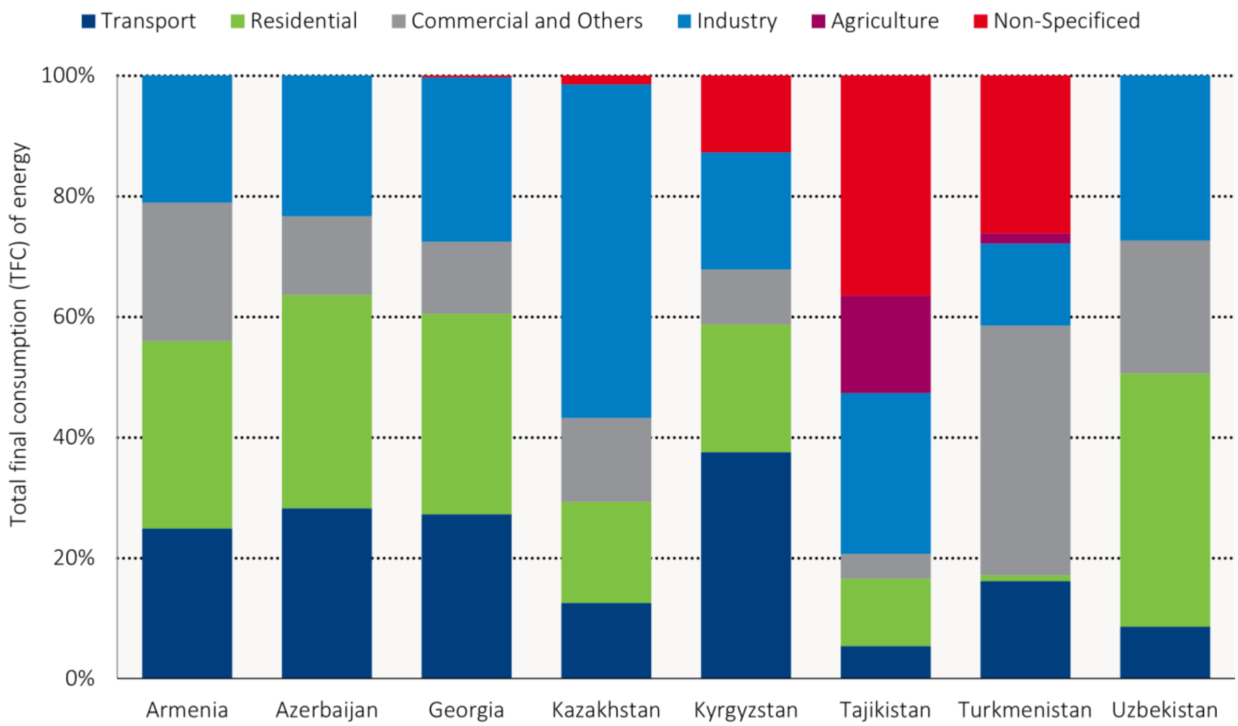
The sub-region has a relatively low level of digitalisation and facilitation of cross-border transport operations. According to the UN Global Survey on Digital and Sustainable Trade Facilitation 2019, the average implementation of a set of 31 trade facilitation and paperless trade measures is 65.6% for the sub-region. Leveraging innovative solutions to facilitate cross-border processes should be a policy priority to achieve more resilient cargo transport for the post-Covid-19 "new normal" in the sub-region. Initial responses to the pandemic included new cross-border restrictions, which caused severe disruption to freight routes. Subsequent improvements, such as increased flexibility and the introduction of electronic documentation, were considered positive advances and lessons learned from the pandemic.

Energy production and consumption

The sub-region is rich in energy resources, including traditional and renewable sources. These abundant natural resources include oil, natural gas, and coal, as well as wind, solar and hydro energy (Liu, 2019). This presents both a challenge and an opportunity for the sub-region. On the one hand, there are incentives for large oil producing countries to maintain the status quo (Kazakhstan has the 12th highest crude oil reserves globally (IEA, 2020)). On the other hand, there is a high potential for energy independence and there are ample alternative resources that could be harnessed to move towards decarbonisation. Additionally, energy-rich countries in the sub-region can leverage improvements in the energy sector to minimise the overall environmental costs associated with transport because they can face the challenge on two fronts.

The IEA (2016) estimates that transport is currently an important component of the national total final consumption (TFC) for many countries in North and Central Asia. In particular, 37.6% of the TFC of Kyrgyzstan is associated with the transport sector. Armenia, Azerbaijan and Georgia also have transport shares above 20%.

Figure 8. Total final consumption of energy, by sector, in selected North and Central Asia countries



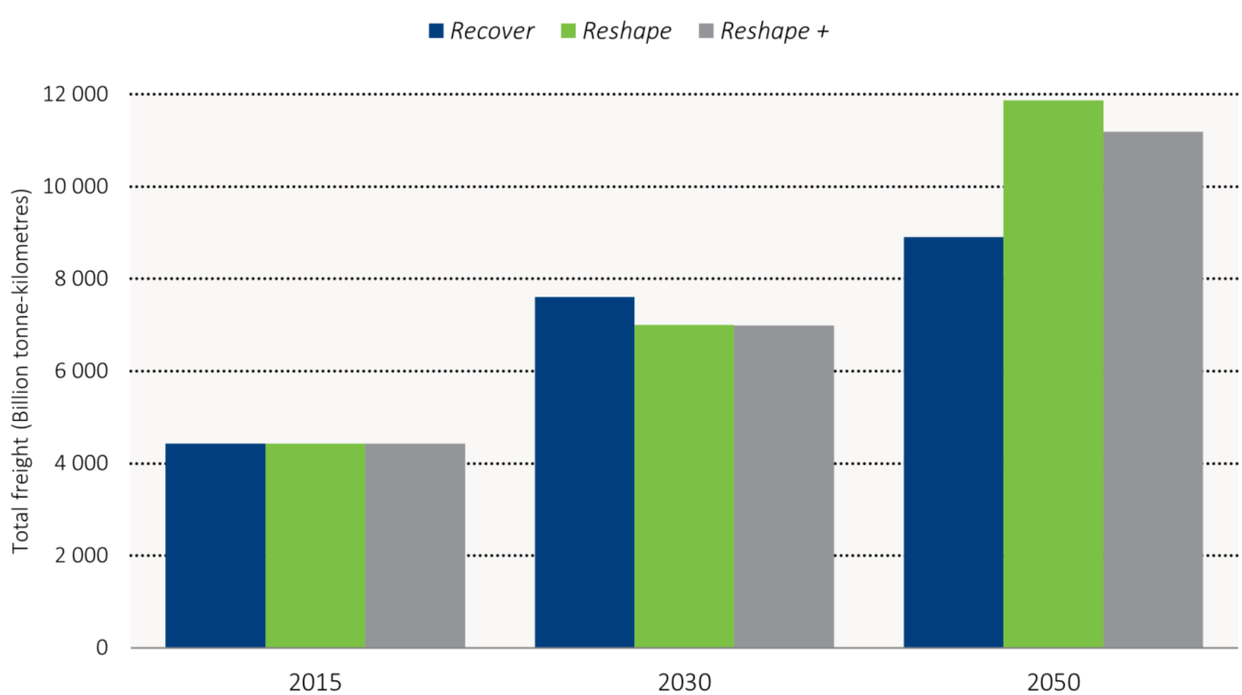
Source: Adapted from IEA (2016), Energy Policies Beyond IEA Countries: Eastern Europe, Caucasus and Central Asia 2015, https://www.iea.org/reports/energy-policies-beyond-iea-countries-eastern-europe-caucasus-and-central-asia-2015.

Freight transport: Non-urban and land transport to dominate future growth

Urban and non-urban freight activity in the North and Central Asia is projected to grow regardless of the policy scenarios applied over the coming decades. Under the *Recover* or, business-as-usual scenario, the total tonne-kilometres (tkm) of freight are expected to grow by 72% by 2030 compared to the 2015 baseline values. However, the growth is only expected to be 58% under the more ambitious policies applied under *Reshape* and *Reshape+*. By 2050, total freight activity under all three scenarios is projected to more than double 2015 values (Figure 9). However, the policies and trends included in the *Reshape* and *Reshape+* scenarios will create more significant growth in freight activity than under the *Recover* scenario for the sub-region. *Recover* is expected to increase freight activity by 17% by 2050 from 2030, whereas *Reshape* and *Reshape+* by 60%.

This growth in freight activity will not be isolated to North and Central Asia. Freight activity is expected to grow in the coming decades globally (ITF, 2021). Yet, under the business-as-usual *Recover* scenario, the freight activity in North and Central Asia is projected to grow slower than in other Asia sub-regions. For example, the freight activity in Southeast Asia and South and Southwest Asia is expected to be four times greater by 2050 than their 2015 baseline values (Figure 10). However, North and Central Asia is only expected to have approximately twice the amount of freight activity by 2050 compared to its 2015 levels, which is below the global average (purple in Figure 10). In contrast, other Asian sub-regions are expected to experience growth well above the world average.

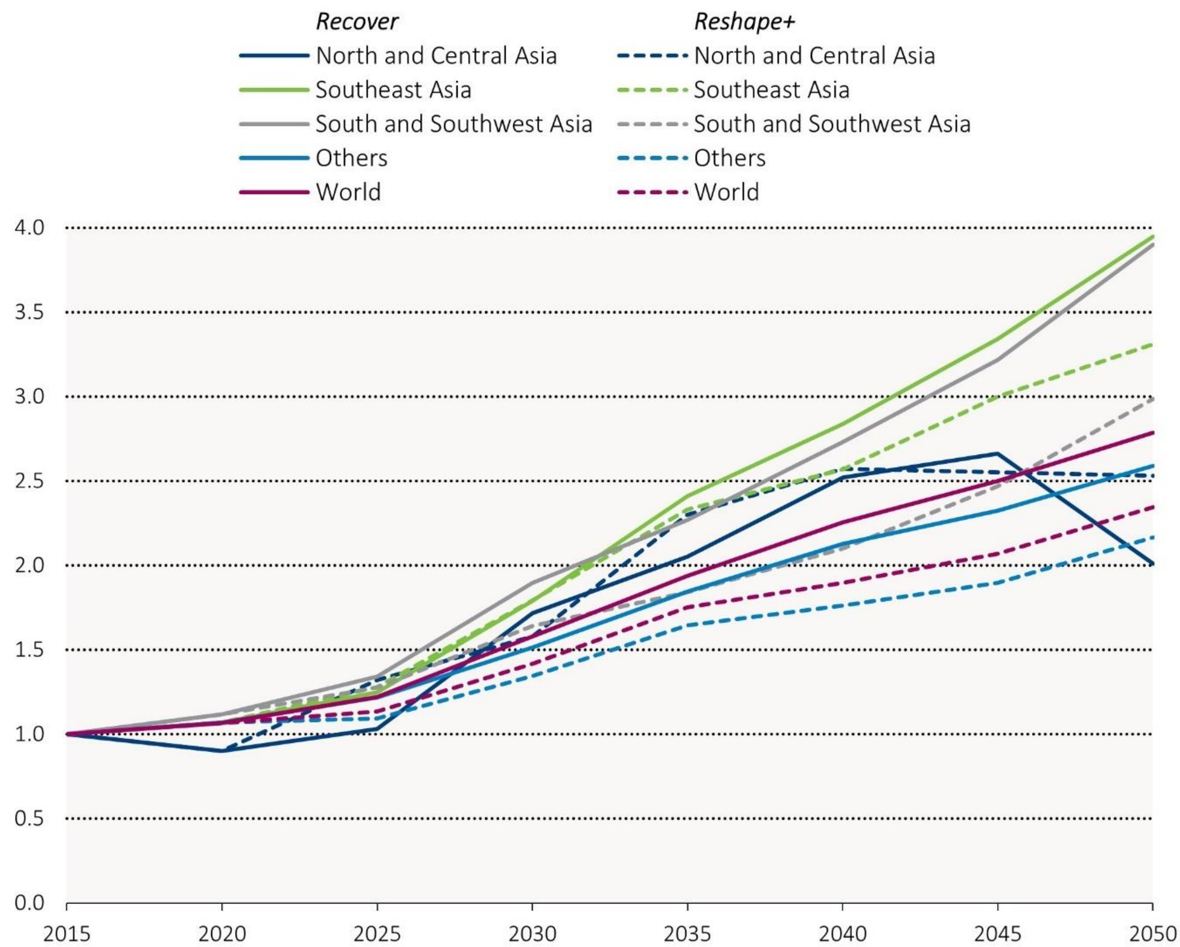
Figure 9. Total freight activity in North and Central Asia by scenario to 2050



Note: Figure depicts ITF modelled estimates. *Recover*, *Reshape* and *Reshape+*, which refer to the three scenarios modelled, represent increasingly ambitious post-pandemic policies to decarbonise transport.

