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Case study on the Development of a Climate Adaptation Strategy for the InnovA58 highway in the Netherlands*

Submitted by the Government of the Netherlands

I. Introduction

1. This document contains a case study on the Development of a Climate Adaptation Strategy for the InnovA58 highway in the Netherlands. The Group of Experts requested at its sixteenth session that this case study is tabled as on official document at the seventeenth session.

II. Brief information on the national framework as basis for conducting infrastructure climate change impact assessments

2. The impact of climate change on roads is mainly associated with extreme weather events related to temperature and precipitation, like heat, drought and intense rainfall. Also changes in hydrogeological conditions, like the rise of sea levels and ground water levels, may affect road infrastructure. In the Netherlands climate adaptation is particularly concerned with the impact of extreme drought, heat, precipitation and floods. The Delta

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Programme describes these as the ‘four threats’ of climate change, which need specific attention. The impact of these threats is context dependent, hence, when it comes to adapting to climate change, localized solutions are required. When it comes to infrastructure, attention should be paid to the fact that most parts of road networks cross multiple borders managed by multiple authorities and levels of government. Therefore, a regionally tailored approach provides an opportunity to create better and more sustainable infrastructure development. With area-oriented approaches, innovative and effective combinations between road infrastructure and other spatial policy sectors, like recreation, water, nature, housing and agriculture, including climate adaptation measures in the area not directly related to the road, can be made.

3. In short, the road infrastructure system needs persistence, adaptability, transformability and preparedness to be able to cope with the impact of new and uncertain climate situations in the future. For this, an area-oriented approach is crucial, since climate change has an effect on the roads in relation to the surrounding environment and vice versa. Moreover, this approach offers the possibility of smart combinations of measures by combining other challenges in the surrounding environment with the climate adaptation challenge of the road infrastructure.

III. Process for assessments

4. To develop climate adaptation strategies for the Dutch highway network, InnovA58, part of the A58 highway, situated in the provinces of Zeeland and Noord-Brabant in The Netherlands, was used as a case. The InnovA58 project, consists of both an extension of the existing A58 highway (with extra driving lanes) over 50 km in length as well as major maintenance and refurbishment. Besides that, InnovA58 is part of a broader regional program focused on integration of urban, natural, recreational and environmental challenges which offered the opportunity to imply an area-oriented approach.

5. To assess the risks, vulnerability and possible measures, a process was designed to develop an adaptation strategy for InnovA58 and the surrounding environment from September 2016 to February 2017. Attention was payed to the surrounding environment, since possible measures that contribute to the resilience of the road can be found in the surrounding environment. However, increased resilience in one place may lead to decreased resilience elsewhere and therefore involvement of local stakeholders and experts was of high priority in this process.

6. After the scope was determined, a stepwise process was designed to develop an adaptation strategy (table 1). The process consisted of three steps according to the ROADAPT[1] methodology and a fourth step using the Dynamic Adaptation Policy Pathways. In the first step, climate threats, key risks and potential measures were scanned, through two joint workshops, with experts and asset managers from Rijkswaterstaat, Deltares and local stakeholders, like municipalities, water boards and provinces. In the second step, the key risks were mapped to determine the places where the key risks can occur on the road. The output of the first two steps were then analysed on costs, benefits and effectiveness. Finally, an adaptation strategy was developed with the Dynamic Adaptation Policy Pathways. In Table 1 the above described steps of the study are summarized.

[1] Roads for today adapted for tomorrow project

Table 1
InnovA58 climate adaptation approach

Process steps	*Actions taken*
Quick scan	Two Workshops: • To determine climate threats for the A58 infrastructure and surrounding environment • To determine key risks and potential measures
Vulnerability Assessment	Assessment GIS-methodology for mapping distinctive vulnerabilities in the road network
Socio-economic Impact Assessment	Two methods: • Cost Effectiveness Analysis • Cost Benefit Analysis
Adaptation Strategy	Dynamic Adaptation Policy Pathways to determine an adaptation strategy

IV. Assessment methodologies

7. In the Quickscan-workshops, experts from Rijkswaterstaat, Deltares and local stakeholders identified unwanted events of current and future weather that pose the greatest risks for the A58 and its surrounding environment. These risks were then combined in risk matrices and each number represented a different extreme weather-related risk.

8. For the risk assessment, a semi quantitative approach was adopted. This means that both likelihood and impact have been scored using classes 1 to 4. The classes themselves were determined in the workshops. The higher the number for probability, the higher the likelihood; the higher the impact class, the higher the consequences. Due to climate change the probability of these risks change in the future. After risk evaluation with the stakeholders five key risk were identified (see Table 2) including possible measures for which an adaptation strategy.

