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The Social Risks of the Environmental Transition in Transportation

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The Social Risks of the Environmental Transition in Transportation

Abstract

This paper aims to map the social risks of the environmental transition in the transportation sector. Existing literature on the risks related to the environmental transition focuses more on economic risks and damages, while social risks are often overlooked. We attempt to address this gap by providing a cross-cutting literature review of the transport sector, mapping the social risks stemming from the environmental transition: direct risks linked to climate change and indirect risks from the policies aimed at mitigating its impacts. We identify the social risks to answer three questions that are still relatively unexplored: what the social risks are, who these risks affect, and the policies put in place to minimise these social risks.

Keywords: Social risks, transport, climate change, climate mitigation, direct and indirect risks

Introduction

Whether for school, work, visiting family, healthcare, leisure or for accessing goods, transport is an indispensable aspect of every individual's life and on a global scale. Climate change has a profound impact on transport, as weather events and conditions may affect transport infrastructure and walkability, causing disruptions in people's daily lives in terms of transportation of people and goods. At the same time, transport is one of the key contributors to anthropogenic climate change. In fact, the transportation sector accounts for approximately one quarter of all greenhouse gas (GHG) emissions. As transport systems play out and evolve in the context of anthropogenic climate change and the environmental transition, they may exacerbate existing inequalities and vulnerabilities of people.

The environmental transition consists of two parts: On the one hand, it refers to climate change due to human activities. On the other hand, it can also include policies to mitigate GHG emissions, such as net-zero policies. Regarding the first part, climate change occurs when direct or indirect human activity alters the composition of the atmosphere in addition to natural climate variability (United Nations, 1992). More specifically, human-induced GHG emissions result in more frequent and/or severe weather and climate events (Seneviratne, et al., 2021). As for the second part, mitigation is a human intervention to reduce the sources or to increase the sinks of GHGs (IPCC, 2001). In case of net-zero, over 140 countries, responsible for about 88% of global emissions, have pledged to decrease their GHG emissions close to zero, with the rest of it to be absorbed by the atmosphere, forests and oceans (United Nations, n.d.).

Both aspects of the environmental transition may have social consequences in and through transportation, negatively affecting people's lives. In order to analyse them, the concept of "transport poverty" has been used. The European Union refers to transport poverty as the lack of adequate transport services necessary to access general services and work, or the difficulty to pay for those transport services (Kiss, 2022). This definition includes the lack of availability, accessibility or affordability of transport, too much time spent for commuting, and inadequate transport conditions (ibid.).

Despite combining a number of elements of transport poverty analysed in the wider literature, this approach is limited because it focuses on everyday shortcomings of transport. In our paper, we seek to adopt a more encompassing approach, by going beyond the transport sphere and including other types of vulnerabilities related to the social sphere, also incorporating some elements from the disaster risk literature. In this literature, risk can be defined as the potential losses as a consequence of a particular reason in a given time and place (UNISDR, 2009). Originally a social security-related term, the notion of "social risk" has increasingly been applied to environmental problems and, more specifically, to natural disasters as well as social exclusion (Lupu, 2019). Following the literature, we define social risk as the vulnerabilities and adverse outcomes in terms of income and well-being that affect individuals and groups of people as a result of the environmental transition, and which may result in exacerbating inequalities. Thus, social risks include, but are not limited to: physical harms (to the human body, e.g. transportation accidents, threats to human health); damage to infrastructures (used by humans, that can

lead to material losses and physical harms); economic losses (e.g. on an individual level such as loss of income or jobs, and on a more global level such as halts in supply chains).

We identified two types of causes for these social risks, in line with Beaussier et al.'s (2024), namely “direct” and “indirect” risks. Direct risks relate to the first part of the environmental transition and include extreme climate and weather events. Indirect risks relate to the second part of the environmental transition and encompass risks from climate change mitigation policies. We will look at these risks by focusing on transportation systems and people working in or affected by transport.

The existing literature does not seem to focus on the social risks (as we define them) of the transport sector related to the environmental transition. We aim to fill this gap by using an encompassing mapping approach. This paper will attempt to answer the following questions: *What are the social risks of the environmental transition in the transport sector? Which groups are most affected by these social risks?* In order to answer these questions, we conduct a review of the existing literature to identify what has already been said and done, as well as exploring what policy solutions are being implemented to better manage these social risks. In this literature review, we choose to focus on research covering developed countries¹.

To do this, we break down our analysis into different transport modes - *maritime, aviation, road transport, public transport and active travel* - and different purposes - *passenger travel and freight transportation*. We also develop an analytical framework to assess the risks of the environmental transition by considering three *risk profiles* - *transport passengers, transport workers, and freight consumers* - and two *risk sources* - *climate and weather events (direct risks) and climate mitigation policies (indirect risks)*.

The paper is structured in four sections. The first section, *Conceptualising the Transport System*, provides an overview and introduces our frameworks. The second section, *What are the Transport-related Risks of the Environmental Transition?*, introduces the two different types of risks (direct and indirect) and explains how they are relevant for different modes of transport and different policies. Our third section, *Who is at risk?*, examines and maps how these two types of risks may affect individuals from various socio-economic, geographic and demographic profiles and characteristics. The fourth section, *How to manage these social risks?*, discusses policies to mitigate the two types of social risks to provide an assessment of them from the literature. The last section concludes.

I. Conceptualising the Transport System

In this section we establish a framework with two dimensions to better understand and identify social risks within the transport system. Conceptualising i) transport modes and purposes and ii) risk profiles will allow us to elaborate on the social risks to people in sections II and III.

¹ This literature review stems from a collective work of students done in the context of the class “Mapping the social risks of environmental transitions” from Anne-Laure Beaussier, Tom Chevalier and Bruno Palier.

1.1. A Framework for Transport Modes and Purposes

We conceptualise transportation systems by dividing them into five modes: (i) Maritime, (ii) Aviation, (iii) Road Transportation, (iv) Public Transport, (v) Active Travel. Maritime encompasses all travel on water, both at sea and on inland waterways, while aviation encompasses all airborne travel. For land-based travel, we distinguish between private road transportation, public transport and active travel. This paper uses the term ‘road transport’ to refer to any travel where the vehicle is owned by the passenger, their friends/family or someone they work for. Therefore, private road transportation includes private cars, light vehicles, motorised two- or three-wheelers, but also heavy trucks. This is distinct from public transport where the vehicle provides a shared transport service open to a variety of, generally paying, customers. This includes railways, whether for passengers or freight, as well as buses. Lastly, we define active travel as a self-propelled, human-powered mode of transportation (Georges & Hubsmith, 2012, p. 4), such as walking, cycling, roller-blading, or kayaking. This also includes micro-mobility, which focuses on lightweight electrically-assisted vehicles, such as e-bikes or electric scooters (McCamy, 2022).

Each transport mode can be used for two broad purposes - transportation of people (passenger) and transportation of goods (freight). Some examples of how each mode of transport can be used for passenger and freight transportation are given below in Table 1.