Interestingly, under the more ambitious *Reshape+* scenario, freight activity is expected to be higher in 2050 than under the business-as-usual *Recover* scenario. This conflicts with projections for Southeast Asia and South and Southwest Asia, where their business-as-usual scenarios are estimated to create higher freight activity than the ambitious *Reshape* scenarios by 2050. These different results between the sub-regions may be due to improvements to rail and waterways, as well as trade regionalisation modelled for North and Central Asia. However, it should be highlighted that the modelling results are aggregated to a set of measures applied simultaneously. The independent impact of particular measures is not modelled. As a result, the impact of particular measures included as part of the scenario package of policy interventions on the total results is not analysed.

Figure 10. Relative growth in freight activity in Asia and the world under *Recover* and *Reshape+* scenarios to 2050



Notes: Index = 2015.

Figure depicts ITF modelled estimates. *Recover* and *Reshape+*, which refer to two scenarios modelled. *Reshape+* represents more ambitious post-pandemic policies to decarbonise transport.

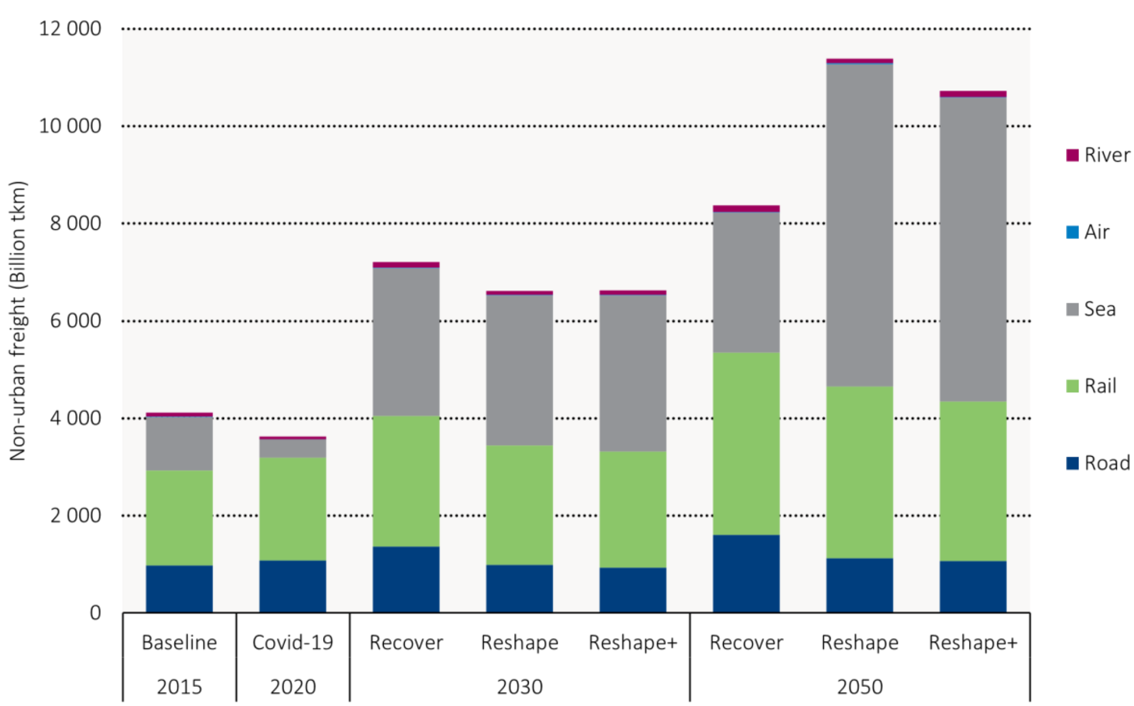
Non-urban freight transport: Preparing for modal shift

Non-urban freight activity, including international freight, constitutes most of the total freight for North and Central Asia. Estimates show that non-urban freight always accounts for at least 90% of the total freight activity for all scenarios in all years. Additionally, other than a slight dip during 2020 due to the Covid-19 pandemic, the tonne-kilometres ratio is expected to grow and reach 95% by 2030 (Figure 11).

In addition to the substantial growth in tonne-kilometres (Figure 11), there are also expected modal shifts (Figure 12). When discussing the modal shares, it is important to note that multimodal trip chains account for most of the freight activity. For instance, a trip between point A and point B may include a road segment to reach a port, a maritime segment, and then a rail segment before reaching its final destination. The modal shares discussed in this section are estimated by assigning the entire trip chain to the most significant (i.e. longest) modal component. In the case of North and Central Asia, this is an important consideration because being part of global trade ensures that maritime transport remains significant despite the sub-region including many landlocked developing countries.

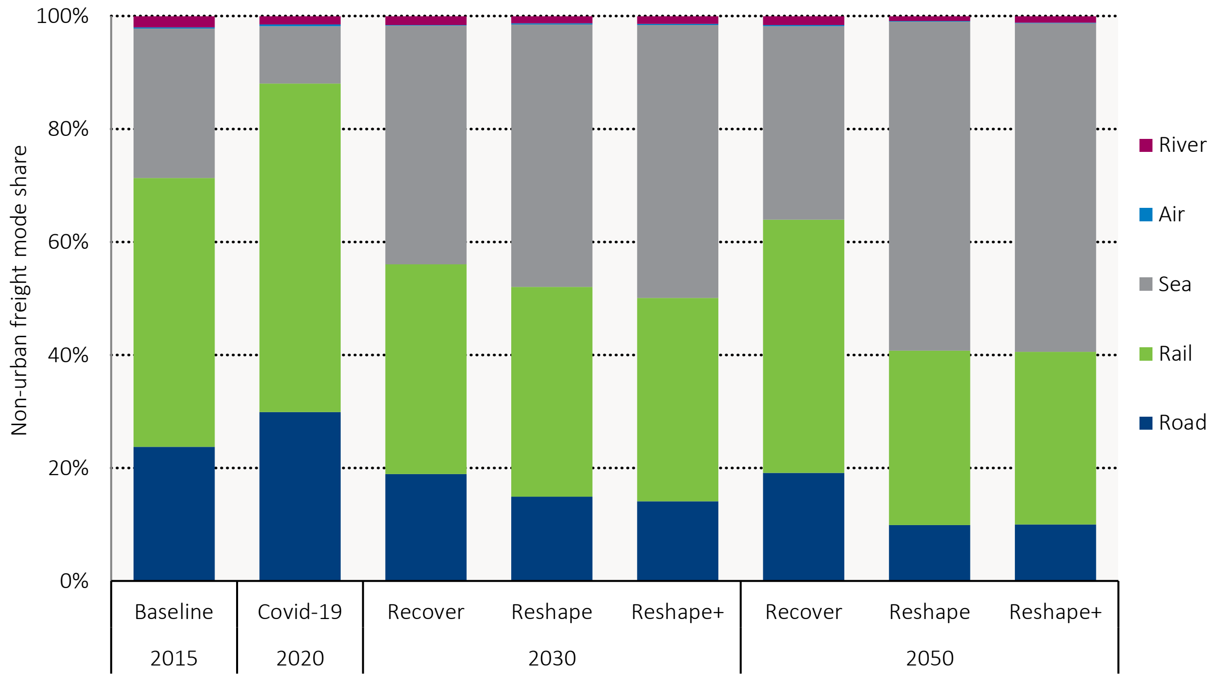
Land freight transport currently dominates regional transport in the sub-region. Rail and road freight transport accounted for more than 70% of its total transport activity in 2015. Rail alone accounted for 48%. The importance of these two modes became even more marked during the pandemic-stricken 2020, when they were estimated to account for nearly 90% of the total transport activity. Before the pandemic, sea freight accounted for 26% of inter-urban freight in North and Central Asia, despite the landlocked nature of many countries in the sub-region. However, in 2020 the share of maritime transport was reduced to only 10%. This highlights potential difficulties for trade growth, as maritime freight accounts for the largest share of global freight activity (ITF, 2021).

Figure 11. Total non-urban freight activity by mode and scenario in North and Central Asia to 2050



Note: Figure depicts ITF modelled estimates. *Recover*, *Reshape* and *Reshape+*, which refer to the three scenarios modelled, which represent increasingly ambitious post-pandemic policies to decarbonise transport.

Figure 12. Modal share of non-urban freight by mode and scenario in North and Central Asia to 2050



Note: Figure depicts ITF modelled estimates. *Recover*, *Reshape* and *Reshape+*, which refer to the three scenarios modelled, which represent increasingly ambitious post-pandemic policies to decarbonise transport.

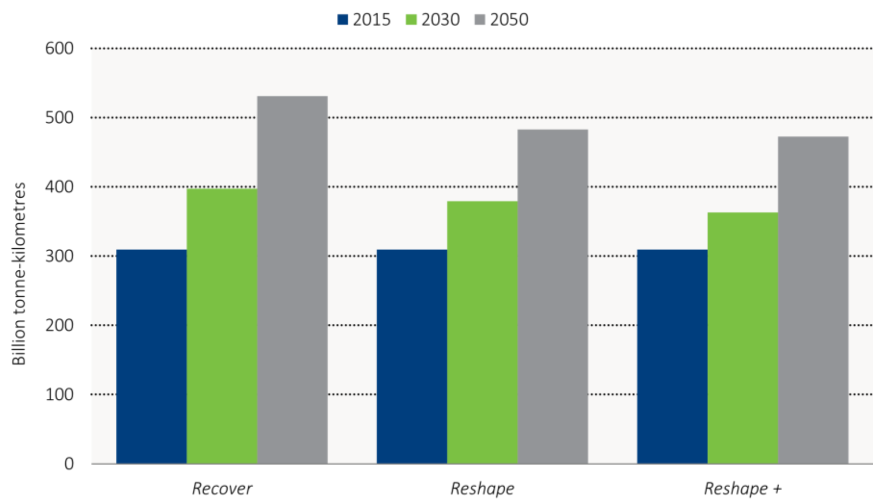
Maritime freight transport can recover and have the largest relative modal growth in the sub-region if ambitious decarbonisation policies are put in place. This result is unsurprising given the low levels of activity and share currently. As the sub-region's global international trade increases, a significant part of this trade is expected to be via maritime. Under the business-as-usual *Recover* scenario, maritime freight is projected to account for 42% of freight activity by 2030 before settling at 34% by 2050. Under *Reshape* and *Reshape+*, the importance of maritime is even more significant. Under both scenarios, the maritime share is projected to be above 45% by 2030 and nearly 60% by 2050.

The total tonne-kilometres of rail freight is also expected to increase (Figure 11). Rail will remain an important component of the sub-regional transport system under all scenarios analysed, still accounting for 31% of the trips. However, due to the increase in demand, the share of maritime transport will be 58% under the *Reshape* scenarios by 2050. The transport network improvements, reduction in penalties for mode transfers at international terminals, and the whole gamut of policies and exogenous factors included in the freight scenarios (refer to Annex B for the complete list) work together to facilitate access to sea ports outside of the landlocked countries in North and Central Asia. This transition would also require soft policy measures, including transit policies, to ensure the operational feasibility of transit activities.

Urban freight transport: Mitigating inevitable growth

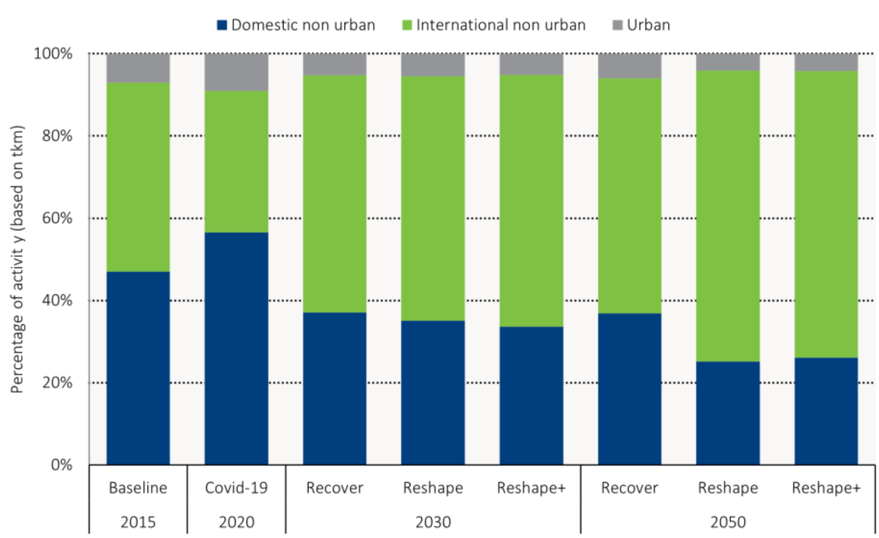
Urban freight activity is expected to increase regardless of the policy scenarios applied (Figure 13). Under the business-as-usual *Recover* scenario this increase is expected to be 72% by 2050. However, activity growth can be limited by the more ambitious scenarios; 56% under *Reshape* and down to 53% for *Reshape+*. The growth of non-urban freight tonne-kilometres will outpace the growth in urban freight activity (Figure 14). By 2050 it is projected that under the *Reshape* and *Reshape+* scenarios, urban freight activity will account for only 4% of the total freight activity.

