ToPDAd

TOOL-SUPPORTED
POLICY-DEVELOPMENT
FOR REGIONAL ADAPTATION

ADAPTATION AND RESILIENCE OF THE TRANSPORT SECTOR

Results of the ToPDAd
research project, 2012–2015

Executive summary

ADAPTATION AND RESILIENCE OF THE TRANSPORT SECTOR

Climate change affects the European transport system in many ways and the impacts will differ across the world. It entails physical damage to transport infrastructure, more maintenance costs and more traffic disturbances and disruptions. For global logistics, climate change will increasingly affect routing, as well as where companies have their transport hubs.

From this large variety of impacts ToPDAd selected four themes for analysis, guided by a broad review and stakeholder consultation. For each of the themes, we assess the effectiveness of various adaptation options, under various climate change scenarios. Adaptation in the transport sector does not only cover investments in infrastructure but also information provision and innovation. The latter options are usually cheaper than changes to infrastructure yet are useful as intermediary or complementary adaptation steps.

The first adaptation strategy ToPDAd considers is the provision of weather-related travel information. Based on a case study of heavy precipitation and travel disruptions in Zurich, we show that travel information can reduce the costs of extreme events with up to one third by helping users to avoid congestion through a combination of choosing other routes or rescheduling activities.

The second study simulates a one-hundred year flooding in London under different climate scenarios and with different levels of damage, with the aim of comparing two possible adaptation strategies: establishing a fund to finance damage repair versus investment in flood defence systems like flood barriers. We find that a fund will speed up damage repair when the damage is limited. In case of big damage, however, a flood defence system is more cost-efficient.

A third study analyses what is the optimal timing for investing in the resilience of the transport infrastructure. The results shows that especially long-lived infrastructure like bridges and railway lines, need to be climate-proofed already now.

The fourth study analyses whether the retreat of the sea ice cover in the Arctic could turn the North-East Passage or the so-called Northern Sea Route (NSR) into a competitive route for container shipping from Europe to Asia. We conclude that by 2050 the NSR might take a small share of container shipping with mid-size container vessels, in combination with the Suez route. Yet there are important environmental concerns linked to this route.

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Key findings

Providing traffic information as an adaptation strategy for urban downpours

Using integrated weather & travel information to inform travelers can reduce the aggregate costs of traffic disruptions with about one third. Taking into account the moderate implementation cost of these options, they are cost-effective ways to increase the resiliency of the transport sector. Supplying on-route information to travellers reduces travel time increase until the moment when about half of the travellers are informed. Informing more may no longer have an effect.

Cost-benefit analysis of flood defence versus a recovery fund in London

Physical measures such as flood defence systems reduce risk of flooding by about 40% in the case of London. However, this adaptation strategy is expensive and is only effective when climate change becomes especially strong.

The exposure of a city like London to a one-hundred year flooding would lead to important GDP losses. In this case, physical adaptation measures become an effective and cost-effective way to adapt.

The additional benefit of combining physical measures with less costly measures like a recovery fund is small.

The optimal timing of investing in resilience of transport infrastructure

Proactive adaptation, before damages from climate change occur, is to be preferred. Reactive adaptation, in reaction to extreme weather events, often leads to wrong investment decisions, which can increase the vulnerability for other events in the future.

Under an optimal investment scenario, transport infrastructures with a long lifespan should be made climate-resilient first. Railways, ports and airports are the most critical, followed by tracks, bridges and rolling stock. Given their longevity, these should be able to withstand the climate conditions of 2050 and 2100.

Long-term predictions and the establishment of national or international adaptation funds are crucial for optimal investment planning.

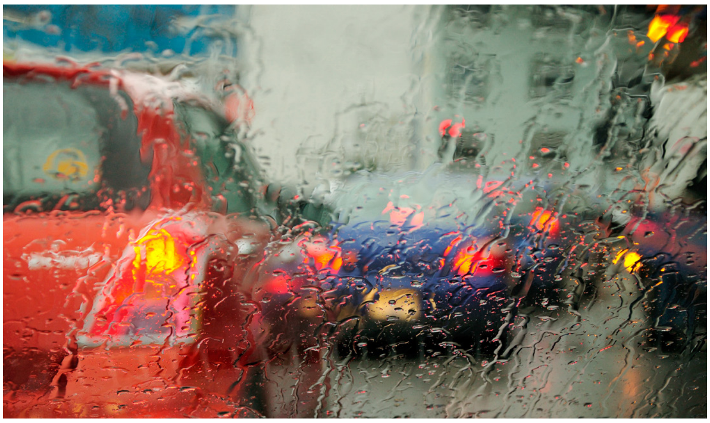
Resilience of maritime trade flows on the Northern Sea Route

The retreat of the Arctic sea ice cover, while being an important environmental threat, may shorten sea routes between Europe and Asia, improve access to numerous ports and thus be beneficial for maritime transport.