Table 1 - Examples of Transport Modes and Purposes

Transport Mode	Transport Purpose	
	<i>Passenger</i> Transportation of people	<i>Freight</i> Transportation of goods
Maritime	Tourists on cruise ships, ferries	Seafarers transporting containers via cargo ships, bulk carriers
Aviation	Workers on business trips, holiday makers travelling internationally	Highly perishable goods or same-day delivery packages from Amazon
Road Transportation	Commuters driving cars	Long-distance trucks delivering goods between states
Public transport	Local commuter buses, trams, subways	Long-distance freight trains
Active Travel	Short-distance commuters (mainly walkers and cyclists)	Short-distance deliveries via micro mobility

These distinctions between passenger and freight transport purposes and different transport modes provide a crucial analytical frame for mapping the social risks of environmental transitions, which we expand on further below.

1.2. A Framework for Risk Profiles

We provide a general framework for considering which profiles are affected by transport risks, as summarised in Table 2 below. The passenger transport-related risks may be experienced either by the passengers themselves - for example car drivers or public transport riders - or by workers engaged in any element of supplying or operating the transport (e.g., a pilot flying a plane or a manufacturing worker assembling a car). For freight transport, goods rather than passengers are transported, but there will still be transport workers who can be at risk. In addition, risks can be experienced by the end consumers of the freight items - i.e. the individuals or households who are buying the items being transported. Given that different modes of transport are used for different purposes, the three risk profiles will vary in importance across transportation modes.

Table 2 - Transportation Risk Profiles

Risk Profiles	Transport Purpose	
	<i>Passenger</i>	<i>Freight</i>
1. Transport <u>Passengers</u> Those who travel using any given transport mode	Key Modes for Analysis: Road Transport, Public Transport, Active Travel, Aviation, Maritime	
2. Transport <u>Workers</u> Those involved in any element of supplying or operating a given transport mode	Key Modes for Analysis: Aviation, Road Transport	Key Modes for Analysis: Maritime, Aviation
3. Freight <u>Consumers</u> Those who consume the goods delivered by any given transport mode		Key Modes for Analysis: Maritime, Road Transport, Public Transport (Rail), Active Travel, Aviation

In the table, the sections corresponding to the intersection of Travel Passengers and Freight, and Freight Consumers and Passengers are left empty because they are not logically applicable according to our classification. It is important to note that this categorisation of profiles is not exhaustive. It can include, for example, local communities who are affected by industrial transport-related production (like mining activities).

The next section will utilise these two frameworks to discuss the two-fold transport-related social risks.

II. What are the Transport-related Risks of the Environmental Transition?

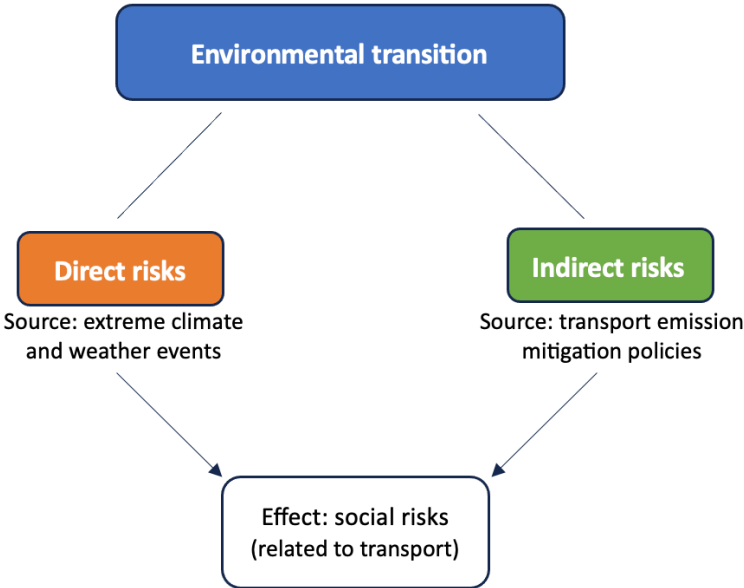
Following Beaussier et al (2024), we have identified two different sources of social risks associated with the environmental transition in the transport sector:

Direct risks stem directly from air pollution and climate change, including extreme climate and weather events, which can cause disruption across multiple transport modes and infrastructures.

Indirect risks stem from climate change mitigation policies that seek to reduce GHG emissions from the transport sector, which can affect the cost and accessibility of transportation.

The diagram below (Figure 1) illustrates the relationship between the environmental transition, the two sources of risk (direct and indirect), and the resulting social risks, in the sense that the two effects are analytically distinct and not necessarily correlated – hence no necessary cumulative effect.

Figure 1 - Diagram showing the relationship between the environmental transition and social risks



Note: For definitions of ‘environmental transition’ and ‘social risks’ see the introduction.
Source: Authors’ design.

The term environmental transition, as defined in the introduction encompasses two definitions that take into consideration both direct and indirect risks. These definitions are reflected in the two sources of risk. The source of direct risks is extreme climate and weather events (as per the first part of the definition of the environmental transition). For indirect risks, the source is the

policies that try to mitigate transport emissions (reflecting the second part of the definition of the environmental transition). Both sources can cause social risks. In this paper, we will only consider the social risks due to or through the lens of transportation.

Risks in each of these types can propagate through the transport system through the three risk profiles noted above - transport passengers, transport workers or freight consumers. Transport-related risks may be experienced by workers and passengers, or by freight consumers. The rest of this section considers each of these sources of risk in turn, considering the profiles that propagate them through the transport system and the implications for Aviation, Maritime, Road Transportation, Active Travel and Public Transport.

2.1. Direct Risks - Stemming from Climate Change

We define direct risks encompassing air pollution, and weather and climate extreme events. Air pollutants are particulate substances that can be emitted by human activities and that can lead to degradation of air quality (Szopa, et al., 2021). Weather and climate extreme events include temperature extremes (such as heatwaves), heavy precipitation, pluvial and river floods, droughts, storms (including tropical cyclones), and compound events (including dry/hot events, fire weather, compound flooding, and concurrent extremes) (IPCC, 2023) (Mills & Andrey, 2002). Climate change may affect the frequency, duration and severity of these elements, leading to extreme weather events, and affecting transport sensitivities (ibid.).

Mills and Andrey (2002) mention several possible implications for transport infrastructure, operations and demand. These include:

- Infrastructure: deterioration or failure of infrastructure, increased maintenance costs, railway track buckling, damage or accessibility risks for low-lying infrastructure (including ports, airports, roads or railway).
- Operations: flight cancellations and reduced rail speed.
- Demand: a possible change in transportation demands due to climate change-induced changing economic/agricultural patterns.

This conceptualisation is useful to understand the vulnerabilities of transport infrastructure caused by direct risks. We complement Mills and Andrey's approach by introducing and including social risks to people.

The next subsections look at the social risks caused by direct risks for each specific mode of transport.

Maritime Transport

The maritime transport sector is vulnerable to several climate hazards. Higher temperatures and rising sea levels, which lead to coastal flooding, can pose a threat to seaport facilities (Torres, et al., 2021; UNCTAD, 2022). Due to rising sea-surface temperatures, tropical cyclones are expected to change significantly in intensity (Bender, et al., 2010; IPCC, 2019). Moreover, bad weather accounted for one in five ship losses in 2019 (Allianz, 2020).