Figure 13. Total urban freight activity by scenario in North and Central Asia to 2050



Note: Figure depicts ITF modelled estimates. *Recover*, *Reshape* and *Reshape+*, which refer to the three scenarios modelled, which represent increasingly ambitious post-pandemic policies to decarbonise transport.

Figure 14. Surface freight activity ratio by type and scenario in North and Central Asia to 2050



Notes: Surface freight includes road, rail and inland waterways.

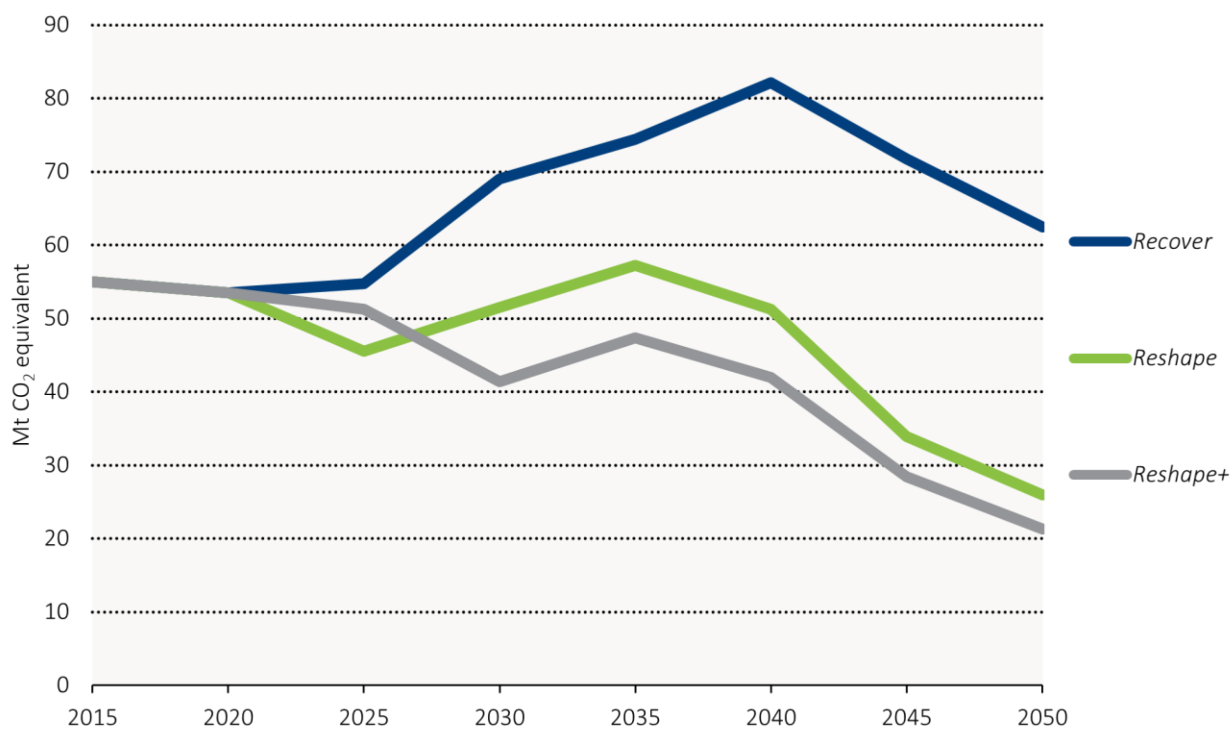
Figure depicts ITF modelled estimates. *Recover*, *Reshape* and *Reshape+*, which refer to the three scenarios modelled, which represent increasingly ambitious post-pandemic policies to decarbonise transport.

Freight transport emissions: Considerable gains from ambitious policies

The energy consumption and associated emissions for freight transport will grow due to its activity increase unless significant changes are made. Tank-to-wheel (TTW) emissions are those generated by transport activity directly. As the name implies, they are the emissions generated while a vehicle operates. These emissions can be directly impacted by transport policies and potentially reduced by changes in the organisation of transport activity. For example, by reducing the number of vehicle-kilometres or by improvements in vehicular efficiency. Under the current business-as-usual *Recover* scenario, non-urban TTW CO_2 emissions in North and Central Asia would peak in 2040 (Figure 15). There would be a 14% increase in TTW emissions by 2050 compared to the 2015 baseline levels without ambitious intervention. To this effect, there would be reductions of more than 50% under the *Reshape* and *Reshape+* scenarios.

Non-urban TTW emissions dropped by 3% in 2020 due to the pandemic. However they are projected to increase by 25% by 2030 and remain 15% above 2015 levels by 2050. Ambitious policies could create significant improvements. By 2030, non-urban emissions could be 6% lower than 2015 emissions under *Reshape* and 25% lower under *Reshape+*. By 2050, these values are expected to be more than 50% lower than 2015 values in both scenarios.

Figure 15. Total tank-to-wheel emission trends for non-urban freight by scenario for North and Central Asia to 2050



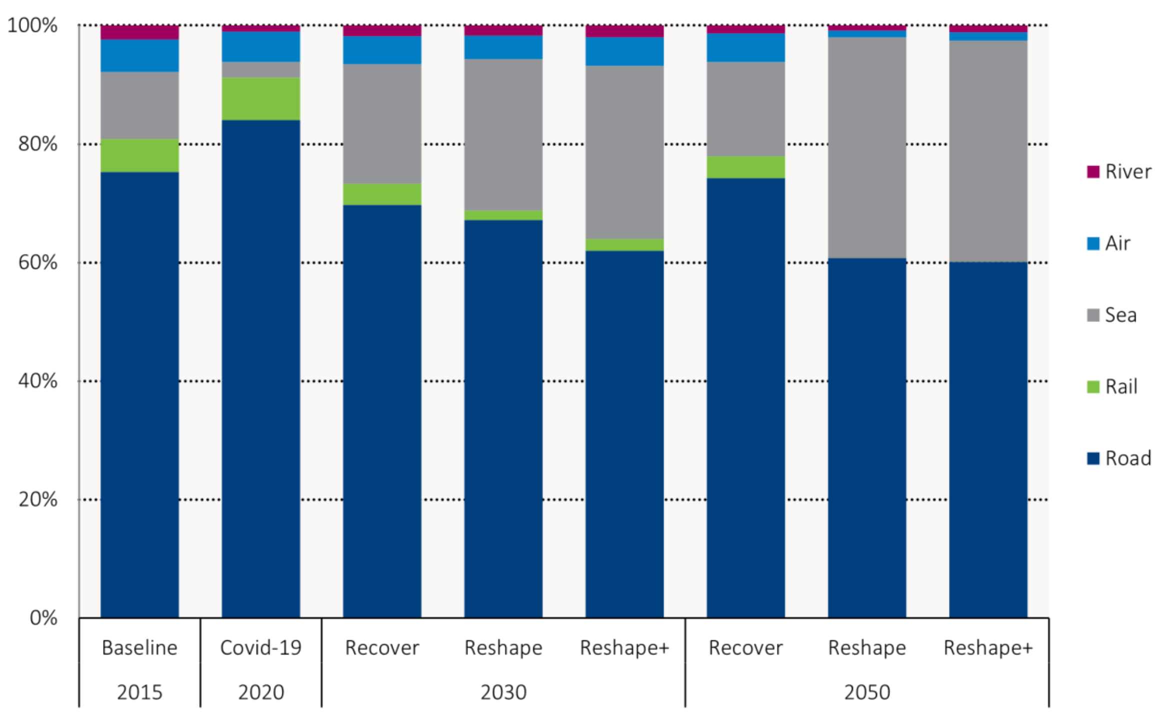
Note: Figure depicts ITF modelled estimates. *Recover*, *Reshape* and *Reshape+*, which refer to the three scenarios modelled, which represent increasingly ambitious post-pandemic policies to decarbonise transport.

Non-urban-road freight and urban freight, both reliant on trucks, have a disproportionate impact on emissions in North and Central Asia, when compared to their total tonne-kilometres. This highlights the importance of improved and more efficient road freight operations (e.g. through asset sharing), better fuel standards, and fleet renewal to greener vehicles. Regardless of the scenario applied, road freight always accounts for at least 60% of the non-urban emissions, and in the business-as-usual *Recover* scenario would emit 75% of these emissions in 2050. However, in terms of the total tonne-kilometres, road freight only accounted for approximately 25% of the non-urban freight activity in 2015 and for all scenarios would only account for 10-20% of this activity in 2030 and 2050.

Similarly, urban freight accounted for only 7% of the total surface freight tonne-kilometres in 2015 but produced 37% of equivalent CO_2 emissions. The activity share of urban freight will remain below 10% of the surface freight activity under all scenarios but this outsized impact will remain unless the ambitious measures in the *Reshape* scenarios are implemented (Figure 16).

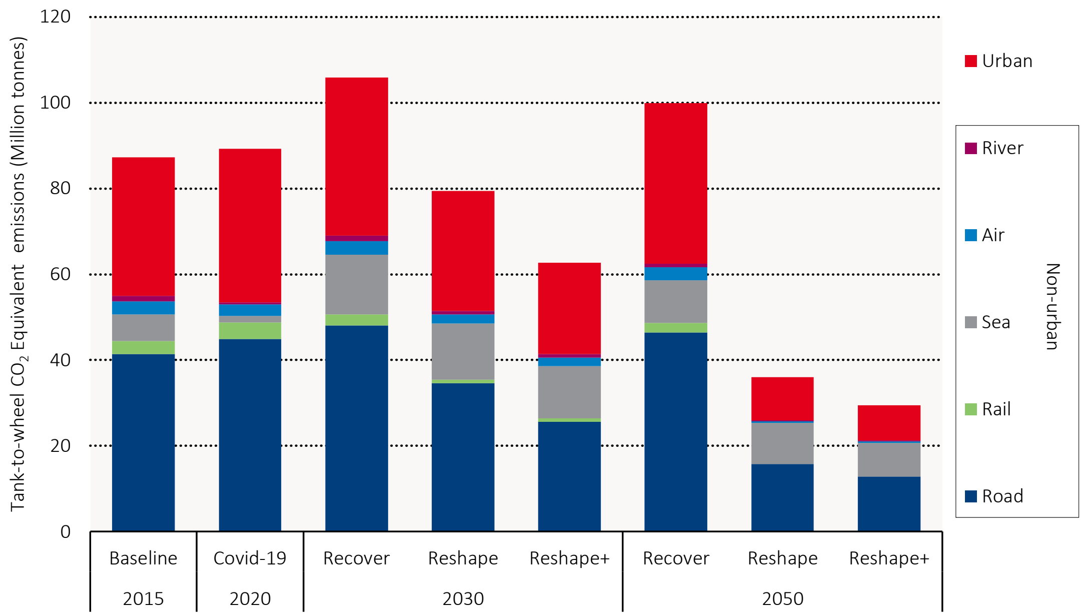
Urban freight emissions in the sub-region could be 14% below 2015 levels by 2030 under *Reshape* and 34% below under *Reshape+*. By 2050, these could extend to 69% lower than 2015 levels under *Reshape* and 75% lower under *Reshape+*. However, on aggregate, urban freight emissions would still account for approximately 28% of all surface freight emissions in 2050 (Figure 16). All emissions considered in this analysis are tank-to-wheel. As a result, upstream leaks are not accounted for in these estimates. Less green and highly carbonised energy generation can therefore diminish the associated emissions reductions. How energy is produced, fuel sources, and the processes used to bring this fuel to vehicles are critical well-to-tank (WTT) lifecycle components of the total emissions associated with transport activity to consider (Garcia et al., 2021). In particular, the share of WTT emissions is critical in highly electrified sectors because the associated TTW emissions trend towards zero as electrification increases.

Figure 16. Tank-to-wheel emissions for non-urban freight by mode and scenario to 2050



Note: Figure depicts ITF modelled estimates. *Recover*, *Reshape* and *Reshape+*, which refer to the three scenarios modelled, which represent increasingly ambitious post-pandemic policies to decarbonise transport.

Figure 17. Freight tank-to-wheel emissions by mode, scenario and year to 2050



Note: Figure depicts ITF modelled estimates. *Recover*, *Reshape* and *Reshape+*, which refer to the three scenarios modelled, which represent increasingly ambitious post-pandemic policies to decarbonise transport.

In the 2015 baseline, 72% of all well-to-wheel (WTW) emissions associated with rail freight transport in North and Central Asia corresponded to the WTT component. Other modes had shares ranging from 28% in aviation to 15% in maritime transport (Table 2). By 2050, due to several trends such as the acceleration of electrification, fuel efficiency standards and improved vehicle technology, the share of WTT emissions will increase for all modes under the more ambitious *Reshape* scenarios.

