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

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

24 – 26 November 2014

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

Submitted by

UNECE, Transport Division

UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE

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

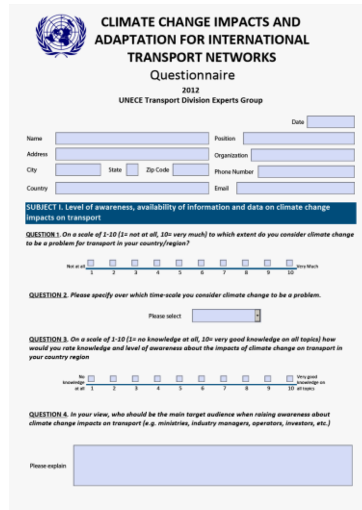
Climate change and associated extreme events will have significant impacts on the transport infrastructure/operations for all modes of transport (road, rail, shipping and air transport)

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

3 Questionnaire Survey

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



CLIMATE CHANGE IMPACTS AND ADAPTATION FOR INTERNATIONAL TRANSPORT NETWORKS

Questionnaire

2012

UNECE Transport Division Experts Group

Date

Name | Position

Address | Organization

City | State | Zip Code | Phone Number

Country | Email

SUBJECT I. Level of awareness, availability of information and data on climate change impacts on transport

QUESTION 1. *On a scale of 1-10 (1= not at all, 10= very much) to which extent do you consider climate change to be a problem for transport in your country/region?*

Not at all 1 2 3 4 5 6 7 8 9 10 Very Much

QUESTION 2. *Please specify over which time-scale you consider climate change to be a problem.*

Please select

QUESTION 3. *On a scale of 1-10 (1= no knowledge at all, 10= very good knowledge on all topics) how would you rate knowledge and level of awareness about the impacts of climate change on transport in your country region*

No knowledge at all 1 2 3 4 5 6 7 8 9 10 Very good knowledge on all topics

QUESTION 4. *In your view, who should be the main target audience when raising awareness about climate change impacts on transport (e.g. ministries, industry managers, operators, investors, etc.)*

Please explain

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 quided 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 panning 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’

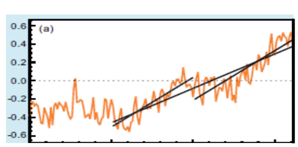
(iii) Initial assessments of the transport sector vulnerabilities are possible without a detailed knowledge of future climatic changes; these assessments can be based upon the analysis of the sensitivity to past climatic variability and the current capacity of the systems to absorb disruption and adapt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

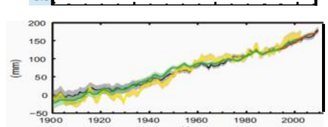
(v) Cooperation must be fostered between relevant International Organizations/Agencies to institute a process for better communication among transport professionals, climate scientists, and other relevant scientific experts, and establish, if possible, a clearing house for transport-climate change relevant information.

Thank you!

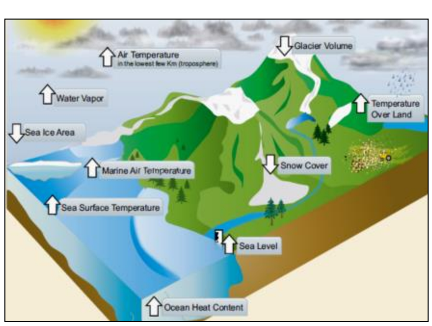
Global CC indicators: Trends



Global mean surface temperature anomalies (in ^{0}C relative to 1961–1990. Key: black lines are least squares trends for 1901–2012, 1901–1950 and 1951–2012. (IPCC, 2013)



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).



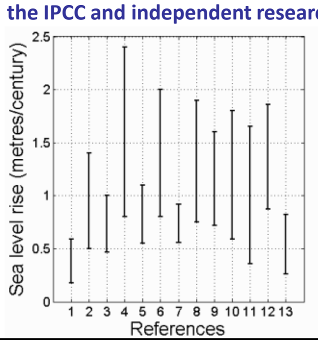
Independent analysIs of different climate system components exhibit trends consistent with global warming (arrow direction sjows the sign of the change), (IPCC, 2013)

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).

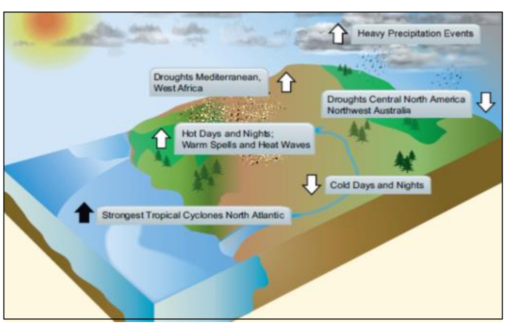
Scenario	Temperature		Sea level rise	
	Mean (°C)	Likely Range (°C)	Mean (m)	Likely Range (m)
RCP 2.6	1.0	0.3 - 1.7	0.40	0.26-0.55
RCP 4.5	1.8	1.1- 2.6	0.47	0.32-0.63
RCP 6.0	2.2	1.4-3.1	0.48	0.33-0.63
RCP 8.5	3.7	2.6-4.8	0.63	0.45-0.82

