Multi-year Expert Meeting on Transport, Trade Logistics and Trade Facilitation:

Third Session: Small Island Developing States: Transport and Trade Logistics Challenges

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Climate Change Impacts and Adaptation for International Transport Networks
Expert Group Report ECE/TRANS/238

Submitted by

UNECE, Transport Division

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Scope and Structure of the Report

In 2011, an International Group of Experts was convened the UNECE to consider the Climate Change (CC) impacts on the infrastructure/operations of the international transport networks and potential adaptation measures. The Group met 6 times, an International Conference was organised in June 2012 and the final report was published in early 2014.

The report contains:
1. A summary of the Climate Variability and Change trends and projections;
2. A review of the CC implications for transport networks;
3. The results of a Questionnaire Survey on
   (a) the awareness and preparedness level,
   (b) the availability of relevant information/tools,
   (c) the existing/planned adaptation policies, measures and initiatives; and
   (d) the research needs, financing requirements and the existing collaboration mechanisms;
4. Relevant national initiatives and case studies on mode-specific adaptation measures/best practices for risk management and resilience enhancement;
5. General and mode-specific resilience-advancing recommendations.
1 Climate Variability and Change trends and projections

Different mean climate indicators consistently show a global warming trend (but with a significant spatio-temporal variability).

It has been suggested that there will likely be a continuation (and, in some cases, acceleration) of CC during the century (IPCC, 2013).

At the same time, extreme events (storms, floods and droughts and heat waves are also projected to increase in many regions.

With regard to the mechanism behind the observed and future global climate change, IPCC (2013) has concluded that:

- It is extremely likely that human influence has been the dominant cause of the observed global warming since the 1950’s.

- Continued emissions of GHGs will cause further warming/changes in the climate system. Limiting climate change will require substantial and sustained reductions of GHG emissions (IPCC, 2013).

2 Implications for transport infrastructure and operations

Climate change and associated extreme events will have significant impacts on the transport infrastructure/operations for all modes of transport (road, rail, shipping and air transport).

Transport infrastructure in low lying areas will be particularly at risk; islands (particularly the SIDS), which depend on coastal transport infrastructure will be also particularly exposed.
A questionnaire survey was carried out to better understand and assess perceptions, capacities and activities related to CC impacts and relevant adaptation policies and measures.

The questionnaire (consisting of 44 questions) was sent out to Governments and Organizations by the UNECE Secretariat; 34 responses were received.

Survey key messages

Two thirds of the respondents view CC as a serious challenge and 80% as a challenge for the next 30 years; in view of the long timelines in design/construction and the long infrastructure life span, immediate action/initiatives are required.

Target audiences for raising awareness: Public regulatory bodies and the industry; this ‘top-down’ approach may reflect the sample demography;

Major constraining factor: Lack of funds/competing priorities;

Transport specific adaptation plans at mid road: Concrete actions show large variety of adaptive actions/measures;

Development and/or planning of emergency response systems at mid road;

Data availability, suitability and quality: Negatively skewed answers (the Data Paradox);

Existing/potential funding mechanisms/sources: Mostly public sources;

There was a clear message for further research/study on CC risks/impacts and effective warning/adaptation measures, as well as an increase to the current levels of cooperation at the national/local level and regional/sub-regional level.
4 Potential adaptation measures to CC impacts

There is no market integration/globalization without resilient transport networks

Adaptation measures aim to reduce vulnerabilities and increase the resilience of transport systems to climatic impacts

In transport, resilience should not only concern the infrastructure physical robustness, but also the transport systems' ability to recover quickly and at minimal cost

Adaptation measures may be considered as ‘insurance policies’, planned/implemented to limit future operational/rehabilitation costs incurred by incremental climatic changes and/or extreme weather events

Developing effective adaptation strategies to CC impacts on transport requires both policy action and collaborative research; well targeted empirical vulnerability studies and risk and cost assessments are required to bridge knowledge gaps and identify priority areas

Approaches to technical CC adaptation measures are controlled by economic considerations; these constrain the global adoption of technical adaptation measures

The UNECE (2014) Report summarised examples of relevant adaptation measures implemented/planned in certain States (e.g. the UK, the US, Canada, France, the Netherlands and Poland) and Transport Organisations (e.g. SNCF, East Japan Railway Company).