Table 2. Proportion of well-to-tank emissions in total emissions in North and Central Asia by year and mode to 2050

Year	Scenario	Air	Rail	Inland Waterways	Road	Maritime	Urban
2015	Baseline	28%	72%	26%	19%	15%	16%
2020	Covid-19	28%	66%	24%	19%	15%	17%
2030	*Recover*	29%	67%	30%	24%	17%	20%
	Reshape	35%	88%	30%	23%	18%	21%
	Reshape +	35%	88%	32%	29%	19%	27%
2050	*Recover*	31%	59%	36%	27%	23%	28%
	Reshape	69%	100%	36%	31%	24%	36%
	Reshape +	70%	100%	40%	35%	26%	39%

On aggregate, the share of non-urban TTW emissions will decrease from 73% in 2015 to 66% in the *Reshape+* scenario in 2050. The percentage of urban TTW emissions would have an even greater proportional reduction under *Reshape+*, accounting for only 61% of urban emissions by 2050. In 2015, worldwide TTW emissions are estimated to account for 77% of non-urban emissions but by 2050 WTT emissions would account for 42% of non-urban freight emissions. These results highlight the importance of coupling energy and transport policies to ensure better environmental outcomes. In particular, sub-regions like North and Central Asia with significant natural and energy resources can leverage improvements in the energy sector to reduce the environmental costs of transport. They should be able to minimise WTW emissions to an extent that other regions cannot.

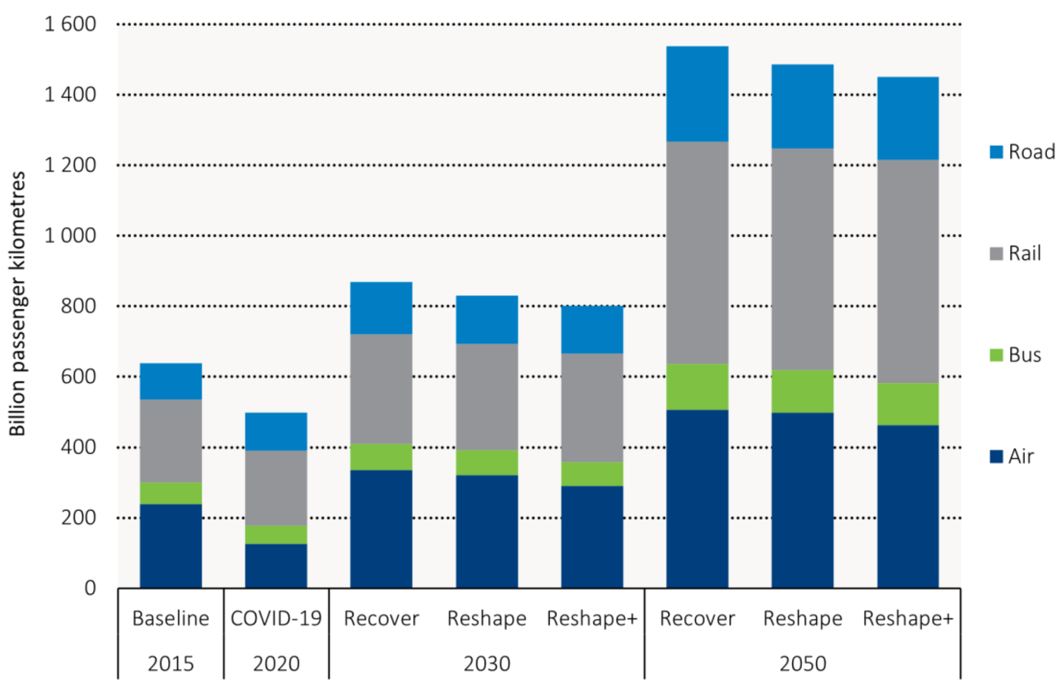
Passenger transport: Changes in travel behaviour for growing population

The growth of urban population in many North and Central Asia countries is likely to influence the way the population travels. Non-urban travel in the sub-region is dominated by rail and air. In the 2015 baseline scenario, it is estimated that each accounts for approximately 37% of the total passenger-kilometres travelled. Bus and other road transport are estimated to have a modal share of 10% and 16%, respectively.

Urban and non-urban passenger transport: Significant growth by 2030

Non-urban passenger travel in North and Central Asia decreased by 22% in pandemic-stricken 2020. Air travel was the most significantly impacted mode with passenger-kilometres decreasing by almost 50%. There were also considerable decreases associated with bus and rail travel. Rail activity was 10% lower than the 2015 baseline and bus activity declined by 15%. Conversely, road travel increased by 5%.

Figure 18. Non-urban passenger demand by mode and scenario for North and Central Asia to 2050

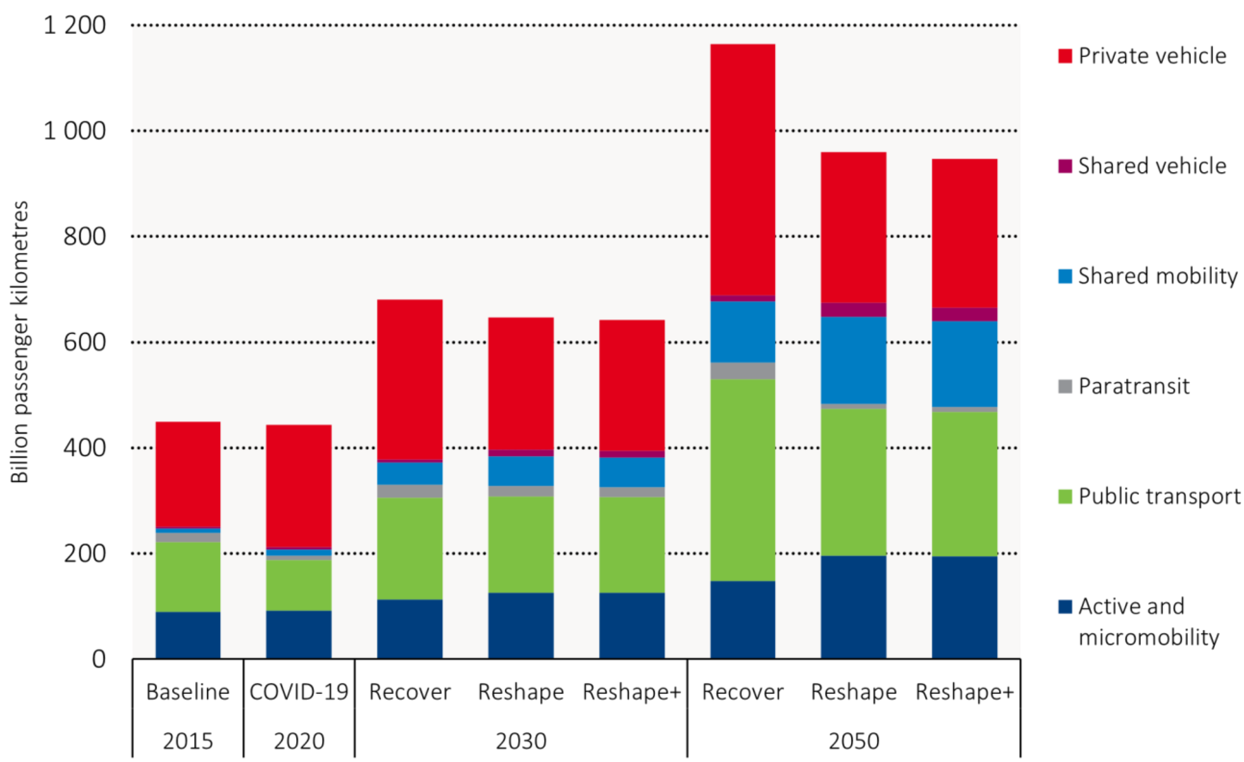


Note: Figure depicts ITF modelled estimates. *Recover*, *Reshape* and *Reshape+*, which refer to the three scenarios modelled, which represent increasingly ambitious post-pandemic policies to decarbonise transport.

This downtrend is not expected to continue in the following decades. In 2030, passenger-kilometres in 2030 would increase by 36% (compared to the 2015 baseline) under *Recover*, 30% under *Reshape* and 25% under *Reshape+*. By 2050, they would all more than double the sub-regional 2015 passenger-kilometres.

Urban passenger kilometres also declined in 2020 but only by 2% and this is expected to grow in the coming decades. By 2030 urban passenger activity is expected to grow by up to 51%, compared to the 2015 baseline. Under the *Reshape* and *Reshape+* scenarios, this increase would be lower but is still projected to be above 40%. By 2050, the impact of the *Reshape* policies and trends will become even more apparent. Applying these measures would limit the increase in urban passenger-kilometres. Compared to the 2015 baseline, passenger demand would increase by 113% under *Reshape* and 110% under *Reshape+*. Under *Recover*, where many of these measures are not incorporated or incorporated much more conservatively, passenger-kilometres are projected to increase by 160%, reaching values 2.6 times larger than the 2015 baseline estimates.

Figure 19. Urban passenger demand by mode and scenario for North and Central Asia to 2050



Note: Figure depicts ITF modelled estimates. *Recover*, *Reshape* and *Reshape+*, which refer to the three scenarios modelled, which represent increasingly ambitious post-pandemic policies to decarbonise transport. Active mobility and micromobility include walking, biking, scooter-sharing, and bike-sharing. Public transport includes rail, metro, bus, light rail transit (LRT), and bus rapid transit (BRT). Paratransit includes informal buses and three-wheeled public transport. Shared vehicle includes motorcycle and carsharing. Private vehicle includes motorcycles and cars. Shared mobility includes taxis, ridesharing, and taxi buses.

In the 2015 baseline scenario private vehicles are estimated to have the largest modal shares of urban passenger travel in the sub-region and account for 44% of the sub-region’s passenger-kilometres. Public transport accounts for 29% of modal share and active mobility and micromobility represents 20%. The remaining modes maintain much smaller shares. Shared vehicles account for 1%, shared trips 2% and paratransit 4% of the remaining passenger-kilometres for the sub-region.

The urban population of North and Central Asia is expected to transform the way it travels in the coming years. In particular, shared mobility is projected to grow under all three scenarios and by 2050 reach 17% under *Reshape* and *Reshape+.* Under these two scenarios, the share of private vehicles is expected to drop to 30%. Paratransit is also estimated to decrease to only 1% of the total passenger-kilometres. Active mobility and micromobility, and public transport should maintain their baseline modal share in 2050.

Urban and non-urban passenger transport emissions: Disproportionate outcomes by mode

Passenger travel emissions in North and Central Asia vary widely, depending on the scenarios applied. Under the 2015 baseline scenario, passenger travel contributed 48% of the region's 166 Mt CO_2 equivalent TTW emissions. The majority of the passenger emissions were the result of non-urban travel and this non-urban passenger activity is projected to increase (see Figure 20).

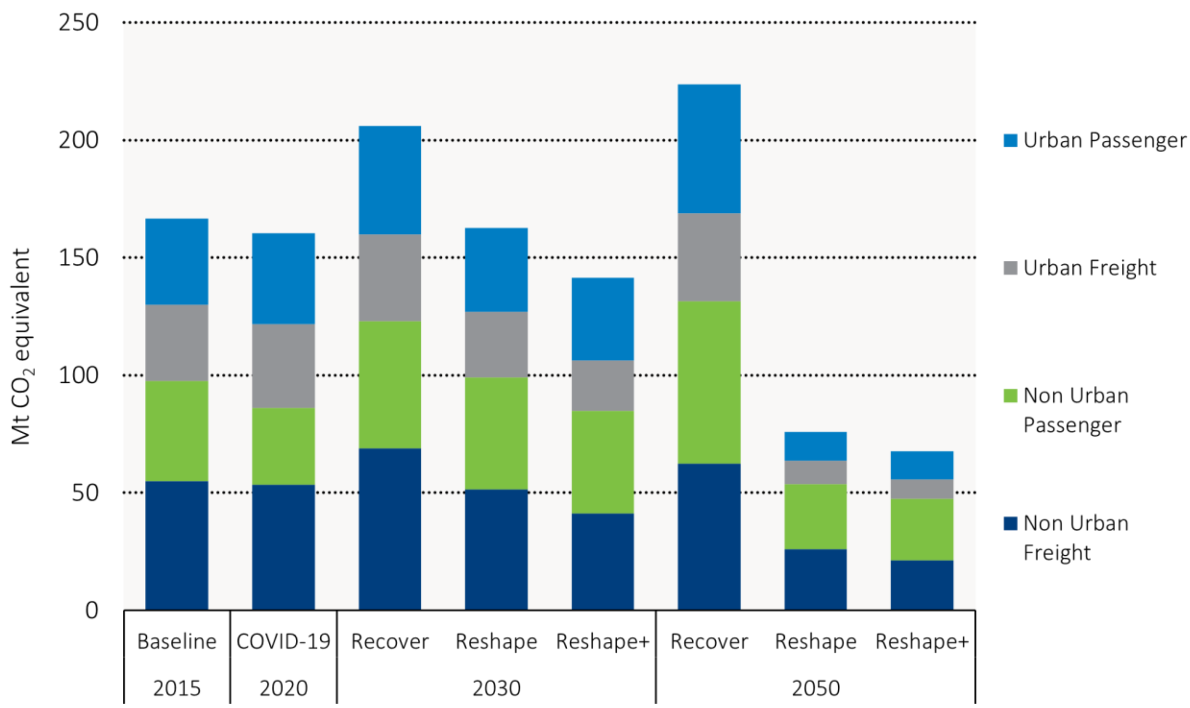
An anomaly to the pattern above occurred in 2020, when non-urban passenger emissions decreased by 22% (Figure 21). Most significantly, there was a 47% reduction in air travel emissions. Road transport was the only mode that increased its associated emissions. However, this growth was much smaller than initially projected and was only 4% higher than 2015 levels.