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 20181-2100). 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)

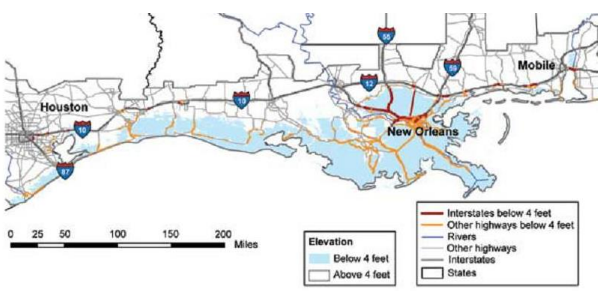
It is *very likely* that there will be a significant increase in the occurrence of future sea level extremes by 2100, with extreme return periods decreasing by at least an order of magnitude in some regions

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 .

Coastal transport infrastructure risks

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 m and period (T) = 7.9 sec.

US Gulf Coast inundation risk



(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

Factor	Impacts		
Temperature	Road	Rail	Ports, IW and airports
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Temperature	Road	Rail	Ports, IW and airports
Higher mean temperatures; Heat waves/ oughts;Increased variability in warm/cool days	Thermal pavement loading/ degradation; asphalt rutting; thermal damage of bridges; increased landslides in mountains; asset lifetime reduction; increased needs for cooling (passenger/freight) and, thus, fuel; shorter maintenance windows; increased construction and maintenance costs; changes in demand	Track buckling; infrastructure and rolling stock overheating/failure; slope fires and failures; electronics and signaling problems; speed restrictions; asset lifetime reduction; higher needs for cooling/ fuel; shorter maintenance windows; increased construction and maintenance costs; demand changes	Damage to infrastructure, equipment and cargo; higher energy consumption for cooling cargo; lower water levels and restrictions for inland navigation; air transport payload restrictions; warmer weather will reduce snow/ice removal costs and extend the construction season
Permafrost degradation and thawing; Reduced arctic ice	Road buckling; decreases in travelling days; slope instability and embankment failures; coastal erosion affecting coastal roads	Rail track damages; slope instability and embankment failures; freight and passenger restrictions	Damages in port and airport infrastructure; longer shipping seasons-NSR; shorter shipping routes-NWP/less fuel costs, but higher support service costs
Precipitation	Road	Rail	Ports, IW and airports
Changes in the intensity/frequency of extremes (floods and draughts)	Inundation; increased landslides and slope, earthwork and equipment failures; impacts on vital nodes e.g. bridges; poor visibility that increases accidents; more frequent slush flows; delays; changes in demand	Submersion, bridge scouring, problems with drainage systems and tunnels; landslides; underground flooding; embankments/ earthwork damages; operational problems; delay, changes in demand	Land infrastructure inundation; damage to cargo and equipment; navigation restrictions in inland waterways due to droughts;
Winds/thunder storms	Road	Rail	Ports, IW and airports
Changes in frequency and intensity of events	Damages to fence; road accidents	Damages to installations and catenary; overvoltage; disruption to operations	Problems in vessel navigation and berthing in ports
Sea level/storms	Road	Rail	Ports, IW and airports
Mean sea level changes;	increased risks of coastal inundation and erosion	Bridge scour, Installations/ Catenary damage,	infrastructure/cargo damages from inundation and wave energy
Increased destructiveness of storms/storm surges; Changes in wave energy and direction	affecting coastal roads; temporary inundation, Unusable roads during storm surge	Restrictions/Disruption of train operation, Embankments/ Earthwork flooding	changes; higher port construction and maintenance costs; sedimentation in port/ navigation channels; effects on key transit points (e.g. the Panama Canal); people/ businesses relocation, insurance issues

Source: UNECE, 2014)

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

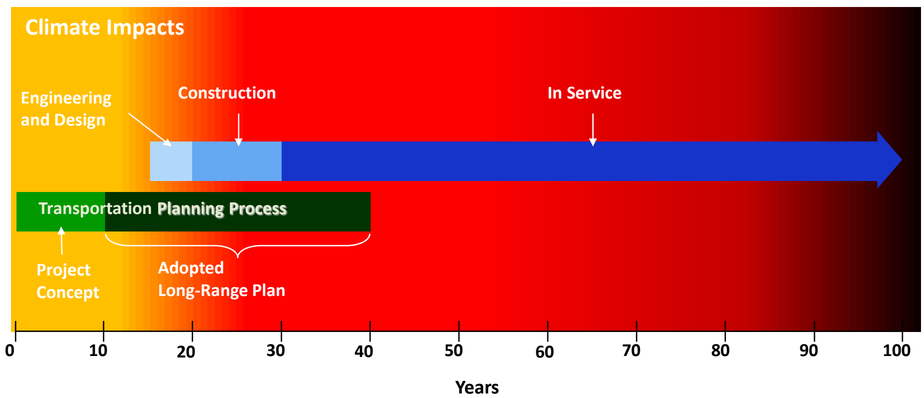
SIDS are characterised by high exposure to sea flooding

- 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

Transportation timeframes vs. Climate Change impacts



Source: After Savonis, 2011

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)