For maritime transport, given its focus on freight transportation, the risk profiles for risks stemming from climate change are mainly workers and consumers. Some effects can also concern passengers during passenger transport (e.g., tourism on cruise ships).

Sea-level rise can cause damage to ports through flooding (Hanson & Nicholls, 2011). Studies have looked at the damage caused to port infrastructures by seawater - including to breakwaters, jetties, cargo, equipment (Agarwala & Saengsupavanich, 2023) - but only some mention risks to people. For instance, extreme winds can endanger berthing operations in ports (UNCTAD, 2022). Waves and winds can also harm vessels and cargo at sea. For instance, bad weather accounted for one in five ship losses in 2019 (Allianz, 2020), and these events can cause spills of dangerous goods. Although the literature mentions direct risks, it only focuses on material effects such as losses of goods and economic losses and not to risks to workers on the ships.

Another risk is interruptions to the daily logistics of maritime transport. Zittis et al. (2023) predict that a combination of tropical cyclones and sea-level rise could decrease operability hours by 66% in northern Spain in ports. If maritime workers, such as dock workers and seafarers, are not protected through insurance and social protection schemes, non-operability can lead to a significant loss of income, resulting in hardships for the workers themselves and their families (ILO, 2022).

Climate changes affecting maritime transport can disrupt global supply chains (UNCTAD, 2022). Consumers might have more difficulties in finding goods or face empty supermarket shelves. The costs of goods can increase, leading to economic hardships (McDonald, 2018). This effect is identified particularly in island communities since they strongly rely on maritime transport for connection with mainland and supply of goods (Zittis, Ahrens, Obermann-Hellhund, & et al., 2023), as demonstrated in the Case Study 1 box (below).

Case Study (Maritime Transport) - Small Caribbean Islands and Inland Canals

Maritime transport in the Caribbean Island Saint Lucia and the Panama Canal provides insights into how climate hazards can put people at risk in different ways. Although the two case studies show a similar causal mechanism - which is adverse climate conditions - they differ in the precise effect that transport disruption has on people.

Saint Lucia

Climate hazards can directly affect port workers and infrastructure. The island's mountainous topography and confined coastal areas make it vulnerable to high winds and storm-induced flooding. Future projections suggest that the northern port, Port Castries (CSP), which lies at 1.5 metres above sea level, could be devastated through flooding of the berths, docks, and surrounding areas. This has already been the case with hurricane Dean in 2007, which damaged the ferry terminal and a berth (UNCTAD, 2018). High winds, heat and precipitation can inhibit crane operations and force operational shutdown (UNCTAD, 2022), posing a threat to port workers who can lose working hours and income.

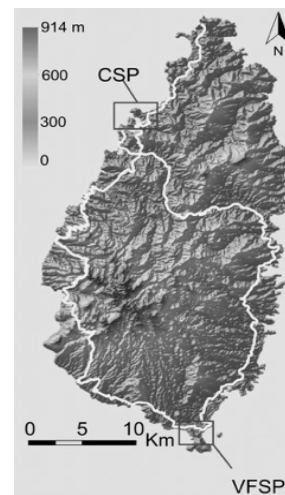
Panama Canal

The Panama Canal transportation system shows how climate hazards can have an indirect effect on people, including disruption to the supply of goods. The Panama Canal is one of the world's most important shipping nodes. The ships that pass through the canal are elevated by a water bridge that uses millions of gallons of freshwater coming from two lakes (Rosales, 2015). A drought in 2015 - linked to climatic event El Niño that warms the surface temperatures of the eastern Pacific Ocean - caused the water levels of the lakes to drop significantly. With less water available, shippers had to limit the amount of cargo that their ships could carry in order to navigate the waterway safely (Spanne, 2014). This resulted in delays to the supply of goods, affecting the United States' supply chain and consumers.

Key takeaway

Adverse climate conditions impact the proper functioning of maritime transport. The effects on people differ and can be: i) direct – with damage to port infrastructures and a threat to people who cannot work in the port, or ii) indirect, with delays or under-supply of goods. Future research could further analyse which groups of people are particularly impacted for each type of effect.

Image 1 - Saint Lucia's topography and ports location



Source: UNCTAD

Aviation

Climate change may bring a range of risks to the aviation sector. Extreme temperatures, changes in wind and precipitation patterns, sea level rise, and atmospheric patterns may disrupt air travel (Ryley, Baumeister, & Coulter, 2020). For instance, storms can cause delays, as well as diverted and cancelled flights, and can damage communications equipment (Eurocontrol, 2023). Extreme precipitation caused a control tower to flood, posing a risk to airport workers and operations, and resulting in the closing of the airport (ibid.). Moreover, turbulence, which already causes fatalities and serious injuries during flights to passengers, is set to get worse due to climate change (Hughes, 2024).

Road Transport

For road transport, passengers are the key risk profile for risks stemming from climate change. Extreme heat and precipitation may result in increased traffic accidents and increased congestion and journey delays (Stern & Zehavi, 1990) (Chung, Ohtani, Warita, Kuwahara, & Morita, 2005) (Shankar, et al., 2004) (Andrey, Mills, Leahy, & Suggett, 2003).

In cases of flooding, authors note that the water could prevent road travel altogether (Alam & Rabbani, 2007), destroy roads (Arndt, Chinowsky, Strzepek, & Thurlow, 2012), and require investments in new road designs with better drainage (Kalantari & Folkesson, 2013). Such disruptions are likely to slow economic growth (Arndt, Chinowsky, Strzepek, & Thurlow, 2012) and increase maintenance costs.

Floods and storms do not only cause infrastructural disruptions: they also have an impact on vehicles. For instance, in 2024, the Spanish city of Valencia was hit by a storm that caused damage on cars (Kassam & Ali, 2024). This led to people losing their cars and not being able to travel.

Public Transport

While public transport is subject to similar risks as road transport, it can also be affected by wider disruptions to infrastructure, particularly energy infrastructure such as the electricity grid, which powers electrified subway and railway systems.

Ogden (2019) notes that events like higher temperatures, wildfires, floods, storms, or other disruptions could threaten the energy infrastructure, including rail infrastructure and urban public transport relying on electricity.

Rowan et al. (2013) find that rail tracks and electrical infrastructure are more likely to be disrupted with rising sea levels, storms, heavier rain, and increasing heat. Under heat, the tracks run the risk of “track buckling”, meaning that the trains need to go slower than normal.

Literature does not seem to explicitly mention how these events affect passengers and consumers.

Active Travel

Active travel is subject to several environmental exposures. These predominantly affect passengers (active travellers and commuters) since they impact on people’s ability to walk and cycle. Poor air quality and air pollution caused by transportation emissions may have a negative impact on pedestrians’ and cyclists’ health, as they inhale particulate matter (Rojas-Rueda, et al., 2016) (Hansmann, Grabow, & McAndrews, 2022).