Looking ahead to 2030 and 2050, it becomes evident that without concerted, focused and ambitious policy interventions total non-urban transport emissions would increase in line with the demand. It is projected that total non-urban emissions will more than double under the business-as-usual *Recover* scenario by 2050. Despite similar demand levels, the impacts of the *Reshape* and *Reshape+* scenarios on emissions are significant compared to *Recover*. Under these two scenarios, non-urban emissions would be lower than the 2015 baseline and even the 2020 levels by 2050.

The environmental impacts of the transport activity greatly differ between the different modes. In the 2015 baseline scenario, air travel accounted for approximately 37% of the non-urban passenger kilometres but was responsible for 57% of the associated emissions. Under all analysed scenarios and for all years, air travel is always responsible for a larger share of the emissions than its activity. Road transport activity, which has the second highest CO_2 emissions, has a similar effect. Despite having a relatively small modal share (ranging between 16% and 22%), it always accounts for at least 35% of the emissions. Rail, which has a significantly larger modal share, contributes much less to overall emissions. The emissions share for rail ranges between 4% and 6% of total emissions in North and Central Asia, despite estimated modal shares between 35% and 44%.

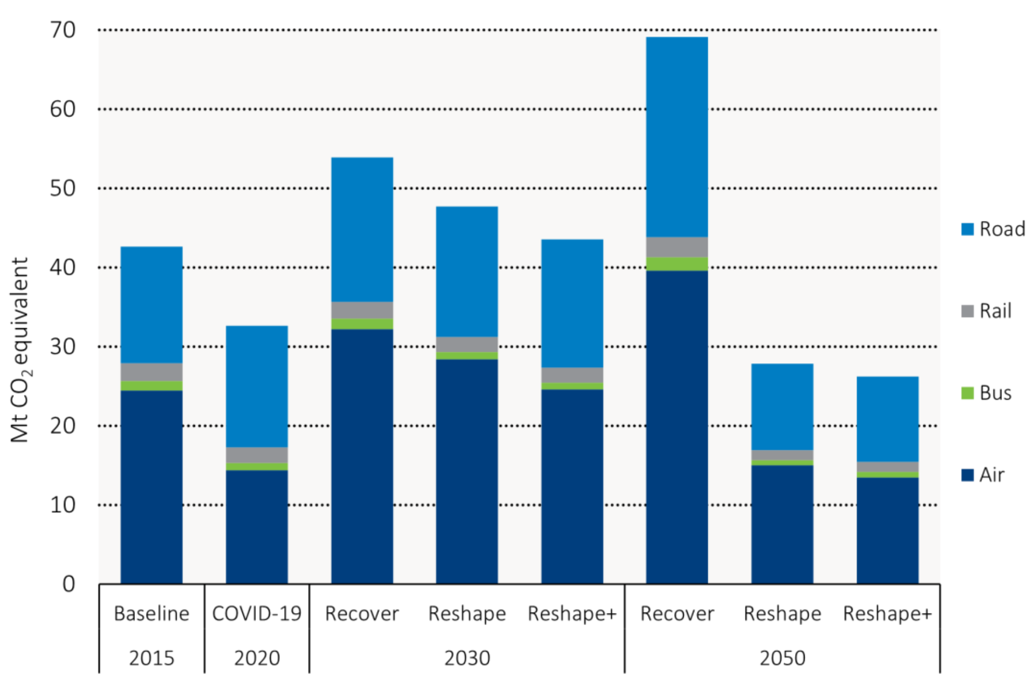
There is also a mismatch between the activity and the emissions associated with different modes at the urban scale (Figure 22). Private vehicle emissions make up the majority of all urban emissions. In the 2015 baseline, the share of private vehicle emissions was 77%. In 2020, the share of private vehicle emissions increased to 85% due to decreased public-transport activity as a result of the pandemic. The private vehicle is projected to continue to account for the lion's share of emissions in coming years, even when there are significant reductions by 2050.

Figure 20. Total tank-to-wheel emissions for freight and passenger transport in North and Central Asia to 2050



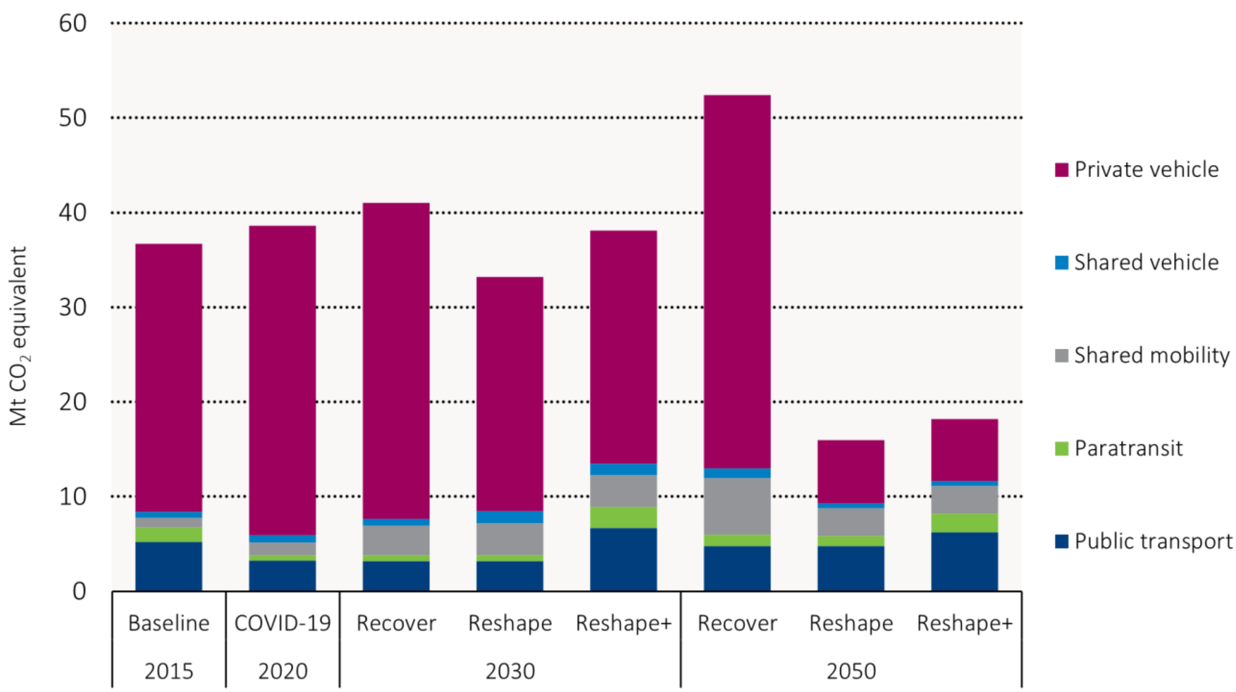
Note: Figure depicts ITF modelled estimates. *Recover*, *Reshape* and *Reshape+*, which refer to the three scenarios modelled, which represent increasingly ambitious post-pandemic policies to decarbonise transport.

Figure 21. Non-urban passenger CO_2 emissions by mode and scenario for North and Central Asia to 2050



Note: Figure depicts ITF modelled estimates. *Recover*, *Reshape* and *Reshape+*, which refer to the three scenarios modelled, which represent increasingly ambitious post-pandemic policies to decarbonise transport.

Figure 22. Urban passenger CO_2 emissions by mode and scenario for North and Central Asia to 2050



Note: Figure depicts ITF modelled estimates. *Recover*, *Reshape* and *Reshape+*, which refer to the three scenarios modelled, which represent increasingly ambitious post-pandemic policies to decarbonise transport. Active mobility and micromobility include walking, biking, scooter-sharing, and bike-sharing. Public transport includes rail, metro, bus, light rail transit (LRT), and bus rapid transit (BRT). Paratransit includes informal buses and three-wheeled public transport. Shared vehicle includes motorcycle and carsharing. Private vehicle includes motorcycles and cars. Shared mobility includes taxis, ridesharing, and taxi buses.

Urban passenger accessibility, affordability and modal dependency

It is critical to better understand the potential accessibility of citizens in urban agglomerations, how costly it is to travel, and whether the system is unduly centred on a particular transport mode. People value how they use a transport system, i.e. their realised mobility, but also the availability of alternatives, even if they are not chosen. An urban transport system where travelling is too costly in monetary or temporal terms, and where it is only possible to easily access opportunities if you use a particular transport mode will likely create unequitable outcomes and negatively impact the well-being of citizens.

Three different indicators were developed for the urban passenger model: a proxy for geographic accessibility, mobility affordability and systemic modal dependency (Box 1). The aim is to establish how easily the city space can be accessed geographically while also highlighting whether this access is likely to depend on a single mode and whether the access is affordable.

The urban analysis of this study relied on functional urban areas (FUAs). Using population density and commuting patterns, the FUA defines the metropolitan regions around densely populated cities whose labour market is highly integrated in a consistent manner worldwide (Dijkstra, Poelman and Veneri, 2019).

Box 1. Urban Passenger Indicators

Measuring geographic access

The methodological approach for measuring access to the city is a proxy measure that estimates the time to reach an equivalent radius of the functional urban area (FUA) from the centre. The indicator is calculated as follows:

$$Time\ to\ edge = \frac{r_{eq}}{\bar{s}} = \frac{r_{eq}}{\sum t_i \cdot s_i / \sum t_i}$$

where r_{eq} is the equivalent radius of the FUA and $\bar{s}$ is the weighted average travel speed for that particular city. $\bar{s}$ is given by weighing the average speed (s_i) by any mode i, by the number of trips in a day by that same mode (t_i).

This proxy measure is used because it was impossible to measure the accessibility to opportunities in the different analysed cities because of data limitations. Namely, given the scale of the model, the distribution of opportunities within each of the cities was not available.

Measuring mobility affordability

The methodological approach for measuring transport affordability in this report is an indicator that estimates the cost of the average mobility as a share of the GDP per capita. The following formula represents the indicator structure:

$$Affordability = \frac{\sum pkm_i \cdot c_i / \sum pkm_i}{GDP_{capita}}$$

where pkm_i is the total number of passenger-kilometres travelled per year by mode i and c_i is the associated average cost of travelling a km by this mode. It is estimated based on 330 days of travel per year.

Measuring systemic modal dependency

This report's methodological approach for measuring modal dependency is an entropy-based measure that indicates the diversity and viability of modal alternatives. The following formula represents the indicator structure:

$$EI = -\sum_{i=1}^{k} \frac{p_i \cdot \ln(p_i)}{\ln(k)}$$

where p_k is the proportion of the total realised mobility performed with the k^{th} transport mode type. In this study, available modes are grouped into five categories (k = 5) of transport modes: non-motorised (including micromobility), private vehicles (including but not limited to cars), shared motorised, heavy public transport (i.e. trains, metros/subways, trams, bus rapid transit), light equivalent public transport.

The index measures the "viable transport alternatives" available to travel in a particular city based on the current conditions and the estimated mobility and mode choice. It is an application of the entropy index used to measure land-use mix developed by Potoglou and Kanaroglou (2008), based on Cervero and Kockelman (1997). 0 represents a dependency on a single transport mode, and 1 represents a uniform distribution between the transport modes.

North and Central Asia FUAs were grouped into four categories based on their population size: (1) small cities with populations below 100 000, (2) medium-sized cities with populations ranging between 100 000 and 300 000, (3) medium-to-large cities with populations between 300 000 and 1 million, and (4) large cities with populations above 1 million inhabitants. The population of cities is not static. The ITF modelling framework includes a population sub-model that estimates population trends (growth or reduction). As a result, the cities included in each of the four categories change over time. The same city may be in different groupings in different years if population changes have been sufficiently large.

In terms of geospatial accessibility to the city, the smallest cities (fewer than 100 000 inhabitants) improve their public-transport travel times the least, gaining almost two and half minutes. This is expected given the scale of the cities. Less populated cities tend to have a smaller geographic scale, and the potential gains are therefore more limited. The remaining cities gain more than ten minutes in their public-transport travel times on average. Cities between 300 000 and 1 000 000 inhabitants in the sub-region would gain the most in public-transport accessibility from the more ambitious *Reshape+* policies. A full description of these policies can be found in Annex B, including transit-oriented development, public-transport prioritisations, and service improvements.