5 General Recommendations (I)

The development/formulation of effective CC adaptation strategies requires the systematic mapping of the transport sector CC vulnerabilities that are determined by the CC nature/extent, the transport system sensitivity and the required capacity to adapt to changes. It was recommended that

(i) Governments, together with owners/operators of transport infrastructure and International Organizations should establish inventories of critical and sensitive nodes of the transport infrastructure to assess whether, where and when projected climate changes might have significant consequences;

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

(iii) Transport infrastructure/services are subject to regulation; thus, accommodation of CC adaptation measures may also require institutional/regulatory adaptation

(iv) Transport infrastructure planners/designers together with transport infrastructure managers, vehicle and rolling stock manufacturers should consider from the planning stage, CC projections and potential impacts at both global and regional scales
General Recommendations (II)

With regard to adaptation strategies, there are the following general recommendations:

(i) Without effective adaptation strategies/actions, resilience of transport networks may prove to be insufficient in the near-medium future. Proactive approaches are required that should include short- and long-term measures, consider economic constraints and guided by ‘Readiness’, ‘Resilience’ and ‘Recovery’ (RRR) principles.

(ii) Adaptation actions will be easier to implement if they would be integrated into existing natural hazard management frameworks.

(iii) Well-structured national/international databases of digitized transport network data, disruption hotspots/incidents, management and maintenance plans and asset management practices should form the core of a natural hazard management system; these should be also supplied with (software) tools that can project future risks.

(iv) Potential climate change impacts should be considered at the early planning stages and included in risk and vulnerability assessments. Future projects should integrate climate change considerations into their asset design and maintenance planning.

General Recommendations (III)

The study has shown that there are significant information and knowledge gaps. It is therefore recommended that:

(i) CC impacts and adaptation requires integration of a wide range of scientific disciplines.

(ii) Focused research should be undertaken for different CC impacts; such studies should be complemented by case studies on the potential economic, social and environmental consequences and the cost/benefits of adaptation options. For example, the riverine flood risk on road/rail networks could be assessed by simulations of the potential extreme flood hazard under different CC scenarios that will be transposed on road/rail networks to identify flooding ‘hot spots’.

(iii) 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.

(iv) In view of the interconnectedness/interdependence of the globalized trading system, the developing counties needs (particularly of the SIDS) must be considered.

(v) Cooperation must be fostered between relevant International Organizations/Agencies 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.
Thank you!

Global CC indicators: Trends


**Global mean sea level** relative to the 1900–1905 (mean of the longest running dataset, and with all datasets aligned to have the same value in 1993)(IPCC, 2013).

Independent analysis of different climate system components exhibit trends consistent with global warming (arrow direction shows the sign of the change), (IPCC, 2013)
Global CC indicators: Projections

Global mean surface temperature and sea level change forecasts for 2081-2100 (means, likely ranges) compared to 1986–2005, for different scenarios (after IPCC, 2013).

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Temperature</th>
<th>Sea level rise</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Mean (°C)</td>
<td>Likely Range (°C)</td>
</tr>
<tr>
<td>RCP 2.6</td>
<td>1.0</td>
<td>0.3-1.7</td>
</tr>
<tr>
<td>RCP 4.5</td>
<td>1.8</td>
<td>1.1-2.6</td>
</tr>
<tr>
<td>RCP 6.0</td>
<td>2.2</td>
<td>1.4-3.1</td>
</tr>
<tr>
<td>RCP 8.5</td>
<td>3.7</td>
<td>2.6-4.8</td>
</tr>
</tbody>
</table>

Projected changes appear to increase with time; for example, sea level rise projections by both the IPCC and independent research show an increase of the min-max ranges since 2007.