Another study found that low temperatures are negatively correlated with modes of active travel, with cycling rates falling in temperatures below 15°C and walking in temperatures below 5°C (Saneinejad, Roorda, & Kennedy, 2012, p. 137). Heavy rains and wind speed also negatively influence cycling rates (ibid.). However, the authors look at the impact of weather conditions on active travel rates, and not risks to people per se. Moreover, there is no precise link between these findings and climate change, which does not appear to be the causal factor. When

the authors try to apply their model to climate change scenarios, they conclude that a warming climate can increase cycling trips. It remains unclear, however, what precise impacts climate change will have on active travel patterns or on people.

2.2. Indirect Risks - from Transport-Related Emission Mitigation Policies

Unlike direct risks which derive from extreme climate and weather events, indirect risks derive from the policies put in place to mitigate GHG emissions in the transport sector. Mitigation policies may have adverse social impacts and inequality outcomes (Markkanen & Anger-Kraavi, 2019).

As noted by the (UN, 2021), policies to reduce emissions from the transportation sector fall into three categories, those that seek to:

- (i) reduce or avoid travel by polluting modes of transport, e.g., carbon taxes on gasoline;
- (ii) induce travellers to shift their mode of transportation, e.g., investments in public transport;
- (iii) improve the carbon efficiency of transport vehicles, e.g., vehicle standards.

The following sections consider the social risks associated with such policies as they are applied to Aviation, Maritime, Road Transport, Public Transport and Active Travel modes. These sections are structured by policy type: carbon taxes, shift to electric vehicles, vehicle emission standards, shift to public transport and active travel, and ban on certain transport modes.

Carbon Taxes in the Transport Sector

In addition to existing taxes on petrol and diesel, a number of countries are considering, or have implemented, a carbon tax on road fuel (OECD, 2021). For example, Sweden has a tax of \$132 per ton of carbon, which adds ~\$0.27 to the cost of a litre of gasoline (Andersson, 2019). Such taxes increase the cost per mile driven in a traditional Internal Combustion Vehicle (ICV), incentivising individuals to reduce the distance travelled and/or to switch to an Electric Vehicle (EV) or public transport (The World Bank, 2021).

Carbon taxes on road transportation pose risks for road passengers. Given the high upfront costs of EVs and unequal access to public transport in some areas (discussed further below) individuals may find it hard to switch to EVs or public transport (The World Bank, 2021). For those who continue to drive ICVs, a carbon tax could increase transportation costs and push some individuals into transport poverty.

Alongside taxes on road transportation fuels, car passengers also face vehicle ownership and purchase taxes which are increasingly being differentiated according to the CO₂ emissions and fuel efficiency of the vehicle, in countries such as Sweden (Nilsson, 2017). As noted by (Eliasson, Pyddoke, & Swärdh, 2018), the cost of these taxes will fall most heavily on individuals reliant on private vehicles for transportation, which may increase social vulnerability among this group.

There is currently no global carbon tax targeting the aviation sector. However, ‘carbon pricing’ exists under two forms within the aviation sector - carbon taxation and carbon offsetting (EASA, 2024). Carbon taxation involves placing a price on carbon emissions from aviation, either through a tax or a cap-and-trade system. The EU Emissions Trading System (EU ETS), for example, includes aviation emissions and requires airlines to purchase carbon credits to cover their emissions (European Commission, n.d.). Aviation carbon offsetting involves the purchase of carbon credits, which represent the reduction or removal of one metric ton of carbon dioxide or its equivalent from the atmosphere.

Carbon taxation and offsetting in aviation represent new social risks for passengers and workers. In 2019 the International Air Transport Association criticised Swiss aviation initiatives, warning that the application of a mandatory carbon tax for passengers, further than raising ticket prices, would reduce Switzerland airports’ competitiveness, leading to a potential loss of more than 3000 jobs (IATA, n.d.)

Regarding efforts to establish a carbon tax on maritime fuels, the EU is currently discussing whether to integrate the shipping industry into the EU ETS, and the decision is expected to take place in 2024 (European Commission, n.d.). The potential impacts of carbon pricing are analysed by some reports and include, among others, speed reduction for ships and the use of shorter shipping routes (International Transport Forum, 2022). However, the social risks have not been explored in the literature.

Policies Incentivising Shifts to Electric Vehicles (EVs)

Policies that shift road users to EVs can pose risks to passengers. EVs tend to have higher initial purchase costs than internal combustion vehicles (ICVs), but lower maintenance and operation costs (Arias-Cazco, Rozas, Jimenez, Orchard, & Estevez, 2022). Given high upfront costs, governments continue to subsidise both the purchase of EVs and the installation of home charging stations (Noussan, Hafner, & Tagliapietra, 2020). For example, France has provided up to €300 towards the purchase of an EV (Lévay, Drossinos, & Thiel, 2017). There is a risk that subsidies may benefit only those who are willing or able to pay the high upfront costs associated with EV ownership (Ku & Graham, 2022); (Borenstein & Davis, 2015); (West, 2004) or those who are able to easily access public EV charging infrastructures (Caulfield, Furszyfer, Stefaniec, & Foley, 2022). Those unwilling or unable to pay high upfront costs are forced to buy ICVs and face higher operation and maintenance costs. The literature reviewed did not explore the impact on people’s quality of life or access to opportunities, nor did it explore interactions between EV subsidies and carbon prices on road transportation fuels.

EV usage may also impact some groups of transport workers. An expanded EV fleet will require increased quantities of lithium for the vehicles’ batteries, thereby posing significant risks to local communities in lithium mining regions, including freshwater usage and waste generation (Vera, Torres, Galli, Chagnes, & Flexer, 2023).

Moreover, Tamba et al. (2022) highlights that transport electrification may change the supply chain and employment patterns. Hence, a shift to EVs could be associated with transitional unemployment in the EU27 and the UK, including a shift from manufacturing traditional vehicles to battery manufacturing and electricity supply (ibid.).

Imposition of Vehicle Emission Standards

Emission standards are regulations that penalise, or ban, products not conforming to energy efficiency or emissions requirements (Zachmann, Fredriksson, & Claeys, 2018). Such standards have already been, or are likely to be, imposed by governments around the world on several modes of transport.

For road vehicles several countries and regions have introduced fuel economy standards requiring car manufacturer fleets of vehicles to meet an average CO₂ emission per kilometre drive. For example, the EU required a 55% reduction of passenger car CO₂ emissions in 2030 compared to the level in 2021 (IEA, 2021). Similar standards, with varying degrees of stringency, have been set in the US, Japan and China, with some countries (EU, UK, China, India) going further and pledging to completely ban the sale of new fossil fuel powered vehicles at various points between 2030 and 2040 (Noussan, Hafner, & Tagliapietra, 2020).

These standards may represent an implicit tax for fuel-inefficient vehicles and an implicit subsidy for fuel-efficient vehicles (Davis & Knittel, 2016), because they push manufacturers to charge lower prices for more efficient road vehicles and higher prices for less efficient ones. This effect is also visible in the second-hand market (Zachmann, Fredriksson, & Claeys, 2018), making used cars less affordable and limiting certain groups' access to private transportation, thereby posing a risk to passengers. These standards benefit individuals who drive long distances, making it worthwhile to invest in an efficient vehicle, while penalising those who drive short distances who may prefer to invest less in an efficient vehicle (Levinson, 2019).