Private vehicle travel times are expected to be minimally but negatively impacted. They are projected to remain fairly constant in North and Central Asia for the four types of urban agglomerations ranging from small to large cities. Cities with populations between 300 000 and 1 000 000 inhabitants would be the cities where private vehicle travel times would increase the most Still, the change in travel times would remain below two minutes by 2050. The changes are never expected to exceed one minute in the remaining city types.

Figure 23. Improvement of public-transport travel times to reach the city limits from the centre in 2050 under the *Reshape+* scenario compared to the *Recover* scenario in North and Central Asia

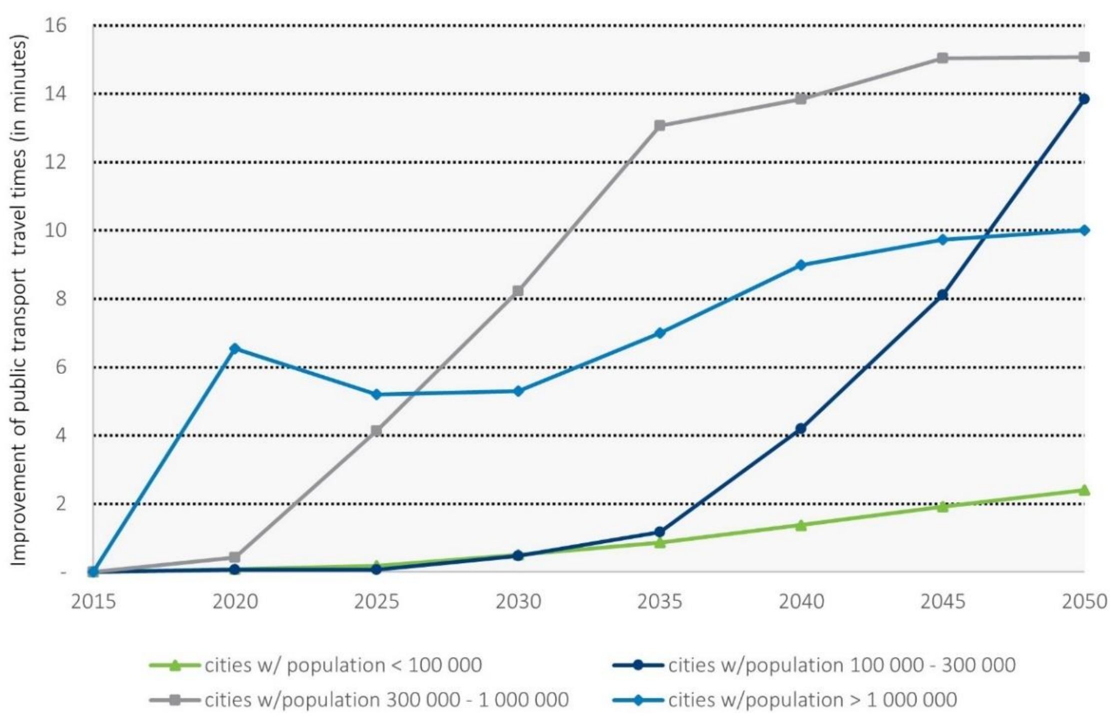


Figure depicts ITF modelled estimates. *Recover* and *Reshape+*, which refer to two scenarios modelled. *Reshape+* represents more ambitious post-pandemic policies to decarbonise transport.

The expected improvements in public-transport travel times with only negligible impacts on the sub-region's private vehicle travel times are a very positive omen. This finding is notable because the cities are expected to increase in size proportionally to the population growth. A major reason that this is possible is the low network capacity usage current estimated and projected in the region. Better urban policies are expected to decrease congestion[3] over time.

On average, the proportion of the network capacity is never above 20% and by 2050 it would be below 5%. While the results highlight that congestion is not a glaring problem in the region, this is still an important indicator for the liveability of cities. Congestion has many negative externalities that the most disadvantaged groups in society often bear. These results also highlight the importance of focusing urban investments towards public-transport development and not towards infrastructure improvements related to road expansions. The road network is currently well below its capacity and is expected to remain well within its capacity range in the coming decades.

Furthermore, the urban transport systems of North and Central Asia are not particularly reliant on a single mode. The average modal dependency is in line with the rest of the world. There are no significant differences in the modal dependence among the three scenarios analysed. Over the analysed time frame the changes to modal dependence are much more significant, becoming slightly more diverse under all scenarios by 2050. This is particularly visible in the largest cities, where the entropy index is expected to increase by approximately 13% in cities with over 1 000 000 inhabitants. In these largest cities, travel is expected to become significantly less affordable by 2050.

Conclusions and policy insights

Transport will continue to be a critical sector for any well-functioning society able to achieve sustainable goals in North and Central Asia. One of the sub-region's notable collective challenges will be to improve its citizens' well-being while addressing decarbonisation to meet the countries' Paris Agreement goals. The efficient movement of people and goods within cities, across regions, and between countries is vital to decarbonising transport as the sub-region experiences population and economic growth over the next 30 years. These growth trends will accompany an increase in urbanisation as cities become larger and higher shares of people begin living in them.

There have been significant disruptions and restrictions in the flow of people and goods due to the Covid-19 pandemic. Landlocked countries and regions that were more reliant on overland border crossings were significantly more impacted by the sanitary measures put in place at a global level to limit the spread of Covid-19. However, there were also some opportunities in addition to these negative impacts. Many planned changes of practices or in the process of changing were accelerated in the sub-region. Soft measures and procedures implemented during the pandemic, including increased digitalisation, can have significant economic and environmental impacts in the long term.

The policy directions and the measures implemented in the coming years will broadly define the decarbonisation trends of the following decades. This section highlights this report's main insights for policy makers to support the sub-region's decarbonisation efforts.

Improve connectivity without increasing carbon intensity

Connectivity continues to be a policy priority for many North and Central Asia governments. Improved connectivity has historically been coupled with higher carbonisation, therefore, it is essential to decouple carbonisation and improved connectivity as trade continues to grow in the region. Lower costs and temporal improvements have tended to encourage more and further travel. As the transition to a more decarbonised world occurs, it is vital that economic growth does not come with an excessive environmental cost. Further carbonisation will likely result in significant negative consequences for the sub-region’s population and counterbalance the positive outcomes sought by better connectivity.

Transport demand was reduced in the sub-region during the pandemic. However, this period of decline is expected to be followed by significant growth in the coming decades. In all analysed scenarios, the tonne-kilometres in the sub-region would be at least twice as high as in 2015. Even when considering a more decarbonised world under the *Reshape* and *Reshape+* scenarios, freight demand is expected to be even higher than in the business-as-usual *Recover* scenario. In particular, the growth under the *Reshape* scenarios would accelerate after 2030. Therefore, the economic and transport pandemic recovery must be aligned with sustainable development goals to ensure this growth is environmentally sustainable.

Target regional linkages and sustainable growth in connectivity strategies

Regional development is an indispensable component to sustainable growth in North and Central Asia. The sub-region faces inherent global connectivity disadvantages due to its vast distances and many landlocked countries. In particular, the implementation of carbon pricing and taxes, and other distance-based measures in global markets will impact low connectivity regions like North and Central Asia to a greater extent than well-connected regions since the cost to reach global markets is likely to increase. Therefore, increasing regional connectivity and trade regionalisation to minimise these additional costs will be crucial to mitigate geographical challenges.

North and Central Asia has a corridor-based approach to transport development due to its geographical position and many countries' landlocked nature. The sub-region's countries often serve as transit between East Asia and Europe. As distance-based charges increase in the coming years, transport infrastructure investment should not encourage transit traffic. Transport policy should advance the connectivity of the sub-region's economy to the rest of the world, particularly connectivity between the countries that make up the sub-region. Relying less on transport transit operations and further regionalising trade will improve the resiliency of the region, potentially reducing the local impacts of foreign crises on the countries in North and Central Asia. Trade regionalisation and increased regional connectivity would provide the basis for more sustainable trade and assist in the decoupling of improved connectivity and carbonisation.

Complement connectivity improvements with initiatives to decarbonise fuel production and energy sources

Policies that decrease the environmental impact of road transport are essential as North and Central Asia governments encourage economic growth to improve the well-being of their citizens and meet decarbonisation ambitions.

The sub-region relies heavily on inland transport and the share of road-based emissions is much higher than road-based activity in both urban and non-urban environments. The sub-region must prioritise regional connectivity while more efficiently accessing markets worldwide to decarbonise successfully. Effective regional policies could reduce total transport emissions by almost 60% by 2050. This will entail infrastructure development, fleet renewal, fuel efficiency standards and improved multimodal operations. Truck and vehicle fleets should be renewed, stringent fuel economy standards should be enacted, and new technologies, including electrification of segments of these fleets, should be considered.

These measures would ensure that less-polluting vehicles are used in the sub-region, thus reducing the tank-to-wheel emissions associated with transport activity. However, this is not the only policy lever available to policy makers in the region. There is also an excellent opportunity for the sub-region to leverage their rich energy resources to address the emissions associated with the well-to-tank component of energy production and consumption. The sub-region can maximise the transport sector's decarbonisation by combining energy and transport operations measures.

Prioritise service improvements and land-use development that encourages public-transport use

Transport impacts go well beyond CO_2 emissions in cities. Exposure to local pollutants, particulate matter, and other transport externalities like noise are complex issues that significantly impact citizens' well-being and health (e.g. Feigin et al., 2016; Munzel et al., 2021). Additionally, transport infrastructure allocation and use in urban areas is fraught with tensions, and these decisions significantly impact the accessibility that the system provides and limits how citizens travel in cities (ITF, 2022a).

Focusing on more inclusive transit-oriented-development and encouraging land-use development that encourages walkability at the local level while maintaining accessibility to opportunities through public-transport development will create fairer outcomes for travellers representing the growing demand for transport. Notably, results show that it is possible to significantly improve the accessibility provided by the public-transport system in the sub-region by reducing associated travel times without significantly impacting the accessibility of private vehicles.

Ensure urban mobility is affordable in North and Central Asia's largest cities

The affordability of urban mobility in North and Central Asia should remain reasonably stable over the coming decades in all but the largest cities. In cities with populations above 1 000 000 inhabitants, mobility is expected to become less affordable as the average cost of travelling, based on the expected modal division, will grow faster than the GDP per capita. The affordability in these cities by 2050 is expected to be two-times lower than the 2015 baseline under the *Recover* scenario. The impacts on transport affordability in both *Reshape* scenarios should be smaller, but urban mobility is still expected to become less affordable overall. It is concerning that urban mobility will become less affordable in these larger cities, given that more people in the sub-region will live there in the coming decades.

Encouraging public-transport development and transport policies that provide citizens with sufficient feasible transport alternatives, including active mobility and other rising micromobility alternatives, will be essential to combat this potential decrease in affordability.

Notes

1 The UNESCAP North and Central Asia sub-region includes Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, the Russian Federation, Tajikistan, Turkmenistan and Uzbekistan.

2 The assessment provided in this report draws on data and projections that were established prior to the war in Ukraine. Any potential impacts of the war, such as on trade, passenger activity, infrastructure connections and border crossings, are therefore not considered.

3 Here congestion is measured as a proportion of the network capacity consumed on average during a day.

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Annex A. ITF Transport Outlook 2021 modelling scenarios: *Recover*, *Reshape*, *Reshape+*

The following text was taken from the ITF Transport Outlook 2021, (OECD/ITF, 2021, p.55-56). The modelling results for the present report were based on the scenarios described below.

The *Recover, Reshape* and *Reshape+* scenarios assess the impacts of different policy pathways on global transport demand, greenhouse gas emissions (reported as CO_2 equivalents), local pollutant emissions, accessibility, connectivity and resilience (depending on the sector) up to 2050. The emissions are based on transport activity and do not include emissions from vehicle production or construction and operation of transport infrastructure.

The three scenarios represent increasingly ambitious efforts by policy makers to decarbonise the transport sector while also meeting the United Nations Sustainable Development Goals (SDGs). All scenarios account for the Covid-19 pandemic by including the same baseline economic assumptions for the pandemic's impacts. Uncertainty surrounds its economic fallout, the behavioural shifts it may trigger, and the extent to which it will affect transport supply and travel patterns both in the long and short term. The ITF models use middle of the road assumptions that lie somewhere between the most optimistic and most pessimistic forecasts available at the time of modelling.

For GDP and trade in 2020, the ITF models assume a drop in all world regions, based on the International Monetary Fund's World Economic Outlook June update (IMF, 2020) and the World Trade Organization's Trade Statistics and Outlook (WTO, 2020) applied to baseline GDP and trade values from the OECD ENV-Linkages model (OECD, 2020). Following years assume the previous country-specific growth rates after 2020. This is approximated by a five-year delay in GDP and trade projections compared to pre-Covid-19 levels from 2020. Assumptions of economic activity and trade are held constant between all scenarios to better compare the true transport policy impact on activity, CO_2 emissions and other outcomes. Air connectivity growth is also adjusted to account for the severity of the pandemic's impact on aviation. For 2020, ITF models assume a drop in flight frequencies and pre-Covid-19 growth rates to meet the projections for 2025 by the International Air Transport Association (IATA, 2020).