Table 2
Identified key risks and possible measures

Key risks	*Possible measures (examples)*
Flooding of infrastructure as a result of inundation	• Enlarge capacity of the existing bridges (wider/higher) • Improving water storage of rainwater drainage of the road (slower discharge into the streams) • Laying the road higher • Adjusting road design so that road may flood plus diversions • Realizing upstream water storage (‘room for

Key risks	*Possible measures (examples)*
	the ditches/streams', other vegetation, slower afflux to the stream) • Pumping water from the one side to the other side of the road when there's high water
Flooding of infrastructure due to extreme precipitation	• Increase capacity of rainwater drainage system • Use gutters rather than gullies • Guarantee flatness of longitudinal profile of the road • Build water storage under or next to the road • Dimension/ design intersections for intense precipitation • Use of 'pluvial flooding culverts'
Erosion of Embankments	• Improving erosion protection
Loss of safety due to splash and spray	• Better-draining asphalt (thicker) or vertical/central drains under the asphalt • Lowering the emergency lane • Better management and maintenance of the verges and rainwater drainage • Adaptive lighting/ notification on the road
Flooding of streams and urban areas due to extreme precipitation	Pumps' longitudinally to road, from wet to dry places • Store water and add it again during drought ('wadis') • Infiltration of pump water into aquifers • Make sure rainwater does not drain into urban drainage system

9. Then the ROADAPT Vulnerability Assessment was carried out to analyse the vulnerability of InnovA58 for related current- and future weather circumstances in more detail. The vulnerability assessment resulted in several vulnerability maps, presenting the most vulnerable locations of the project. This provided the starting point for more detailed location specific analysis, to examine whether a key risk constitutes an unacceptable risk for the road and the environment, and whether or not measures can and should be taken.

10. Subsequently, the ROADAPT Socio-economic Impact Assessment provided an analysis whether specific climate change related measures could be potentially viable. This analysis has been made by assessing the economic impact of congestion (related to the loss of travel time) due to climate related events and the chances of occurrence of these events. Furthermore, the benefits of measures have been scored using a multi criteria approach (relevance/effectiveness, flexibility, robustness, maintenance and lifecycle costs and secondary benefits). Last, a cost effectiveness analysis and a cost benefit analysis of the potential measures were made.

V. Conclusions and outlooks

11. Previous literature on resilience and adaptive planning approaches for infrastructure mainly focused on the need of regionally tailored approaches to foster resilience and climate adaptive environments. However, literature on the actual design of resilience and adaptive planning for infrastructure is scarce.

12. The ROADAPT method provides a clear structure of generating risks, opportunities, consequences and possible measures. In addition, the Dynamic Adaptation Policy Pathways provide insight into which measures can be logically combined into an adaptation strategy. However, the methodologies are highly dependent on the input of involved experts. Local knowledge is essential, since local stakeholders often have location specific knowledge that can lead to realistic and better solutions. Looking at the environment holistically, rather than merely focusing on the road, is important to increase climate resilience, since knowledge about local water systems, ecology and urban planning is crucial to match possible measures for the road to measures that are beneficial for the environment and vice versa. For the A58 project 'matching solutions' with other goals provided opportunities to achieve multiple goals.

13. However, in the process it proved difficult to integrate information from stakeholders of the area surrounding the road with information of the road itself. The ROADAPT methodology has primarily been designed specifically for roads, being line- and object oriented, rather than area-oriented. The methods are also technical in character and focus mainly on the functionality of the road. This made it more difficult to make an integral assessment of the climate resilience of the road as an integral part of the surrounding environment. Also, attention should be paid to the differences in the perception of urgency between the different involved stakeholders when applying an area-oriented approach. Climate resilience for road infrastructure is a new issue for Rijkswaterstaat, whereas several stakeholders in the InnovA58 project area have already experienced the effects of extreme weather on the environment. However, within the Rijkswaterstaat organization the lack of urgency and knowledge makes it difficult to translate resilience and adaptive planning into practice.

14. The Dynamic Adaptation Policy Pathways may help to address these issues, since the pathways plot potential measures against normative climate parameters. This may help authorities and engineers to assess which measures are needed and when they are needed to achieve climate resilient roads and environments, whilst still being able to make adjustments in the future.

15. The ROADAPT methodology aims to increase the robustness of the A58, through the vulnerability assessment and the development of potential physical measures. The adaptation pathways provide a means to design a road with measures that increase resilience, whilst still being able to adjust to future circumstances. This fosters the adaptability and transformability of the road and the surrounding environment. 'Matching solutions' with other goals for the A58 provided a further chance to increase the adaptability of the infrastructure.

16. However, the social learning capacity is not addressed, which is a vital element to be able to move towards more desirable state of the road and environment, by learning from previous events.