For shipping, the International Maritime Organisation (IMO) adopted the first set of international mandatory measures to improve the energy efficiency of ships in 2011. The current IMO GHG reduction roadmap of 2018 mandates that annual emissions from shipping should be reduced by 50% by 2050 (Inal, Zincir, & Dere, 2022). Emission mitigation policies mostly have an impact on workers in shipping industries and workers on ships. The main effect is known as the 'rebound effect' (Dos Santos, Pereira da Silva, & Ventura Serrano, 2022); (Psaraftis, 2019), manifesting in two ways.

First, regulations can increase the cost of maritime transport for workers in shipping industries, leading to a shift to land transport to carry goods and thus increasing GHG emissions (Dos Santos et al., 2022). A similar effect is identified with the use of alternative and greener fuels, such as biodiesel feedstock coming from food resources and deforested areas.

Second, a rebound effect can threaten the physical security of workers on ships. To comply with the IMO's Energy Efficiency Design Index, less safe or underpowered ships may be constructed (Psaraftis, 2019). The ships might also attempt to go faster or just maintain speed

in bad weather (ibid.). The literature tends to consider the economic costs of reducing CO2 emissions of maritime transport, rather than the distributional effects or risks to people that result from these policies.

Incentivising Shifts to Public Transport & Active Travel

The social risks related to shifting transportation modes towards public transport and active travel mostly relate to personal health risks. These risks predominantly affect passengers (including active travellers).

Regarding direct personal health risks, active travel policies can create safety hazards to travellers and commuters if introduced inadequately, for instance when there are not enough precautions taken to protect pedestrians and cyclists against cars. Firstly, there is a risk of injuries or even death. In cities like Warsaw and Prague, the risk of being injured in a traffic accident is far greater for pedestrians than for car passengers (Rojas-Rueda, et al., 2016). Cyclists and pedestrians made up more than half of the road accident deaths in 2017 in the EU (Engels, 2019).

Secondly, active travel policies are introduced against a background level of preexisting air pollution, exposing walkers and cyclists to health risks associated with high concentration levels of particulate matter (as seen in the section on direct risks above). In Barcelona, due to high concentrations of air pollutants in the city, a policy intervention that encouraged car passengers to shift towards public transport and active travel led to negligible effects on air quality and negative health outcomes for active travellers (Rojas-Rueda, et al., 2016).

Bans on Certain Transport Modes

In an attempt to improve air quality and mitigate the impacts of climate change, many cities have introduced Low-Emission Zones which prohibit the use of highly polluting vehicles in designated areas whilst incentivising public transport and active travel. Currently, 250 LEZs exist in European cities, also with some prominent non-European examples such as Seoul and Hong Kong (Zhang, 2022); (Cui, Gode, & Wappelhorst, 2021). The Netherlands and China announced plans to further introduce Zero-Emission Zones for Freight, reducing the footprint of freight transportation within cities with possible disruptions to consumers' supply chains. The Brussels Environment agency has estimated that by 2025, the Brussels LEZs will have led to a -86.31% reduction in Black Carbon and a -66.17% reduction in Nitrogen Oxides emissions (Bernard, Dallmann, Lee, Rintanen, & Tietge, 2021).

Despite these environmental benefits, similar direct measures may have negative distributional impacts on passengers, disproportionately affecting those who cannot afford purchasing less-polluting vehicles or shift modes of transportation to lower-carbon alternatives (Zhang, 2022). These limitations are important as countries prepare to roll out even more restrictive Zero-Emission Zones, which may require close synergies with public transport and active travel infrastructure, as well as incentivising shifts to electric vehicles.

Conclusion - What are the Risks?

Referring back to the analytical framework set out in the introduction to this section, the risks stemming from climate change (direct risks) may have a major impact on different profiles including passengers using aviation, road transport, and active travel. They may also have a significant impact on workers and freight consumers in the aviation and maritime industries. The risks stemming from government policies to respond to climate change (indirect risks) may have impacts across all transportation modes with implications for a wider spectrum of passengers and workers.

III. Who is at risk?

In the previous section, we explained our typology of risks and identified them. This section now aims, through these risks, to identify the people who are affected. The literature identifies certain characteristics or groups of people (geographical location, socio-economic background, and demographics) that can explain the different levels of vulnerabilities to direct and indirect risks. Thus, we identified the following social cleavages, including geographic location, income, occupation, age, gender and ethnicity, to review the literature on related sub-groups and to analyse which sub-groups are most at risk. These sub-groups are not exhaustive, and they might overlap.

3.1. Geography

Exposure to climate events (Direct risks)

Some geographic areas are more exposed to climate events than others due to their natural topography and climate patterns (UCAR, n.d.). Additionally, some regions might be better prepared than others to deal with these events: they have different levels of resilience, defined by the IPCC as the ability of a system and its parts to “anticipate, absorb, accommodate, or recover from the effects of a hazardous event” (IPCC, 2012, p. 563). This means that people living in different geographic areas may be affected differently by direct risks. Climate change may affect transport networks in forms of natural disasters, causing social and economic risks, such as additional costs to restore transport and loss of access to food and medicine supplies (Greenham, et al., 2023).

- **Coastal areas** are affected by rising sea levels, causing disruptions to maritime and road transportation infrastructure (Mills & Andrey, 2002). Floods, cyclones and erosion may disrupt infrastructure such as road networks, disproportionately affecting poor people in Bangladesh (Adshead, et al., 2024). This is also illustrated by (Wardekker, de Jong, Knoop, & van der Sluijs, 2010) assessment of the climate risks in Rotterdam, threatening Europe’s largest seaport and potentially causing damage and societal disruption.
- **High precipitation/Flood zones** may be exposed to mobility disruptions, including an increased travel distance for people, travel delays and cancellations, and route failures (He, et al., 2022). Roads might be unsafe to travel, posing a risk to passengers (Rebally,

Valeo, He, & Saidi, 2021). This might also pose a threat to consumers, who might not receive goods and services due to roads being submerged or closed (Diakakis, Boufidis, Salanova Grau, Andreadakis, & Iraklis Stamos, 2020). In Madagascar, due to high rainfall, rural roads often become impassable, preventing access of health personnel and disrupting supply of medications (Iimi & Rajoela, 2018). A similar problem can occur in urban areas, such as Dhaka, Bangladesh (Alam & Rabbani, 2007). Flooded areas may also affect urban people's mobility and usage of public transport, as well as slowing down emergency workers (Wolf, et al., 2023).