Under reasonable conditions, a regular transit of container vessels combining the Suez and NSR route is possible. However, the volume of goods transported via the NSR in 2050 will remain limited to 2 to 5% of the overall container market volume in Europe and Asia, or 5 to 30% of the overall value of this market.

Overall, the NSR's potential remains limited even under optimistic market conditions and high levels of climate change. So, the possible benefit for maritime transport does not justify a delay in efforts to counter Arctic ice melting.

Assessing the cost of traffic disruptions as a result of extreme downpours



Extreme downpours are projected to increase in severity and/or frequency in most parts of Europe due to climate change. This entails high risks for large built-up areas in particular. These areas contain more critical infrastructure, while a high share of hard surface makes storm water treatment difficult. Many EU Member States have made or are planning risk assessments of natural hazard related damages to transport infrastructure. The disturbance and disruption effects of extreme weather on traffic have been studied less.

Using the Swiss city Zürich as an example, ToPDAd assessed the economic impact of urban downpour by means of the MatSim traffic model. The extra travel costs caused by extreme downpour in a medium-sized city like Zurich, range between 7 million to 32 million euro per year. For Switzerland cost estimations range between 20 and 94 million euro. These figures are based on one-day disturbances or disruptions and only concern passenger transport. The real costs of disruptions due to extreme precipitation events can be significantly higher as one should add multi-day disruptions, additional logistic costs and the cost of damage to infrastructure.

Tentative upscaling of the Swiss figures to EU-level results in additional costs of between 0.3 billion to 1.5 billion euro. The upscaling is based on the GDP share of the Swiss economy as compared to the GDP of the EU (in 2010). The EU estimate presented here overlaps with the time cost estimate of EUR 0.5 ~ 1.0 billion in the FP7 EWENT study (Nokkala et al 2012).

Providing traffic information as an adaptation strategy

How badly traffic gets disrupted or disturbed under extreme events, depends to a significant degree on how well informed different actors in the system are and to which extent they let this new information prevail over their default choices and habits. ToPDAd explores these information and response processes, which are so far not very well studied. Having a better insight in how travellers can alleviate negative effects on the road network can help us adapting to extreme events. The provision of traffic & weather information can induce a broad range of responses by travellers. We range common behavioural changes below according to their impact (from strongest to smallest):

1. Cancelling of the trip
2. Rescheduling activities, changing time and duration
3. Changes in the location where the activity is performed, such as working at home
4. Change transport modes
5. Changes in trip routing

In our study, the above responses were grouped in two response levels:

1. Changes in activities & timing: Cancellation or change timing of a trip (meaning replanning of activities that day)
2. Changes in transport choices: Rerouting and changing transport mode (meaning more travel time and/or additional travel expenses)

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The simulations of the MatSim model indicate that informing travellers adequately can reduce the costs of disruptions and disturbances by about 1/3. Of this reduction, about 70% is realised through changes in the daily schedule (response level 1).

Rerouting and modal change (response level 2) are effective strategies, but the benefits per traveller decrease as more travellers get adequately informed.

Supplying on-route information to travellers is beneficial until the moment when about half of them are informed. Informing more may no longer have an effect. The reason is twofold: 1) the overall system reaches an optimum situation when a certain amount of travellers switches routes and 2) travellers may overreact to new travel information, reducing its efficiency.

