Netherlands Ministry of Infrastructure and Environment
Delta Programme – Urban Development and Reconstruction

Guideline for Stress Testing the Climate Resilience of Urban Areas

Extended summary

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Introduction

The guideline for stress testing climate resilience of urban area facilitates effective investigation into climate resilience of your urban area. It also assists in planning measures to adapt living environments to more extreme climatic conditions. The guideline provides an approach to collecting knowledge and information about:

a. Sites vulnerable for flooding, drought and heat stress;
b. Potential adaptation measures to reduce this vulnerability.

This guideline is part of the knowledge portal Spatial Adaptation (www.ruimtelijkeadaptatie.nl also available in English). The document is a guideline, meaning that other approaches to conducting a stress test are equally applicable.

Climate resilience is about dealing with the vulnerability of our urban system to extreme weather including heavy rainfall, drought, heat and fluvial and coastal flooding. Next to substantial material and economic damage, damage can occur to public health and emotional wellbeing. This is all to be taken into account when making decisions on spatial adaptation for creating climate resilience.

Insight into the functioning of a water system, in particular during extreme weather events, is essential for testing the actual resilience of urban areas; this includes its interaction with the water in its rural surroundings. Equally important is in-depth insight of the urban plan, infrastructure, objects and functions; these determine how sensitive the area is for damage from extreme weather events. Moreover, knowledge of the subsurface, soil, groundwater and land subsidence is required to understand the slowly changing conditions that are relevant for strengthening climate resilience.

Stress testing climate resilience

Key questions for the stress test are: How capable are we to prevent climate damage? And how capable are we in minimizing the damage in case our protection systems are overloaded by extreme weather and damage is unavoidable? Adaptation measures are meant to achieve this.
Probably, for some of you this will all be new. Others are already working on data collection and/or adaptation planning. Either at local or at regional scale, with municipalities, water authorities, consulting firms, urban planning and design offices and so on. Consequently, each of you have your own information demands, and each project requires its own approach. This guideline is therefore no more than a guideline that needs adaptation to each local situation you have to deal with.

Reasons for stress testing urban resilience

Sustainable economic strength, social and competitive attractiveness of an urban area often are accepted reasons for starting stress testing. But quality of life in urban areas is subject to more challenges beside climate change. Other challenges such as intensified investments per hectare, increased mobility, new technologies, public health concerns or increasing public expectation of a perfectly functioning environment are valid arguments for adaptation too. Land subsidence, a consequence of drought and low groundwater levels, aggravates our vulnerability to flooding and is therefore essentially included in our vulnerability scan and adaptation planning.

Two phases

The stress test is essentially split into two parts:

a. Vulnerability scan
   This first 'light' phase is meant to identify the most vulnerable spots in town, the urgency of adaptation and potential adaptation strategies and measures. Vulnerable objects, networks and groups get extra attention. The scan is based on existing data and knowledge; knowledge gaps are being identified.
b. Adaptation planning
   Aimed at planning and agreeing on an adaptation plan, alternative solutions are being evaluated. Synergies with other reconstruction activities are sought as these create windows of opportunity for cheaper implementation of the planned measures.

Steps within the two phases are illustrated in Figure 1.