- **Drought-prone areas**, especially when affected by high precipitation, may cause disruptions in the rail and road infrastructures by creating cracks in the soil and destabilising it (Wang, Liu, Wang, Koks, & Wang, 2024).
- **High pollution zones**, especially in urban zones, may reduce the health benefits of active travel (Tainio, et al., 2016). Although the benefits of active travel (increased physical activity) generally outweigh the risks deriving from air pollution, this is not the case in extremely polluted environments (ibid.). People engaging in high levels of active travel, for example bike messengers, in extremely polluted environments (PM2.5 concentration) may be exposed to air pollution in a way that negates the benefits of increased physical activity (ibid.).
- **Heatwave-prone regions** can pose safety risks to passengers and transportation workers, both on land and at sea. For instance, vehicles can overheat and roadway joints can deform, causing uneven surfaces or hazards for vehicles such as accidents (Jacobs, et al., 2018).
- **Hurricane-prone regions** - hurricanes may cause damage to property, local economy and other kinds of physical and social disruptions, especially in coastal communities (Nofal, et al., 2023). Coastal roads and bridges may also be more prone to destruction caused by hurricanes, and the lack of transport access may cause people to dislocate in the aftermath of a hurricane (ibid.).
- **Areas with different levels of preparedness / resilience** - Pre-existing physical and social conditions such as lower income, lack of access to resources may cause differences in social vulnerability both during disasters and during the recovery efforts (Kim & Sutley, 2021). Low-income countries may be more vulnerable to climate change, which disrupts transport networks (Greenham, et al., 2023). Some barriers identified for the low level of preparedness include: lack of data or knowledge, climate change budget and planning, as well as stakeholder engagement, which require a better-established international coordination (ibid). This means that regardless of geographical exposure to these climate events, collective socio-economic vulnerability can play a role in the level of risks.
- **Small Island Developing States (SIDS)** are particularly vulnerable to direct risks. Extreme weather events can disrupt maritime transport around and to SIDS, including connection with the mainland and transportation of goods and passengers (Zittis, Ahrens, Obermann-Hellhund, & et al., 2023), posing a threat to both passengers and consumers. Since SIDS are remote areas, disruption in supply chains (due to direct risks impeding maritime transport) can lead to a surge in prices of goods and cause food

insecurity to the people living on those islands, similarly to what occurred during COVID-19 (UNCTAD, 2021).

Mitigation Policies in Different Geographical Areas Within and Across Countries (Indirect risks)

Transport-related emission mitigation policies may have different effects on people living in different geographical locations. This is the case i) within the same country, for people living in different settlement densities (urban, suburban, rural areas) ii) and across different countries.

- **Urban areas**, particularly the city centres, can be at an advantage compared to other areas when it comes to climate mitigation policies. EV purchases may benefit those who live in cities, due to a denser network of EV charging stations (Caulfield, Furszyfer, Stefaniec, & Foley, 2022). Additionally, the density of residence and a cohesive neighbourhood positively correlates with less transport disadvantage and higher subjective well-being (Ma, Kent, & Mulley, 2018).
- **Suburban areas**: policies to encourage public transport may be more difficult to implement in suburban areas compared to city centres. This is because suburban transit providers usually serve low-density, automobile-oriented areas (Braun, Barajas, Lee, & Martin, 2022). For instance, in sparse settlements such as the US suburbs, fewer people use public transport, respectively 6% and 3%, compared to 21% of urban dwellers (Anderson, 2016). Similarly, in the case of active travel, those who have to commute over longer distances, and are faced with a disconnected street network, will not be able to shift towards active modes of transport (Saneinejad, Roorda, & Kennedy, 2012, p. 132). Disparities persist between urban and suburban areas when it comes to access to EV charging. For instance, Hardman et al. (2021) show that low-income neighbourhoods, including suburban areas, have a lower concentration of public EV charging infrastructure.
- **Rural areas** can be vulnerable to mitigation policies. For instance, carbon taxes on road transportation disproportionately affect those living in rural areas who may be more reliant on cars for their transport needs, compared with urban areas (Harju, Kosonen, Laukkanen, & Palanne, 2022; Pyddoke, Swärdh, Algers, Habibi, & Sedehi Zadeh, 2021) (Eliasson, Pyddoke, & Swärdh, 2018). For example, in 2018, the Yellow Vests (Gilets Jaunes) movement in France appeared as a backlash to the proposed carbon tax by the government (Willsher, 2018). Other alternatives, such as electric vehicles, are also less available in rural areas where households may have to pay the extra expense of installing EV charging infrastructure at their home, with (Caulfield, Furszyfer, Stefaniec, & Foley, 2022) showing that EV uptake has been lower in rural communities.
- **Across countries**: People living in developing countries might be more affected by mitigation policies compared with people living in developed countries: The effects of a carbon tax on ship fuels may be on average 6% higher for Small Island Developing States than the rest of the world (International Transport Forum, 2022). For instance, Fiji coffee exports would be impacted (Rojon, Lazarou, Rehmatulla, & Smith, 2021). Transport emission mitigation measures in the Global North such as higher prices may

have adverse impacts on the Global South, due to lower tourism income, and higher food and fuel costs (Gilmore & Buhaug, 2021).

3.2. Income

People with different levels of income (e.g. high-income, low-income) in groups or households can be affected differently by Direct and Indirect risks.

People exposed to Direct risks:

Even in wealthy countries, lower-income people may be restricted in terms of their choices for transport modes (Furszyfer Del Rio, Sovacool, Griffiths, Foley, & Furszyfer Del Rio, 2023). This can be the case also in the context of Direct risks. Lower income groups might have more difficulties in coping with extreme weather events compared to higher income groups. For instance, people with lower income were more vulnerable to Hurricane Katrina (Masozera, Bailey, & Kerchner, 2007). This is relevant in the context of transportation: a research on hurricane evacuees in Houston shows that lack of transportation (car, more specifically) was a reason why some people were not able to evacuate their homes on time (Brodie, Weltzien, Altman, Blendon, & Benson, 2006).

People exposed to Indirect risks:

Transport-related mitigation policies such as carbon taxes, EV subsidies, and encouragement of public transport and active travel may affect people with different income levels.

Carbon taxes on transport fuels may be regressive, disproportionately affecting lower-income households, or the lower middle class (Beaussier et al 2024). This is because fuel costs represent a greater proportion of poorer households' income (Zachmann, Fredriksson, & Claeys, 2018). However, carbon taxes on aviation may be progressive as flying tends to increase with income (ibid).

Vehicle standards and EV subsidies may also be regressive as tax rebates for EV purchases may benefit higher income households (Guo & Kontou, 2021); (Borenstein & Davis, 2015); (Ku & Graham, 2022). For example, in California, the top income decile has received 33% of the tax rebates (Ku & Graham, 2022). Similarly, rigid vehicle standards may penalise lower income households who are more likely to buy second hand cars (Davis & Knittel, 2016). Lower income households may not be able to claim EV subsidies in the form of tax breaks (Borenstein & Davis, 2015). Moreover, low-income households may be less likely to live close to public EV charging infrastructure (Hardman, Fleming, Khare, & Ramadan, 2021).

Public transport may play an important role in democratising transportation and contributing to the social cohesion through affordable schemes (Silva, Cadima, Castro, & Tennoy, 2021). However, new public transport infrastructure may disproportionately benefit higher-income neighbourhoods at the expense of areas where low-income households live, as was the case for infrastructure projects in Rio de Janeiro before the Olympics (Pereira, Banister, Schwanen, &

Wessel, 2019). Studies conducted in the UK have also demonstrated that higher levels of income, as well as education, usually translate into increased patterns of cycling and walking (Goodman, Sahlqvist, & Ogilvie, 2013; Aldred, Woodcock, & Goodman, 2021); , benefitting higher income households in shifting transportation modes.