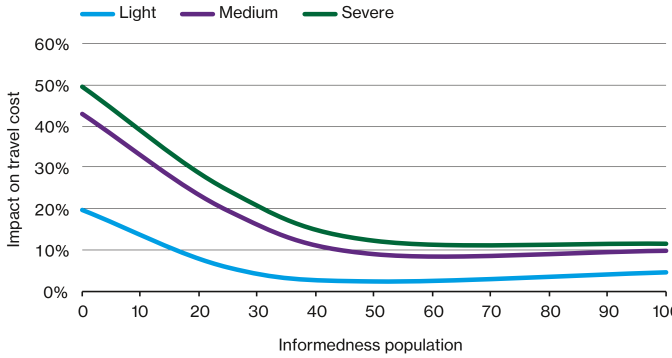

Figure 1: The relation between travel information and travel time

Impact of investments in physical infrastructure in case of flooding

This study simulates flooding and the resulting damage in the greater London-area, caused by a one-hundred year extreme downpour, and evaluates different adaptation strategies.

Compared to the Zurich case study, the London case concerns much longer disruptions, with long-term reductions in economic activity due to limited access. While the Zürich case study was about adaptation strategies at operational level, this case study is about long term recovery from extreme events in larger cities. A substantial part of the damage will be transport related, as the flooding will block access to businesses and offices.

The research builds on the ARCADIA assessment of the vulnerability of London's economy to extreme climate events. This study used a city-level macro-economic model (ARIO) to analyse the impact of damaging production capacity. The simulation imitates a one-hundred year pluvial flooding in London in the years 2015, 2050 and 2100, including both its direct and indirect economic impacts. Combining these results with insights from the simulations for Zürich, this study considers two possible adaptation options for London:

1. Establishing a city-wide priority recovery fund for sectors that are critical in the economic recovery process (transport, construction materials, communication)
2. Physical investments in flood defences to reduce the overall flood risk, protecting several vulnerable sectors (transport, tourism, energy)
3. A combination of both strategies

ToPDAd examines how each of the above scenarios, as well as a baseline scenario without adaptation, would affect London's GDP. This is done for three different climate change scenarios

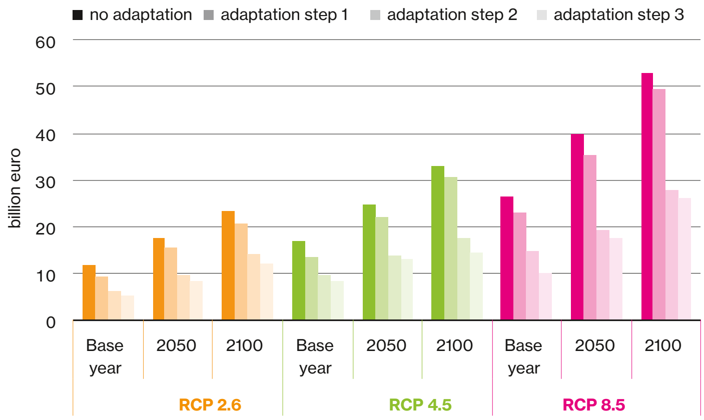

Figure 2: Cost-benefit analysis of recovery fund versus flood defence measures in London

(RCP 2.6, RCP4.5 and RCP 8.5 – representing different pace and impacts of climate change) and on different timescales (2050 and 2100). The simulations (see Figure 2) show that exposure to a one-hundred year flooding would cause an important loss in GDP for London (at city-level). The GDP loss ranges between 15% and 40% in 2050 and 22% to 53% in 2100. Physical measures reduce risk of flooding by about 40% in the case of London. The additional benefit of combining physical measures with a less costly priority recovery fund is small, compared to physical measures only.

The results can help decision makers to direct adaptation funds in order to ensure the greatest reduction in the vulnerability of the city's economy to extreme weather events. The methodology can be applied to any community, nation or region for which the necessary input-output data are available.

The optimal timing of investments in adaptation

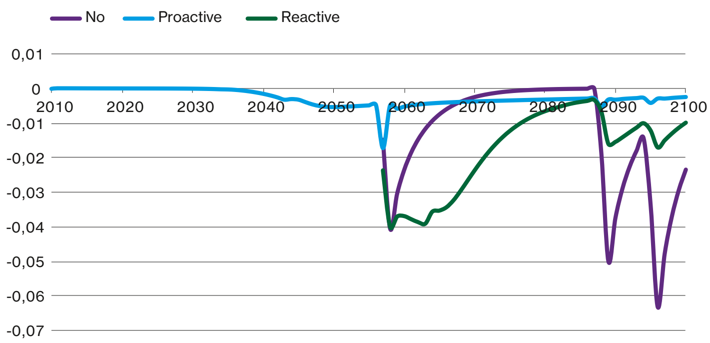

Figure 3. % Deviation of GDP as compared to GDP development without extreme events in three adaptation approaches (none, full-proactive, reactive)