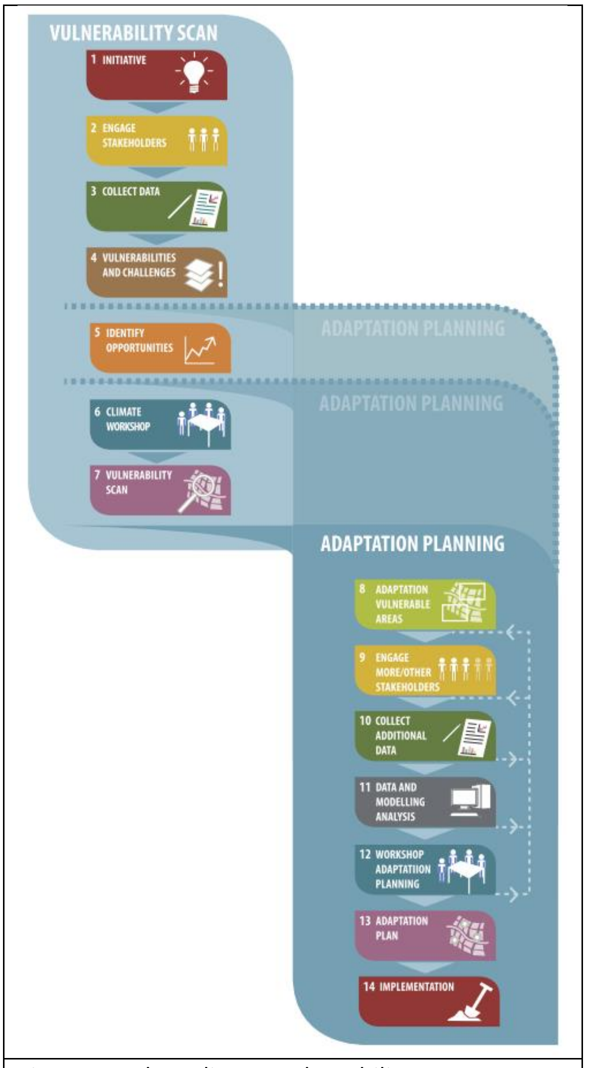

Figure 1: Urban climate vulnerability stress test

As soon as the first vulnerable spots have been identified adaptation planning can start. Many parties are involved, both public and private, such as green managers, home owners associations and representatives of companies and shops. Appropriate adaptation solutions are sought in good cooperation in conjunction with political decision makers.

Project approach

A good stress test requires a project approach, including a widely accepted, feasible and suitable project plan before commencing with budgetary needs, team leader selection and well outlined objectives.

Quick scan or thorough investigation

Depending on the local situation and situational acceptability, you may decide to start the stress test with a quick scan or with proceed to a thorough investigation. A quick scan based on practical expertise of the practitioners and down-to-earth but keen analysis of available data and information, (tough incomplete and qualitative in nature) will help focus further analysis and helps to quantify and prioritize urgencies. The more effort spent on data collection and analysis in the quick scan phase, the less work will be required in the final phase of adaptation planning. But also the larger the risk that efforts are being spend on activities that turn out to have less priority in hindsight. Final decisions on adaptation investments have to be made on the basis of solid analysis of the problems and of the effectiveness of the proposed solutions.

Vulnerability scan

1. Initiative

The vulnerability of the physical urban system is to be mapped. Maps should cover issues like flooding from rivers and brooks and other surface water, pluvial and groundwater flooding, drought damage, water shortages, heat stress, water quality problems, public health threats, fire risks, potential failure of public services and so on. To be able to set priorities, first the damage sensitivity of the most vulnerable and vital objects, networks and specific groups is identified, so that we can identify their exposure to flooding drought and heat stress, now and in the decades to come, taking climate change as well as other changes into account. These insights provide the basis for prioritizing the adaptation strategy, to be elaborated in the Adaptation Planning phase.

2. Engage stakeholders

Both public and private parties are involved in adapting the urban environment. Co-operation is required. Not all these parties need to be actively involved in the very first steps; however, they have to be informed about developments. A core-team of key players can take the lead in this vulnerability scan. Governments are to be involved both at the administrative and at the political level. A simple stakeholder identification tool was developed to assist the project management in identifying relevant parties.
Motivation and time is required to develop a common language in this co-operation among various disciplines and backgrounds. Collaboratively making plans for improving the urban environment often provides the energy to break through existing barriers. Participation in line with the benefits per stakeholder, now or later, is a recommended approach for success.

3. Collect data

Data are to be collected to answer four questions:

1. What/where are vulnerable objects, networks and groups in our project area
2. What/where/ what size are the climate hazards? Where are high risk situations located?
3. Where are new opportunities emerging due to climate change?
4. Which recent extreme weather events can be used as a reference in our analysis

In the very first phase of the vulnerability scan only existing data is being used. Time and budget to collect additional information is often lacking; in such cases we have to rely on expert judgement and practical field knowledge e.g. urban district managers. Field visits could improve our understanding of the vulnerability of specific sites in the project area.

An overview of local vulnerable objects, networks and groups is made as a starting point for mapping these in our project area. This map helps emphasizing the urgency of the vulnerability assessment and – if the results ask for it – adaptation of the most vulnerable 'hot spots'. The magnitude of the flooding, drought and heat stress hazards could have been assessed earlier using hydraulic, hydrological and heat stress/ circulation models. If not, expert opinions could provide a first, preliminary picture; district managers generally know where such hot spots are located. A climate effect atlas that shows first estimates of the climate hazards was made for urban areas in the Netherlands.

An overview of the required data was provided as an annex to the Guideline. At first sight this list seems long but the need for data on many aspects such as land elevation, soil type, land ownership, temperature and rainfall data is self-evident. Data should include climate projections and urban and economic development scenarios for 2050 and beyond. The challenge is to bring the data together from a large number of owners.

First result of the vulnerability scan is an overview of missing data for a climate vulnerability analysis. Ultimately, this could result in a drastic change of the project plan.