In *Recover,* governments prioritise economic recovery by reinforcing established economic activities. They continue to pursue existing (or imminent) commitments to decarbonise the transport sector, predating the pandemic. Alongside these, governments take action with policies that ensure some of the transport trends that hinder decarbonisation observed during Covid-19 revert back to previous patterns by 2030, as a bare minimum. These include reversing trends in greater private car use and reducing public-transport ridership, for example. Changes in behaviour such as reduced business travel or significant shifts to active mobility, which have lowered CO_2 emissions, also revert to pre-pandemic norms by 2030. Due to limited policy action on technology innovation, cost reduction in clean energy and transport technologies does not take place to the extent it could. The *Recover* scenario is an updated version of the Current Ambition scenario in the ITF Transport Outlook 2019, accounting for Covid-19 related changes and policies announced since.

The *Reshape* scenario represents a paradigm shift for transport. Governments adopt transformational transport decarbonisation policies in the post-pandemic era. These encourage changes in the behaviour of transport users, uptake of cleaner energy and vehicle technologies, digitalisation to improve transport efficiency, and infrastructure investment to help meet environmental and social development goals. As in

Recover, the *Reshape* scenario also assumes that transport trends and patterns observed during the pandemic revert to previous patterns by 2030.

In *Reshape+*, governments seize decarbonisation opportunities created by the pandemic, which reinforce the policy efforts in *Reshape.* Measures reinforce changes in travel behaviour observed during the pandemic, such as reducing business travel or encouraging walking and cycling. Some of these policies are fast-tracked or implemented more forcefully than in *Reshape*. The scenario assumptions also include pandemic impacts on non-transport sectors that may nevertheless influence transport, for instance, a regionalisation of trade due to near sourcing to improve resilience. Under *Reshape+*, CO_2 emission targets for the transport sector can be achieved sooner and with more certainty and with less reliance on CO_2 mitigation technologies whose efficacy is still uncertain.

The *Reshape* and *Reshape+* scenarios show what is possible with technologies and policies available today, but with increased investments and more political ambition. The policies act additively, meaning that while there are adjustments made for regions, most policies are applied to most regions with some adjustment for regional contexts. Results are not prescriptive in assigning certain combinations of measures to specific regions. The results show what is technically feasible under full implementation. Still, it is recognised that there may be political and financial constraints that require prioritisation of measures depending on local contexts. The policy scenarios show what may happen at a global and regional level under a set of policies to manage transport demand, shift to more sustainable modes, and improve the energy efficiency of vehicles and fuels.

There are many modelling approaches to assess necessary actions for decarbonisation. The ITF models are demand-based and favour a bottom-up approach which starts with potential policy scenarios and evaluates resulting activity and CO_2 emissions. Other useful modelling exercises such as backcasting from a specific goal offers a different set of advantages and drawbacks. Backcasting starts with a goal and works backwards to see where demand and technologies must be to meet such a goal. The ITF favours the current method over backcasting because it allows for creating the most realistic, and therefore relevant scenarios. The current lack of data available to determine regional and sectoral goals across the globe means that selecting a realistic scenario that reflects the unique constraints of every region is not possible.

Annex B. Freight transport scenario specifications from the ITF Transport Outlook 2021

The following text was taken from the ITF Transport Outlook 2021, (OECD/ITF, 2021, p.184-186). Shading denotes policies with stronger implementation in *Reshape+*.

Measure/ Exogenous factor	Description	*Recover*	*Reshape*	*Reshape+*
Economic Instruments				
Distance charges	Distance based charges for road freight.	Charges introduced in 2030 growing to 1 cent per tonne-kilometre by 2050.	Charges introduced in 2030 growing to 2.5 cents per tonne-kilometre by 2050.	Charges introduced in 2025 growing to 6 cents per tonne-kilometre by 2050.
Port fees	Differentiated port fees depending on environmental performance of vessels, i.e. ships with no clean technologies have higher port fees.	Port fees grow an additional 1% by 2050 decreasing the carbon intensity of shipping by 0.5%.	Port fees grow an additional 20% by 2050 decreasing the carbon intensity of shipping by 10%.	Port fees grow an additional 30% by 2050 decreasing the carbon intensity of shipping by 15%.
Carbon pricing	Pricing of carbon-based fuels based on the emissions they produce.	Carbon pricing varies across regions: USD 150- 250 per tonne of CO_2 in 2050.	Carbon pricing varies across regions: USD 300-500 per tonne of CO_2 in 2050.	
Enhancement of infrastructure				
Rail and inland waterways improvements	Increase in attractiveness of intermodal solutions, namely trips with a rail or inland waterway component.	The penalty for mode transfers at intermodal terminals is decreased and alternative specific constant of rail and inland waterways increases. The rate of change varies by world region, e.g. in Western Europe it grows from 2% in 2020 to 20% in 2050.	The penalty for mode transfers at intermodal terminals is decreased and alternative specific constant of rail and inland waterways increases. The rate of change varies by world region, e.g. in Western Europe it grows from 4% in 2020 to 40% in 2050.	The penalty for mode transfers at intermodal terminals is decreased and alternative specific constant of rail and inland waterways increases. The rate of change varies by world region, e.g. in Western Europe it grows from 10% in 2020 to 80% in 2050.
Transport network improvement plans	Construction and upgrade of new infrastructure, e.g. new roads, railways or port expansion.	The transport network is updated with planned new infrastructure and upgrades (e.g. increases in port capacity, developments in Central Asia, TEN-T European projects) expected to become operational between 2020 and 2050.		
Energy transition for long-haul heavy-duty road freight vehicles	Includes a range of solutions to achieve zero emissions for long haul heavy duty road vehicles, including: Electric Roads (ERS), hydrogen fuel cells, advanced batteries, or low carbon fuels (for more check (ITF, 2019[1]))	Very low, marginal implementation	14% of heavy trucks tkm are on these systems by 2050. Costs begin higher than conventional fuels but by 2050 become lower. Differences in uptakes and costs by regions.	37% of heavy trucks tkm are on these systems by 2050. Costs begin higher than conventional fuels but by 2050 become lower. Differences in uptakes and costs by regions.

Measure/ Exogenous factor	Description	*Recover*	*Reshape*	*Reshape+*
Operations management				
Asset sharing and the Physical Internet	Sharing assets (e.g. vehicles or warehouses) to make resource management for logistics activities more efficient.	Less than 1% Increase in average loads of road freight by 2020 growing to 2% in 2050.	4% Increase in average loads of road freight by 2020 growing to 10% in 2050.	Less than 4% Increase in average loads of road freight in 2020 growing to 20% in 2050. Accelerated increase between 2020 and 2030.
Regulatory instruments				
Slow steaming and speed reduction for maritime and trucks	Reduction of the average speed of ships or trucks to reduce emissions.	Decrease in the speed of road and maritime transport is less than 1% in 2020, growing to a 10% decrease by 2050.	Decrease in the speed of road and maritime transport is 1% in 2020, growing to a 20% decrease by 2050.	Decrease in the speed of Road and Maritime modes by more than 1% in 2020, growing to a 33% decrease by 2050.
Fuel economy standards for internal combustion engine (ICE) vehicles and fuel	Increase in fuel efficiency of ICE road freight vehicles.	Carbon intensity per tkm of ICE trucks reduces by less than 1% in 2020 up to 10% by 2020.		Carbon intensity per tkm of ICE trucks reduces by 2% in 2020 up to 15% by 2020.
Low emission fuel incentives (including electric vehicles) and investment in distribution/supply infrastructure	Increases the share of low emission vehicles km (e.g. electric, hydrogen, clean biofuels, biogas) in commercial vehicle fleets, lowering the average carbon intensity of road freight.	Increases in low emission fuels vehicle shares vary by world-region, in faster adoption regions (e.g. Western Europe) there is an increase of 1% by 2025, growing to 10% by 2050.	Increases in low emission fuels vehicle shares vary by world-region, in faster adoption regions (e.g. Western Europe) there is an increase of 2.6% by 2025, growing to 20% by 2050.	Increases in low emission fuels vehicle shares vary by world-region, in faster adoption regions (e.g. Western Europe) there is an increase of 4% by 2025, growing to 30% by 2050.
Heavy Capacity Vehicles (HCV)	Road vehicles that exceed the general weight and dimension limitations set by national regulations. Truck loads increase 50% and costs fall 20% per tonne-kilometre where HCVs are adopted.	By 2050 2% of non-urban road freight transport activity (tkm) is done with high capacity vehicles.	By 2050 5% of non-urban road freight transport activity (tkm) is done with high capacity vehicles.	By 2050 10% of non-urban road freight transport activity (tkm) is done with high capacity vehicles.
Stimulation of innovation and development				
Autonomous Vehicles and Platooning	Simulates the adoption of autonomous trucks (platooning and full autonomy) in road freight. The adoption of this technology reduces costs for road freight, but also its CO_2 intensity, on the other hand it can induce demand and reverse modal shift.	Adoption varies by sector (urban and non-Urban) and world-region. Very low to marginal adoption in this scenario.	Up to 45% uptake on non-urban in some regions by 2050 (Europe, North America, China, Japan and South Korea). Uptake on urban freight is lower. Decrease of 14% on carbon intensity and 45% on costs.	Up to 90% uptake on non-urban in some regions by 2050 (Europe, North America, China, Japan and South Korea). Uptake on urban freight is lower. Decrease of 14% on carbon intensity and 45% on costs.
Electric/alternative fuel vehicle penetration and increases in efficiency for all transport modes	Electric/alternative fuel vehicle penetration and increases in efficiency for all transport modes (including average loads and vehicle capacity).	Follows the IEA STEPS Scenario.	Follows the IEA SDS Scenario.	

Measure/ Exogenous factor	Description	*Recover*	*Reshape*	*Reshape+*
Intelligent Transport Systems (ITS) and eco-driving	Development of ITS to provide better quality, real-time, automatic data collection and processing to improve fleet management, routing and assist driving.	Implemented with regional variations, in regions with faster deployment (e.g. Western Europe) reductions of 4% in carbon intensity in 2020 and close to zero in 2050.	Implemented with regional variations, in regions with faster deployment (e.g. Western Europe) reductions of 10% in carbon intensity in 2020 and 1% in 2050.	Implemented with regional variations, in regions with faster deployment (e.g. Western Europe) reductions of 15% in carbon intensity in 2020 and close to 2% in 2050.
Exogenous factors				
3D Printing	Enables manufacturing closer to the point of consumption, leading to drop-in long-distance trade for several commodities compared to estimated values, namely manufactured goods.	Negligible impact on trade.	International trade shrinks 10% by 2050. Values differ by commodities, electronic and manufactured goods have higher falls.	
Decarbonisation of energy	Decreases in trade and consumption of oil and coal as societies decarbonise, directly impacting freight transport demand for fossil fuels.	Oil and Coal grow less than other commodities (following ENV-Linkages model (ENV-OECD), (Chateau, Dellink and Lanzi, 2014)	Yearly decrease of 3.35% for coal and 2.1% for oil. By 2050 coal trade has reduced 65% and oil close to 50%, compared to 2020 estimates.	Yearly decrease of 10% for coal and 2.1% for oil. By 2050 coal trade has reduced by 96% being almost phased-out globally and there is close to a 50% decrease in oil consumption compared to 2020 estimates.
Trade regionalisation	Simulates increased trade exchanges within regions or trade blocks, while decreasing longer distance trade between regions.	No additional fees compared to baseline.		5% increase in penalty fees for intra-regional trade.
E-commerce	Simulates the impact of growth in e-commerce and home deliveries. Increases the estimated demand of goods over time in addition to the projected values.	Urban freight with an additional 5% demand increase by 2050, smaller impacts on non-urban freight.		

Note: There is an overlap between the "Energy transition for long-haul heavy-duty road freight vehicles", "Low emission fuel incentives (including electric vehicles) and investment in distribution/supply infrastructure" and "Electric/alternative fuel vehicle penetration" measures. But they apply differently to different regions of the world and vehicle types, the adoption rate implemented in the scenario matches the highest value between these three measures for each world region and vehicle type/operation.

Source: ITF (2021, p.184-186).

Annex C. Urban passenger transport scenario specifications from the ITF Transport Outlook 2021

The following text was taken from the ITF Transport Outlook 2021, (OECD/ITF, 2021, p. 93-95). Shading denotes policies with stronger implementation in *Reshape+*.