The increase in both frequency and intensity of extreme weather events has sparked research about adaptation. Many decision makers still struggle with the question when they should invest in adaptation measures. Climate change is a slow process, with large uncertainties on the eventual effects. Making a solid model for investments in adaptation & mitigation is especially hard. This study proposes an innovative approach, coupling an optimal investment module with a macro-economic model for the EU (EDIP). This was set out against climate models that predict gradual and increased occurrence of extreme events from 2010 to 2100.

We distinguish two types of adaptation in this study: reactive adaptation means that the adjustment to the new conditions follows on events perceived as damaging or extreme. Reactive measures drift on the surge in political support after the event. Proactive adaptation aims at adopting infrastructure and operational processes, before the actual damage has happened but based on expected future climate conditions and extremes. We call this an optimal investment scenario or full adaptation. In most countries, reactive adaptation is the norm, even though a proactive strategy may lead to significantly lower costs on the long term.

However, decision makers are often uncertain about the future damages from climate change and therefore afraid of taking “wrong” adaptation decisions (maladaptation). Our study shows that risk for maladaptation and the potential GDP loss is higher in the case of reactive adaptation than under an optimal investment scenario. Decision makers may react to seasonal events that according to climate projections will only occur seldom or occasionally. This increases the exposure to future extreme weather events, rather than increasing resilience.

The vital element to consider in adaptation planning is the longevity of infrastructure. Railways, ports and airports are the most critical with respect to their long-term exposure. Tracks and bridges can endure up to 100 years. Rolling stock is at risk as well, with lifetimes up to 40 years. The long lifetime of these infrastructures requires a design that meets conditions that have a low occurrence today, but will be more common by 2050 and 2100. While road signs and other traffic signaling are important for the current resilience of the system, they have little relevance for the long-term climate adaptation strategies for the next 50 years.

Resilience of maritime trade flows

In the final transport case study, ToPDAd assesses whether the North-East Passage or the so-called Northern Sea Route (NSR) could become an alternative to existing routes for maritime container traffic. The NSR is an overarching name for a number of fairways that go from the Bering Strait, in the east, to Novaya Zemlya, in the west. It is a stretch of roughly 2100 to 2900 sea miles, which runs mostly along the Northern shore of Russia.

For a long time, using this route on regular commercial basis was considered unrealistic. However, with the Arctic ice cap melting, several actors are now prospecting for shipping containers via the NSR. There are multiple arguments against exploiting the NSR, including the shallow passages, the need for icebreakers, the lack of infrastructure, and environmental damage. However, using this route could potentially reduce the distance from Northern Asia to Northern Europe with 35–40%. This implies a faster transit (+-10 to 15 days) and a significantly lower fuel consumption (+-20 to 30%).

This study focuses on bulk transport of minerals and oil or gas transport, which is also the main interest of the maritime sector. In particular, we evaluate the prospects for container transport to Europe. The European market is large, about 20 million TEU in 2011, and is expected to double by 2050.

Adaptation to climate change in this case means investing to enable a better use of the stretch, e.g. modifying and retrofitting existing ships and upgrading of ports and navigation services along the route, as well as avoiding damage to the environment.

We apply a model of the global container market called the World Container Model to assess the potential of this route. The modeling also takes the interdependency of the European economy and global economies into account, including how climate change might affect global trade conditions.

The results show that under reasonable conditions, a regular transit of container vessels combining the Suez and NSR routes is possible. However, the pace of ice cover retreat is uncertain in the current climate scenarios. Whereas at the long term access will improve, the NSR is subject to decadal variations, meaning that years with reasonable access for (Polar-class) container ships may be followed by years with limited access.

The trade potential of the NSR in terms of volume remains rather limited at values between 1 to 2.5 million TEU or around 300–900 transits per year in 2050. This represents between 2 and 5% of the overall container market in 2050 in volume and 5 to 30% of the overall value transported.