Even if active travel may be a cheap and viable option, people with lower income may suffer from greater baseline exposure to issues such as cycling in polluted air or traffic injuries, relating to the geographical area in which they live and accessibility to adequate infrastructure (Hansmann, Grabow, & McAndrews, 2022).

3.3. Occupation

Within the transport sector and other sectors providing raw materials for it, different types of occupations may require different levels of skills. Exposure to direct and indirect risks may impact their working and living conditions. Their skill levels depend on the nature of the work performed, on the level of education, and training, and these are categorised into groups by the International Labour Organisation (n.d.); for the sake of simplicity, we employ the terms low-, medium- and high-skill occupations. People might also be affected by the different types of jobs they engage in: Workers in polluting sectors (brown jobs) and sectors promoted by climate mitigation policies (green jobs) (Bohnenberger, 2022) may face different social risks to various extents.

People exposed to Direct risks:

Extreme heat can cause adverse outcomes for transport sector workers, where physical effort and exposure to the outdoors may be more common (ILO, 2019).

People exposed to Indirect risks:

- **Low-skill occupations** may also be affected by high levels of electrification of road transportation reducing the demand for biofuels and agricultural workers (Tamba, et al., 2022). However, this electrification of transport may also drive employment in construction and manufacturing.
- **Green jobs:** As demand for Lithium for EV batteries increases, lithium miners² could be exposed to increased risks. Literature notes the increased risks of water pollution with toxic waste (Riofrancos, et al., 2023) and severe health and biodiversity consequences of water pollution (Agusdinata, Liu, Eakin, & Romero, 2018), as well as irritation of respiratory tracts (UNCTAD, 2020). Lithium rock mining is prevalent in countries such as Australia, Chile, Argentina and Bolivia (Statista, 2024; Ahmad, 2020).

² “Green job” is a contested concept in the literature. According to ILO (ILO, 2016), green jobs “contribute to preserve or restore the environment”, therefore this might not be the case for some lithium miner jobs.

3.4. Age

Older and younger people can be exposed differently to risks related to the environmental transition in transportation.

People exposed to Direct risks:

- **Elderly people** - extreme weather events, such as precipitation, storms and ice, may cause a bigger disruption for elderly people in terms of travel patterns and travel cancellations compared to the non-elderly population (Böcker, van Amen, & Helbich, 2017). Moreover, Karthick et al. (2021) found that transportation workers over 50 years old are significantly more affected by extreme weather conditions in the workplace compared to younger workers.

People exposed to Indirect risks:

- **Young people** - mitigation policies, such as promoting active travel infrastructures and spaces, can influence the level of physical activity of young people. For instance, it was found that physical attributes of the built environment, such as the presence of sidewalks and lower traffic volumes, is positively associated with levels of youth physical activity (Piccone & D'Agostino, 2021).

3.5. Gender

Gender has important implications when it comes to transport-related risks both for workers within the sector and for passengers.

People exposed to Direct risks:

- Female transportation workers and pregnant women were found to be at a higher risk of a cardiac strain compared to male workers due to extreme weather conditions (Karthick, Kermanshachi, Rouhanizadeh, & Namian, 2021).

People exposed to Indirect risks:

- Policies for shifting to greener transportation modes may exclude certain groups like women if they do not take into account gender perspectives. For example, in California men are three times more likely to cycle than women who cite lack of safety and family-appropriate adjustments as serious constraints (Heesch, Sahlqvist, & Garrard, 2012).
- In general, women's travel patterns may be more frequent and shorter compared to men, as they may be performing a greater number of activities on a given day. They also tend to be more likely to walk and use public transport, making active travel policies and public transport availability a bigger concern for them (Pirra, et al., 2021; Goel, et al., 2023).

3.6. Ethnicity

People belonging to particular ethnic or racial minorities may be more vulnerable to direct and indirect risks. This might be the case both for workers within the transport industry and for passengers.

People exposed to Direct risks:

- In the United States, ethnic minorities tend to be more concentrated at metropolitan centres where pollution may be higher (Sadeghvaziri, Javid, & Jeihani, 2024).
- Hispanic transportation workers were found to suffer more from heat disorders compared to non-Hispanics (Karthick, Kermanshachi, Rouhanizadeh, & Namian, 2021).

People exposed to Indirect risks:

- **Ethnic and racial minorities:** studies find either no significant difference or a favourable impact of Indirect policies that promote active transportation (e.g. walking, cycling, public transit) on the health outcomes for disadvantaged groups of different races and ethnicities (Hansmann, Grabow, & McAndrews, 2022). Moreover, while new policies such as active travel infrastructure or bike-sharing lanes are being implemented, they are more concentrated on higher-income neighbourhoods. This can potentially exclude people of colour and lower-income households from active travel infrastructure in the United States (Sadeghvaziri, Javid, & Jeihani, 2024).
- **Indigenous communities** may be left behind in active travel interventions as they live further away from cycling infrastructure. In New Zealand, prior to the implementation of inclusive cycling policies, Māori citizens spent almost 23% less time travelling actively relative to citizens of European origin (Keall, et al., 2022). Policies to switch to electric vehicles can negatively impact indigenous communities. For example, in the US, many Native American reservations are located near deposits of lithium, a necessary metal for EVs (Riofrancos, et al., 2023). Indigenous communities living next to or working in the mines may be more exposed to the risks associated with lithium mining, such as contamination of water sources (Blair, Balcázar, Barandiarán, & Maxwell, 2023).

Conclusion - Who is at risk?

This section has shown that various social groups have different exposures to the social risks of the environmental transition in transport, both when it comes to climate-related risks (Direct), as well as the risks stemming directly from mitigation policies (Indirect).

- In terms of geography, it is the rural and suburban areas that may be particularly disadvantaged in the shifts of transportation modes towards more carbon-neutral alternatives. Additionally, regions prone to extreme weather events and Small Island Developing States (SIDS) are more exposed to the risks stemming directly from climate change.

- In terms of socio-economic status, lower-income households may be at a disadvantage when it comes to extreme weather events but also mitigation policies such as carbon taxes and EV rebates. For certain sectors linked to transport such as mining, mitigation policies such as EV subsidies may cause additional vulnerabilities and health risks.
- In relation to demographics, some social groups - such as the elderly, youth, women, ethnic and racial minorities, indigenous communities - may be particularly vulnerable to the social risks discussed, due to exclusion from active travel or vulnerability to extreme weather conditions. Exposure to these risks is not uniform, and literature shows that at-risk categories may vary from one risk source to another.

IV. How to manage these social risks?

Given the risks noted above and how they affect certain groups of people in particular, we explored some of the existing public (government) economic and social policies that aim to i) address the social risks generated by environmental degradation and climate change on transport (addressing direct risks) and ii) address the social risks generated by policies to mitigate carbon emission from the transportation sector (addressing indirect risks).