Recent sea level rise projections for 2100 compared to that of IPCC (2007a). Key: 1, IPCC (2007a), 0.18-0.59 m; 2, Rahmstorf et al. (2007); 3, Horton et al. (2008); 4, Rohling et al. (2008); 5, Vellinga et al. (2008); 6, Pfeffer et al. (2008); 7, Kopp et al. (2009); 8, Vermeer and Rahmstorf (2009); 9, Grinsted et al. (2010); 10, Jevrejeva et al. (2010); 11, Jevrejeva et al. (2012); 12, Mori et al. (2013); and 13, IPCC (2013, average for 2081-2100). Projection variability reflects differences in assumptions/approaches.

Extreme events: Trends and Projections

Trends in the frequency/intensity of climate extremes (arrow direction shows the change sign) since the 1950’s (for N. Atlantic storms since the 1970s). (IPCC, 2013)

It is very likely that there will be a significant increase in the occurrence of future sea level extremes by 2100, with extreme return periods decreasing by at least an order of magnitude in some regions.

It is likely that annual mean significant wave heights will increase in some regions (e.g. the Southern and Arctic Oceans), whereas the Pacific islands might also face more extreme precipitation due to tropical cyclones.
The main railway line to Sochi (Black Sea) will be in jeopardy, if the fronting beach is eroded – which, will be (red line) under 1 m storm surge and offshore waves with height \( H = 4 \text{ m} \) and period \( T = 7.9 \text{ sec} \).

**Coastal transport infrastructure risks**

**Sochi, S. Russia**

(a) Flood risk at US Gulf coast under sea level rise of 0-6-1.2 m (MSL+ storm surge); such rise could inundate > 2400 miles of roads, > 70% of the existing port facilities, 9% of the rail lines and 3 airports.

(b) In the case of a ~5.4-7 m rise (MSL+ storm surge), > 50% of interstate and arterial roads, 98% of port facilities, 33% of railways and 22 airports could be affected (CCSP, 2008).
Major climate change impacts on the different transport modes

<table>
<thead>
<tr>
<th>Factor</th>
<th>Road</th>
<th>Rail</th>
<th>Ports, IW and airports</th>
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</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>Road</td>
<td>Rail</td>
<td>Ports, IW and airports</td>
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<tr>
<td>Higher sea temperatures; Heat waves/</td>
<td></td>
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<tr>
<td>increased variability in winter/spring days</td>
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<td><strong>Source:</strong> UNECE, 2014</td>
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| **CC and transportation in SIDS**

International (maritime and air) transportation, crucial for the sustainable development of SIDS

SIDS transportation infrastructure has been mostly designed for typical weather patterns and, thus, is particularly vulnerable to the projected (extreme) conditions

SIDS are characterised by high exposure to sea flooding

- Large population densities at the coast
- Most infrastructure (including transport facilities), industry and services (particularly tourism) located at the coast
- Global hotspots for marine biodiversity

and elevated CC-induced risks due to

- Long-term sea level rise (SLR)
- Increased air and sea surface temperatures and ocean acidification, resulting in habitat losses that increase environmental risks and lower incomes (tourism)
- Increases in extreme events

Source: UNECE, 2014)
Transportation timeframes vs. Climate Change impacts

The Data Paradox

There is not enough data
- High quality Digital Elevation Models-DEMs rarely available
- Specific data on facility location, condition, costs (of inaction/action) unavailable
- Data are often poorly managed or non-existent

There is too much data
- Lots of climate data, but often conflicting or at irrelevant temporal or spatial scales
- Disparate data formats; even good quality spatial information requires significant manipulation
- Overwhelming number of tools, websites, and resources

(After Potter, 2012)