The route faces competition from the Trans-Siberian Railway (TSR) for the handling of high-value and time-dependent goods. Large investments in the Trans-Siberian Railway further reduce the potential of container traffic on the NSR.

Models used in transport case studies:

The **World Container Model (WCM)** is a transport network model used to predict changes in global container flows. It is a strategic model that can make predictions up to 2050. In ToPDad it is used to predict the potential traffic on the Northern Sea Route

EDIP is a CGE (Computable General Equilibrium) model of 31 European countries. The primary aim of the model is to assess transport policy impacts on equity and on income distribution, but it also assesses energy and environmental effects. For ToPDad EDIP was extended to handle forward-looking investment in adaptation.

ARIO or **Adaptive Regional Input-Output model** was originally developed for disaster modelling using a modified input-output structure to model recovery patterns after disasters. For ToPDad and similar projects, the model was extended with the capacity to assess specific adaptation strategies. ARIO was used in the case study of London

MatSim is an agent-based microsimulation model that has been designed to model changes in behaviour and timing of activities corresponding to changes in the transport network. It has been used for disaster modelling (evacuation), but in this project, it was used to model travel disruptions and rescheduling of activities in the presence of weather disruptions.

About the ToPDAd toolset and project

ToPDAd

TOOL-SUPPORTED POLICY-DEVELOPMENT FOR REGIONAL ADAPTATION

ToPDAd stands for "tool-supported policy development for regional adaptation" to climate change. This EU-funded research project developed a toolset to help decision makers at various levels – from individuals and private businesses to national and European policy makers, mapping future challenges related to climate change adaptation and making a cost-benefit analysis of different adaptation strategies.

The ToPDAd toolset integrates climate scenarios and socio-economic data from 15 existing models, allowing for an integral assessment of adaptation strategies. It builds on a broad range of data – from the impacts on choices of transport routes and tourist destinations to impacts on macroeconomic indicators, such as GDP, sector composites, market prices and greenhouse gas emissions.

Decision makers at local level or SMEs often sit on different information than national decision makers or multinational companies. Therefore, national or European adaptation strategies may imply limitations, barriers and constraints to local initiatives for increasing climate resilience, and vice versa. By bringing together information from different sectors and disciplines and combining the output from both micro- and macro-models, ToPDAd is among the first to show strong interdependencies between various sectors and decision levels.

To demonstrate its potential, the ToPDAd toolset was applied in seven case studies about three economic sectors – energy, tourism and transport. While starting from local events and situations, the results of these studies are also relevant for and applicable in wider regions in Europe. The cases look forward to 2050 and some to 2100, while applying different climate scenarios, based on combinations of the climate pathways (RCPs) and socio-economic pathways (SSPs).

The case studies cover the following themes: (1) summer beach tourism, (2) winter skiing tourism, (3) the effects of extreme events on traffic in cities, (4) new potential arising for shipping as a result of Arctic ice melting, (5 & 6) effects of climate change on energy production (renewable energy and nuclear energy), and (7) the macro-economic impact of extreme rainfall in cities.

In addition, ToPDAd studied the potential consequences of climate change on public health and assessed adaptation strategies from a macro-economic perspective. Available studies on the impacts of climate change on public health focus primarily on mortality under heat waves. Adaptation strategies therefore focus mainly on monitoring vulnerable people during heat waves and enhancing services to tackle heat stress. This is for example relevant for beach tourism, which is one of the case studies of ToPDAd. Integrating the available knowledge on health impacts in a macroeconomic model however reveals some broader consequences of climate change on public health. While some affected people might need surgery, others will need to rest more and become less productive. This may also affect labour productivity. In other words, adaptation strategies need to go beyond monitoring vulnerable people, but also need to take into account the labour market. Again, these results show the importance of an integral cost-benefit assessment of adaptation strategies, as is done with the ToPDAd toolset.

For more information on the research project and its outputs, visit www.topdad.eu or explore how results may be relevant for your sector or region with the interactive tool at http://topdad.services.geodesk.nl/.

The research project ran from October 2012 to September 2015 and received EUR 4 556 233 in funding by the European Union's research programme FP7 under agreement number 308620. It involved ten research institutes from nine European countries, coordinated by VTT Technical Research Centre of Finland Ltd.

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