Measure/Exogenous factor	Description	*Recover*	*Reshape*	*Reshape+*
Economic instruments				
Carbon pricing	Pricing of carbon-based fuels based on the emissions they produce.	Carbon pricing varies across regions: USD 150-250 per tonne of CO_2 in 2050	Carbon pricing varies across regions: USD 300-500 per tonne of CO_2 in 2050	
Road pricing	Charges applied to motorised vehicles for the use of road infrastructure.	0% to 7.5% increase of non-energy related car use costs by 2050, half for motorcycles.	2.5% to 25% increase of non-energy related car use costs by 2050, half for motorcycles.	
Parking pricing and restrictions	Regulations to control the availability and price of parking spaces for motorised vehicles.	5% to 50% of a city area subject to parking constraints, and 0% to 60% increase in parking prices by 2050.	7% to 75% of a city area subject to parking constraints and 20% to 150% increase in parking prices by 2050.	
Enhancement of Infrastructure				
Land-use planning	Densification of cities.	Density variation of -10% to +20% for the city centre of urban areas over 300 000 inhabitants. Density variation of -10% to +10% for cities under 300 000 inhabitants and for suburbs of urban areas over 300 000 inhabitants.	Density variation of 0% to +40% for the city centre of urban areas over 300 000 inhabitants. Density variation of 0% to +20% for cities under 300 000 inhabitants and for suburbs of urban areas over 300 000 inhabitants.	
Transit-Oriented Development (TOD)	Increase in mixed-use development in neighbourhoods around public transport hubs.	Increases the land-use diversity mix and increases the accessibility to public transit by 5% by 2050.	Increases the land-use diversity mix and increases the accessibility to public transit by 7.5% by 2050.	Increases the land-use diversity mix and increases the accessibility to public transit by 10% by 2050.
Public transport priority measures and express lanes	Prioritising circulation of public transport vehicles in traffic through signal priority or express lanes.	0% to 40% of bus, light rail transit and bus rapid transit network prioritised by 2050.	10% to 60% of surface public transport network prioritised by 2050.	
Public transport service improvements	Improvements to public transport service frequency and capacity.	-10% to +10% service improvement for rail or corridor based public transport systems resulting in a -1% to +1% speed variation by 2050. 10% to 30% service improvement for bus and paratransit transport systems resulting in a 0.25% to 0.7% speed variation by 2050.	10% to 15% service improvement for rail or corridor based public transport systems resulting in a 1% to 1.5% speed variation by 2050. 20% to 50% service improvement for bus and informal public transport systems resulting in a 0.5% to 1.25% speed variation by 2050.	
Public transport infrastructure improvements	Improvements to public transport network density and size.	0% to 100% growth increase for the public transport network by 2050.	0% to 200% growth increase for the public transport network by 2050.	

Measure/Exogenous factor	Description	*Recover*	*Reshape*	*Reshape+*
Integrated public transport ticketing	Integration of public transport ticketing systems.	1.5% to 4.5% reduction of a public transport ticket cost, and 2.5% to 7.5% reduction of public transport monthly subscription cost by 2050.	1.5% to 7.5% reduction of a public transport ticket cost, and 2.5% to 12.5% of public transport monthly subscription cost by 2050.	
Bike and Pedestrian infrastructure improvements	Increase in dedicated infrastructure for active mobility.	20% to 300% increase in road space available to active modes by 2050 and a simultaneous increase in the speed of active modes, including micromobility	40% to 500% increase in road space available to active modes by 2050 and a simultaneous increase in the speed of active modes, including micromobility.	50% to 600% increase in road space available to active modes by 2050 and a simultaneous increase in the speed of active modes, including micromobility.
Speed limitations	Traffic calming measure to reduce speed and dominance of motor vehicles through low-speed zones or infrastructure.	2% to 30% reduction of speed on main roads, by 2050	5% to 50% reduction of speed on main roads, by 2050	
Regulatory instruments				
Urban vehicle restriction scheme	Car restriction policies in certain areas and during certain times to limit congestion. Typically applied in the city centre.	0% to 17.5% reduction of car ownership by 2050, Reduction of the car and carsharing speeds while increasing the car and motorcycle access time.	3.5% to 25% reduction of car ownership by 2050, Reduction of the car and carsharing speeds while increasing the car and motorcycle access time.	
Low-emission vehicles incentives and infrastructure investment	Financial incentives for the purchase and use of alternative fuel vehicles and investment in charging infrastructure.	Decreases average vehicle-kilometres made with diesel, gasoline and methane fuels between 0% and 4% by 2050.	Decreases average vehicle-kilometres made with diesel, gasoline and methane fuels between 0% and 36% by 2050.	Decreases average vehicle-kilometres made with diesel, gasoline and methane fuels between 0% and 45% by 2050.
Stimulation of innovation and development				
Electric/alternative fuel vehicle penetration	Degree of uptake of electric/alternative vehicles in an urban vehicle fleet	Follows the IEA STEPS Scenario	Follows the IEA SDS Scenario	
Carsharing incentives	Incentives to encourage car rental schemes where members have access to a pool of cars as needed, lowering car ownership	0% to 15% increase in shared car availability per capita, and 0% to 40% increase in shared motorcycle availability per capita, by 2050.	5% to 30% increase in shared car availability per capita, and 10% to 60% increase in shared motorcycle availability per capita, by 2050.	
Carpooling policies	Carpooling policies encourage consolidating private vehicle trips with similar origins and destinations.	3.5% to 8.3% increase in average load factor by 2050.	7.6% to 16.7% increase in average load factor by 2050.	
Ridesharing/shared mobility	Increased ridership in non-urban road transport (car and bus)	25% to 200% increase of ridesharing vehicles per capita growth by 2050. Load factor evolution from -50% to +25% by 2050.	25% to 300% increase of ridesharing vehicles per capita growth by 2050. Load factor increase from 0% to 100% by 2050.	

Measure/Exogenous factor	Description	*Recover*	*Reshape*	*Reshape+*
Mobility as a Service (MaaS) and multimodal travel services	Improved integration between public transport and shared mobility (app integration, as well as physical infrastructure, ticketing and schedule integration). Increase in availability and load factors of shared mobility	1.7% to 10% reduction of a public transport ticket cost, and 1.0% to 6.0% reduction of shared mobility cost by 2050. Increase in the number of shared mobility vehicles and stations	3.3% to 20% reduction of a public transport ticket cost, and 2.0% to 12.0% reduction of shared mobility cost by 2050. Significant increase in the number of shared mobility vehicles and stations	
Exogenous factors				
Autonomous vehicles*	Introduction of vehicles with level 5 autonomous capabilities	The percentage of autonomous vehicles in use varies across regions: for car 0% to 3%, for bus 0% to 1.5%, for shared vehicles 0% to 6%.		
Teleworking	Reduces business and commuting trips, while increasing short non-work trips.	2.5% to 20% of the active population could telework by 2050.	3.5% to 30% of the active population could telework by 2050.	5% to 40% of the active population could telework by 2050.

Note: Range of values reflect the varying degrees of implementation of policy measures across the different world regions in each scenario. Unless otherwise specified, a % change indicates an alteration of a certain variable in a given year compared to the absence of a policy. For example, PT ticket costs are endogenously calculated for each city and year by the model, indexed to GDP, assuming no policy action. An X% decrease would be applied to the ticket price of the specific city and year.* Autonomous vehicles are considered but are not a primary factor in any of the scenarios. All scenarios assume a constant level of introduction of vehicles with Level 5 autonomy. The *ITF Transport Outlook 2019* focussed more specifically on transport disruptions, including autonomous vehicles, and assessed related scenarios.

Source: extract from ITF (2021) Transport Outlook 2021, Table 3.3, p. 93-95.

Annex D. Non-urban passenger transport scenario specifications from the ITF Transport Outlook 2021

The following text was taken from the ITF Transport Outlook 2021, (OECD/ITF, 2021, p. p.142-144). Shading denotes policies with stronger implementation in *Reshape+*.

Measure/Exogenous factor	Description	*Recover*	*Reshape*	*Reshape+*
Economic instruments				
Ticket taxes (air travel)	Percentage tax applied on the cost of airfare	Ticket taxes vary across regions: 3% - 15% in 2050	Ticket taxes vary across regions: 8% - 30% in 2050	
Carbon pricing	Charges applied on tailpipe CO_2 emissions	Carbon pricing varies across regions: USD 150-250 per tonne of CO_2 in 2050	Carbon pricing varies across regions: USD 300-500 per tonne of CO_2 in 2050	
Enhancement of infrastructure				
Development of ultra-high-speed rail	Introduction of new ultra-high-speed rail routes, such as Maglev	No development of new ultra-high-speed rail	Development of Maglev routes where economically feasible	
Improvements in rail infrastructure	Investments in existing rail infrastructures leading to frequency and speed increases	Frequency increases by 50% (year of improvement varies across regions)	Frequency (50%) and speed (20%) improvements across regions	Earlier frequency (50%) and speed (20%) improvements across regions
Regulatory instruments				
Synthetic fuels (aviation)	Decrease of synthetic aviation fuel cost relative to conventional fuel as a result of technological developments	Synthetic fuels cost is 3.3 times more expensive than conventional fuel	Synthetic fuels cost is three times more expensive than conventional fuel	
Mandates in aviation for sustainable aviation fuels (SAF)	SAF should constitute a minimum percentage of total fuel used	Minimum SAF percentage varies across regions 5% - 10% in 2050	Minimum SAF percentage varies across regions 10% - 25% in 2050	Minimum SAF percentage varies across regions 15% - 30% in 2050
Operational instruments				
Optimise aircraft movements	Flights are closer aligned to greater circle paths	Deviations are reduced by 50% in 2030	Deviations are reduced by 50% in 2020	
Simulation of innovation and development				
Electric/alternative fuel vehicle penetration	Increased penetration of electric vehicles in non-urban road transport due to financial incentives for the purchase and use of alternative fuel vehicles and investment in charging infrastructure.	Follows the IEA STEPS Scenario	Follows the IEA SDS Scenario	Increased penetration on top of IEAs SDS Scenario

Measure/Exogenous factor	Description	*Recover*	*Reshape*	*Reshape+*
Hybrid-electric planes	Development of new hybrid-electric aircraft.	Hybrid-electric aircraft are available from the year 2030. They provide 5% - 7.5% of total energy required reaching up to 20% - 30% in 2050 depending on the region.	Hybrid-electric aircraft are available from the year 2030. They provide 7.5% - 10% of the total energy required reaching up to 30% - 40% in 2050 depending on the region.	
Ridesharing/shared mobility	Increased ridership in non-urban road transport (car and bus)	The percentage of shared trips of total trips by car equals 6.7%	The percentage of shared trips of total trips by car varies across regions 13.3% – 20.0%	
Mobility as a Service (MaaS) and multimodal travel services	Improved integration between different transport modes. Integration of ticketing and increase of intermodal terminals/stations	Switching between different modes is twice as penalising as between the same mode	Switching between different mode is no more penalising than between the same mode	
Improvement in range and cost of all-electric planes	Development of all-electric aircraft	Flying range of all-electric planes increases by 2050 up to 1 000 km Cost of all-electric aviation is 1.5 times that of conventional aircraft	Flying range of all-electric planes increases by 2050 up to 1 500 km Cost of all-electric aviation is 1.2 times that of conventional aircraft	
Exogenous factors				
Autonomous vehicles*	Introduction of vehicles with level 5 autonomous capabilities The percentage of autonomous vehicles in use varies across regions: for car 0% - 2.5%, for bus 0% - 1.25%			
Reduction in long-distance leisure-tourism	Reduced tendency to take long-distance leisure trips as a consequence of Covid-19 pandemic	none	none	Long distance trips are reduced by 15% to 22% (compared to demand without this factor) between 2020 and 2030. The impact reduces linearly reaching 0% in 2050.
Reduction in business travel due to teleconferencing	Replacement of business trips with teleconferencing as a consequence of Covid-19 pandemic	none	none	Air trips are reduced by 12.5% (compared to demand without this factor) between 2020 and 2030. The impact reduces linearly reaching a 2.5% reduction in 2050.
Reduced propensity to fly	Segments of the population avoid flying due to climate considerations	10% - 15% fewer people fly in some regions in 2050	5% - 30% fewer people fly in most regions in 2050	

Note: Range of values reflect the varying degrees of implementation of policy measures across the different world regions in each scenario.

*Autonomous vehicles are considered but are not a primary factor in any of the scenarios. All scenarios assume a constant level of introduction of vehicles with Level 5 autonomy. The *ITF Transport Outlook 2019* focussed more specifically on transport disruptions, including autonomous vehicles, and assessed related scenarios.

Source: extract from ITF (2021) Transport Outlook 2021, Table 4.3, p.142-144.

ITF North and Central Asia Transport Outlook

This report provides scenarios for future transport demand and CO_2 emissions in North and Central Asia up to 2050 to help decision-makers chart pathways to sustainable, resilient transport. The scenarios reflect existing policy initiatives and specific constraints in the region. They also examine the potential impact of policies addressing the challenges and opportunities for transport from Covid-19.

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