4.1. Policy Measures addressing Direct risks

In the maritime sector, investments in port infrastructure and hinterland connections (UNCTAD, 2022) could protect consumers from disruptions to global supply chains as a result of direct risks. This includes investing in terminal operations, expanding storage and warehousing capacity.

Another solution to address direct risks is social security, including social schemes that protect maritime workers. The International Labour Organization (ILO) Recommendation of 1920 encourages member states to provide unemployment insurance for seamen (ILO, 2021). Moreover, the ILO Social Security (Seafarers) Convention of 1946 mandates cash benefits to seafarers for their incapacity to work (*ibid.*). However, not all categories of workers seem to be protected (i.e. dock workers).

Various policies exist to mitigate the direct social risks deriving from active travel. Since traffic safety and poor air quality are recognised in the literature as the main risks for individual commuters, active travel policies could be viewed as a strategy of population health management (Hansmann, Grabow, & McAndrews, 2022). To improve road safety and create safe and accessible streets, policies focus on introducing improvements, such as multi-use pathways, proven to increase active travel by 35% (Georges & Hubsmith, 2012). To decrease differential exposure at baseline to issues such as poor air quality, public actors complement other transportation policies, such as disincentivizing the use of motor vehicles through the introduction of Low- and Zero-Emission Zones (Zhang, 2022).

4.2. Policy Measures addressing Indirect risks

In the road transport sector, carbon taxes can be improved to reduce social risks related to existing mitigation measures. For example, the Yellow Vest movement in France has been closely related to rises in fuel taxes (Douenne & Fabre, 2022). Levinson (2019) has suggested that rebating carbon tax revenues back equally to households could mitigate regressivity concerns and address such opposition. For instance, Switzerland and Canada have implemented a carbon tax together with a rebate programme.

In Canada a CAN\$50/tonne carbon tax is offset by a Climate Action Incentive Payment given as an income tax credit (Mildenberger, Lachapelle, Harrison, & Stadelmann-Steffen, 2022; Government of Canada, 2024). The amount received is based on the number of adults and children in each household, with a 10% increase for rural households, and varies significantly across States (Mildenberger, Lachapelle, Harrison, & Stadelmann-Steffen, 2022). In 2023, an individual was eligible for \$120 in Prince Edward Island but \$772 in Alberta (Government of Canada, 2024). In Switzerland, by 2018 there was a carbon tax of 96 Swiss Francs /tonne, and citizens were eligible for a per capita rebate via deductions from their mandatory health insurance costs (Mildenberger, Lachapelle, Harrison, & Stadelmann-Steffen, 2022).

Regarding the disadvantage of EV take-up by households with different incomes, a range of measures have been proposed to support EV adoption among lower income households. For instance, in Scotland free-interest loans for a new EV purchase are already available, as well as other plans that allow for a longer repayment period (Caulfield, Furszyfer, Stefaniec, & Foley, 2022). In Ireland, policies that have a high impact on the adoption of EVs but less adverse effects on social equity are being discussed, such as a grant scheme for taxis and other small public service vehicles (Department of Transport, 2021). Moreover, California redesigned its EV subsidy scheme in 2016 to make high-income households ineligible for the subsidy. While this did ensure that the subsidy went to households lower down the income distribution, it did not effectively target the very lowest income groups - an evaluation of the policy found that the programme continued to be regressive (Ku & Graham, 2022).

Some policies are implemented to allow a more accessible and equitable use of public transport. For instance, the transport provider in Paris and Île-de-France region, Île-de-France Mobilités, offers discounted travel passes for handicapped people, people accompanying them, students, the youth, unemployed youth in job insertion programmes, low-income people, and people with health problems (Île-de-France Mobilités, n.d.).

A report on Nairobi, Kampala, and Dar as Salam (Muhoza, Wikman, & Diaz Chavez, 2021) focuses on inclusive policies for public transport from a gender perspective. They emphasise the necessity of having more women in decision-making positions for a more effective gender inclusion in public transport, and better surveillance as well as more enforcement of laws against abuses or harassment during daily commutes.

In terms of active travel, innovative policy solutions have been piloted in cities around the world to address indirect risks. For example, the “Beat the Street” intervention implemented in 113 municipalities worldwide and engaging 1.1 million participants introduced elements of gamification and competition into citizens’ daily commutes, encouraging active travel behaviours through a rewards system (Harris & Crone, 2021). However, this can also serve as an example of a policy which only targets the commuting population (typically 16-64 age group) and those who are already more likely to use this mode of transport (Rojas-Rueda, et al., 2016).

Conclusions - Policies to Address Social Risks

Some governmental policies are already in place to mitigate the social risks deriving from both direct and indirect risks for different transportation modes. These include social security schemes and improvements in transport infrastructure, as well as attempts to improve the uptake of EV subsidies and more equitable public transport. The list of examples chosen are not exhaustive. At the same time, there does not appear to be an overarching and one-size-fits-all set of policies to address social risks across countries worldwide. These policies are relatively recent and are still developing.

Conclusion

This paper has attempted to fill a gap in a relatively unexplored research field by mapping the social risks associated with the environmental transition in the transport sector. To do this, we broke the transportation system down into different modes - maritime, aviation, road transport, public transport and active travel - and different purposes - passenger travel and freight transportation. We then developed an analytical framework to assess the social risks of the environmental transition by considering three risk profiles - transport passengers, transport workers, and freight consumers. These social risks stem from two inextricably linked sources: extreme climate and weather events exacerbated by climate change and transport emission mitigation policies.

Using this framework, we found that the risks stemming from extreme climate and weather events have a major impact on passengers using aviation, road transport, and active travel, while also having a significant impact on workers and freight consumers in the aviation and maritime industries. The risks stemming from policies to mitigate transport emissions have impacts across all transportation modes with implications for a wider spectrum of passengers and workers, including deaths and injuries, restricted mobility, and economic harm.

We then assessed how these risks were distributed across different social groups, considering the variation in impact across geography, income, occupation, age, gender and ethnicity. Different social groups - like women, youth and the elderly, ethnic minorities, low-skilled workers, people in urban and rural communities, people living in small island developing states, etc. - may have a substantially differentiated exposure to the social risks of the environmental transition in transport, with some groups being more vulnerable than others.

In the final section we reviewed the current governmental policies in place to manage the social risks identified. These policies attempt to address social vulnerabilities caused by both direct and indirect risks. These include, but are not limited to, social security schemes and improvements in transport infrastructure, as well as attempts to improve the uptake of EV subsidies and more equitable public transport. Most of these policies are relatively recent and their full effects should be further explored.

Our analysis shows that this is a complex policy area which would benefit from further research. Across each of the sections above we provided an overview of the current state of the literature. While much has been written quantifying impacts on emissions and on transportation costs across several modes of transport, there is consistently less attention paid to social risks and how systematically these risks vary across different social groups or segments of society.

This is of course preliminary work that needs further development, but which has tried to underline the stakes and avenues for further research. Indicators, and consequently data, are for instance missing to identify and assess the social risks to different groups. There are currently no global standardised metrics or encompassing studies. We believe a greater focus on these topics could help develop improved policies for the management of the social risks of the environmental transition.

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