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Strategic questions of a horizontal policy nature:**Climate change and transport – Impacts of climate change
on international transport networks and adaptation requirements****Climate Change Impacts and Adaptation for International
Transport Networks****Note by the secretariat***Summary*

The document presents the Executive Summary of the Final Report of the UNECE Expert Group on Climate Change Impacts and Adaptation for International Transport Networks.

The Committee may wish to consider and approve the continuation of work on climate change adaptation.

I. Executive Summary

1. In recent years, the impacts of climate change on various human activities have been addressed by both Governments and international organizations, though relatively little consideration has been given to impacts associated with the infrastructure and operations of international transport networks and related adaptation measures. Recognizing the need for concerted action, experts from various countries, international organizations and academia, under the auspices of the United Nations Economic Commission for Europe (UNECE) established a Group of Experts on Climate Change Impacts and Adaptation for International Transport Networks. The Group met six times and organized an international conference in June 2012 on this subject. Information from the ECE region and beyond was analysed and the potential implications of climate variability and change on transport infrastructure and services were identified. Information was collected (questionnaire

survey) on (a) the current level of awareness and preparation, (b) the availability of relevant information and tools, (c) the existing and planned transport adaptation policies, (d) measures and initiatives and (e) the research needs and financing requirements as well as (f) the collaboration mechanisms at national, regional and international levels. Relevant national initiatives, case studies and research projects were reviewed, and experiences on mode-specific adaptation measures were shared together with existing best practices in national policies for risk management and enhancing resilience. The experts concluded on the need for increased awareness about the assessment of climate change impacts on the transport sector and of adaptation measures.

II. Climate Variability and Change Trends and Projections

2. A long-term increasing trend in the mean air temperature is clear in the current climate trends. Precipitation has also changed, but in a more complex manner. These trends are predicted to hold or even increase in the future. A damaging side effect of the temperature increases is the significant rise in the mean sea level. Since the 1860s, sea levels have risen by about 0.2 m, with satellite information showing a progressive increase in the rates since the 1990s. The recent report (AR5) of the Intergovernmental Panel for Climate Change (IPCC, 2013) projects temperature increases between 1.0 and 3.7 °C (depending on the scenario) for the end of the twenty-first century. Such temperature increases could also drive substantial mean sea level rises, which for the same period, are projected to between 0.26–0.82 m. Other recent studies project even higher rises.

3. Changes in the average climate conditions can also lead to fluctuations in the frequency, intensity, spatial coverage, duration, and timing of weather and climate extremes, which can, in turn, modify the future climatic conditions. Extreme events (e.g. storms, storm surges, floods and droughts and heat waves), as well as changes in the patterns of particular climatic systems such as the monsoons can have, at smaller spatio-temporal scales, more severe impacts on transport networks than changes in the mean variables. One of the clearest trends appears to be the increasing frequency and intensity of heavy downpours. Climate models project the continuation of this trend, with heavy downpours that occur presently about once every 20 years being projected to occur every 4–15 years by 2100, depending on the location. River floods also appear to present a significant hazard, particularly for central and eastern Europe and for central Asia. Evidence also suggests increases in the frequency and intensity of heat waves and droughts.

4. One of the major causes of the observed temperature increases is considered to be the increasing atmospheric concentrations of Greenhouse Gases (GHGs), which absorb heat reflected back from the Earth's surface and, thus, increase the heat storage in the Earth System. Since the industrial revolution, atmospheric concentrations of GHGs have been steadily increasing, higher now than they have been for some million years. Global warming can be amplified by reinforcing feedbacks, i.e. climate change-driven processes that can induce further warming, such as the activation of currently inert carbon reservoirs (e.g. the tropical peatlands, the vast CH₄ stores in the Arctic permafrost) and the rapid reduction in the spatial coverage of Arctic Ocean ice.

III. Implications for transport networks

5. Demand for transport services grows in line with the global economy, trade and world population. As transport is a demand-driven industry, climate change-induced changes in, for example, population distribution, commodity production and its spatial distribution, tourism patterns and the trade and consumption patterns can also have significant implications.

6. Climate variability and change (e.g. mean sea level rise, warmer water temperatures, higher intensity of storms and storm surges and potential changes in the wave regime) may severely affect coastal transport infrastructure and services, such as ports and other coastal transport hubs/networks. Ports, which form key-nodes in international transport networks and link international supply-chains, will be particularly affected, due mostly to the long life-time of their infrastructure, exposed location and dependence on trade, shipping and inland transport that are also vulnerable to climate variations and change. Daily port operations can be directly influenced by storm surges; coastal inundation will render ports unusable for the flood duration and damage terminals, intermodal facilities, freight villages, storage areas and cargo and, thus, disrupt intermodal supply chains and transport connectivity.

7. Precipitation changes can result in stream flow changes that are likely to affect roadways, railways, rail and coach terminals, port facilities, and airports. Direct damages during the impact may necessitate emergency responses. Other effects can be on the structural integrity and maintenance of roads, rail lines, bridges, tunnels, drainage systems, telecommunication and traffic management systems, necessitating more maintenance that is frequent and repairs. Increases in heavy precipitation events and floods will cause more weather-related accidents, delays, and traffic disruptions in the already congested networks. Inland waterways may suffer from navigation suspensions, silting, changes in river morphology and damages of banks and flood protection schemes, whereas airports may suffer infrastructure damages and increased delays and cancellations of operations.

8. Extreme winds can damage port facilities (e.g. cranes and loading terminals), damage airport facilities and interrupt air services and stress road and rail operations; directly destroy agricultural crops and indirectly affect the transport industry. Changes in the directional patterns of winds and wind-waves can affect seaport operations and safety. Heat waves may also affect transport services and infrastructure by inducing wildfires and crop failures, stressing water supplies, food storage and energy systems and increasing refrigeration requirements. They can also deform/deteriorate road pavements and disrupt road traffic, deform rail tracks and desiccate track earthworks causing lengthy delays through speed restrictions. Airport facilities, runways and operations will be also affected as will inland waterway transport. The decline in the ice of the Arctic Ocean may allow the opening of new shipping routes, but also alter demand and supply of regional transport services and significantly increase the costs for linking Arctic ports to major national and international inland transport networks. Arctic warming may also affect the freezing and thawing cycles, damaging building foundations, causing frost heaving on roadways and rail lines, and affecting the integrity of bridges and other transport structures.

IV. Recommendations

9. To avoid significant future expenditures, it appears that transport policymakers and stakeholders should address the climate change issue as a matter of urgency. A clear understanding of the potential impacts, risks and vulnerabilities appears to be both a first step and a prerequisite for the design and construction of resilient transport infrastructure and their management systems. It must be noted that the transport sector of the developing and poorly-diversified economies will be particularly vulnerable not only to catastrophic, large-scale extreme events but also to ‘slow-burning’ stresses due to the projected higher average temperatures and mean sea levels and more frequent flooding and/or droughts.

10. Adaptation action aims to reduce vulnerabilities and increase the resilience of systems to climatic impacts. In the transport sector, resilience refers not only to the physical strength and durability of the infrastructure that allows it to withstand adverse impacts without losing its basic functions, but also to its ability to recover quickly and at a minimal

cost. It follows that potential climate change impacts should be factored into the planning, design, construction and operations, as well as in the broader economic and development policies involving the sector. Developing effective adaptation strategies requires policy action, investment and collaborative research. Well-targeted vulnerability studies, empirical studies and assessments of projected risks and related costs are deemed as a necessary first step towards bridging the current knowledge gap and defining priority areas.

11. The following general recommendations are based on experiences gained so far and on scientifically confirmed potential manifestations of climate change impacts. A prerequisite in Government action for the development and formulation of effective climate change adaptation strategies should be a clear understanding and systematic mapping of the transport sector vulnerabilities to climate variability and change based on the nature/extent of change, the transport system sensitivity and the required adaptive capacity. It is recommended that:

(a) Governments, in collaboration with transport infrastructure owners/operators and international organizations establish inventories of critical and sensitive transport nodes.

(b) Climate variability and change be incorporated into the long-term capital improvement plans, facility designs, investment works, maintenance practices, operations, engineering practices and emergency response plans.

(c) Transport infrastructure and services are regulated; therefore, institutional and regulatory adaptation may also be necessary.

(d) Transport infrastructure planners and designers, together with transport infrastructure managers, vehicle and rolling stock manufacturers take into account from the planning stage, climate change projections and their potential impacts.

12. Adaptation strategies:

(a) Adaptation actions should take place within integrated natural hazard management frameworks; such frameworks should be able to pro-actively address the present weather-related challenges and disruptions and also to design and build mid- to long-term climate change adaptation measures. Building upon current management systems that already deal with the present weather related impacts is likely to create a working adaptation framework.

(b) Well-structured national as well as international integrated databases of digitized network data, disruption hotspots and incidents, management and maintenance plans and asset management practices could form the core of an efficient natural hazard management system for the transport sector.

(c) Possible climate change impacts should be considered in the early stages of planning and be included in risk and vulnerability assessments; future projects should integrate climate change considerations into their asset design and maintenance planning.

13. Although the present report deals with adaptation of the transport sector to climate change, issues relevant to climate change mitigation should always be kept in mind.

(a) Adaptation is not an alternative to reducing GHG emissions. Global emission monitoring is considered necessary to mitigate climate change.

(b) Many fundamental decisions on both climate change adaptation and mitigation will be influenced by cost-benefit assessments. Presently, such assessments are constrained by uncertainties; and reducing such uncertainties, where possible, should become an urgent integrated research priority.

(c) The possibility of developing synergies with GHG emission mitigation and other environmental objectives should be investigated further.

14. The present study has shown that there are significant information and knowledge gaps that require appropriate research. The following recommendations are presented:

(a) The study of climate change impacts and adaptation requires integrating a range of disciplines, such as law, natural and social science, engineering and economics.

(b) Focused research should be undertaken for different climate change impacts. These studies could be complemented by case studies on the potential economic, social and environmental consequences and the costs and benefits of adaptation options. For instance, the river flood risk on road and rail networks could be assessed by detailed studies that will model the potential extreme flood hazard in the ECE region under different scenarios of climate change in order to identify flood 'hot spots'.

(c) Initial assessments of the transport sector vulnerabilities are possible without a detailed knowledge of future climatic changes; these assessments can be based upon the analysis of the sensitivity to past climatic variability and the current capacity of the systems to absorb disruption and adapt to changing conditions.

(d) In view of the interconnectedness and interdependence of economies in a globalised trading system, the special needs of developing countries, and particularly Small Island Developing States, should also be taken into consideration.

(e) It is important to foster cooperation between the UNECE and other relevant international organizations and agencies, in particular with United Nations Framework Convention on Climate Change, and the Global Framework for Climate Services (GFCS) of the World Meteorological Organization, in order to institute a process for better communication among transport professionals, climate scientists, and other relevant scientific experts, and establish, if possible, a clearing house for transport-climate change relevant information. Bearing in mind the global nature and implications of climate change on the transport sector as well as the importance of considering climate change challenges when international transport norms and standards are discussed in the Inland Transport Committee and in its subsidiary bodies, UNECE must take the initiative and contact the Partners Advisory Committee of the GFCS. Sharing best practices for addressing potential impacts of climate variability and change in the transportation sector is also warranted.