4. Vulnerabilities and challenges

Now that the data is available we can start with a first analysis of the vulnerabilities of the physical urban system. Maps are being produced of:

a. **Objects, networks and population groups vulnerable to flooding, drought and heat stress**. This could include problems with water quality and land subsidence. Local district managers can often quickly provide an overview for their area. Potential damage to public health, quality of the urban environment, economy and environment are to be estimated and shown on these **damage sensitivity** maps.
b. **Flooding hazard** (pluvial, fluvial, coastal and groundwater flooding). Sources and potential depth of flooding are mapped; also inundation flow velocities could be relevant. Climate change effects and changes in urbanization are to be taken into account when considering future probability of exposure to extreme conditions. By combining information on potential depths and velocities with the damage sensitivity maps we can now produce **flood risk maps**, showing the flood risk hot spots in our project area.
c. **Drought hazards**, focussing on local water shortages for the vegetation and on low groundwater levels, triggering land subsidence and decay of wooden foundation piles. A water balance model provides insight in the effect of long dry periods. By combining these maps with the damage sensitivity maps we can now produce **drought risk maps**, showing the drought risk hot spots in our project area.
d. **Heat stress hazards** are analysed and mapped on the basis of properties of the urban area. Data on urban green, trees, shade, albedo, surface water, wind canyons and other factors are used to identify hot and cool places in an urban area. Operational models for this analysis however are few. Heat stress is strongly related to the availability of water; a city that is not able to sweat runs hot. Heat stress hazards are therefore related to drought hazard. A **heat risk map** that shows the heat risk hot spots in our project area is produced by combining the hazard map with the damage sensitivity maps.
e. **Land subsidence** is mapped because of its direct relation with drought as a driving force and with increased flood risks as a consequence. Land subsidence has costly consequences and is a long term process, like climate change, that is to be considered in planning adaptation measures.

A thorough understanding of the urban physical system underlies the risk analysis. An urban system analysis is required too.

Urgency

On the basis of the risk 'hot spot' maps we can make an analysis of the urgency of adaptation and also set priorities. This priority analysis is combined with information on planned reconstruction activities (streets, sewerage, public green, houses, office buildings) to identify 'windows of opportunity' for retrofitting adaptation measures.

5. Identify opportunities

Climate change creates many challenging opportunities, not just negative consequences. New business opportunities arise for recreational activities and adaptation technologies. And adaptation measures can help close cycles of water, energy, nutrients and building materials; operation and maintenance costs can be reduced by implementing adaptation measures and new (co)financing mechanisms can be applied to reduce the costs for each individual party. A systematic search for such opportunities provides input for the next step.

6. Climate workshop

A first workshop is held with all relevant stakeholders to discuss the challenges, solutions and opportunities. This climate workshop is meant to achieve agreement on:

- Climate-vulnerable sites and objects in the urban area;
- Urgency of each of these sites and objects;
- Adaptation assignments regarding flooding, drought, land subsidence and heat stress;
- Options for adaptation;
- Opportunities created by adaptation;
- Missing information for adaptation planning.

The workshop could result in a long term vision for climate adaptation.

7. Vulnerability scan

Results of the earlier steps are bundled in a vulnerability scan report. This report could be subjected to peer-review by experts from other municipalities and/or knowledge institute.

Adaptation planning

8. Adaptation of vulnerable areas

In the next phase we can focus on the most urgent vulnerable areas and objects. Adaptation plans can be made by different parties at different spatial scale levels: the urban sewerage plan, the green plan, the zoning plan, a district development plan or a reconstruction plan for a street, a park or an industrial facility.

9. Engage more/other stakeholders

Now that we have a well-defined focus we are able to engage all relevant local stakeholders, experts, funding parties and local leaders.

10. Collect additional data

Additional data is collected, not only for an in-depth analysis of the physical urban system but also to check the applicability of specific adaptation measures in view of the local institutional context, the potential synergy with other adaptation measures and the potential benefits of adaptation. Data is collected to calibrate and validate the simulation models as well as to define the design load or design exposure that is to be used for planning and designing adaptation measures. The applicability of specific measures can be checked using the PRIMO-chain approach. PRIMO stands for Policy, Regulations, Implementation & financing, Maintenance and Organization. If one of these components is weak the applicability of the measure is to be questioned.

11. Data modelling analysis

The effectiveness of adaptation measures in preventing and minimizing damage of flooding drought and heat stress is investigated with simulation models. These models are first calibrated and validated with the data before being used to study the effects of adaptation measures. Climate and urbanization scenarios of 2050 and beyond are being used to assess future performance. Alternative solutions are proposed and compared on performance indicators calculated by the models. Performance indicators include additional storage volume, peak flow reduction, water quality effects, cost, potential benefits and other parameters. It is up to the stakeholders to decide which ones are to be considered in the selection and decision making process.

As adaptation planning is an iterative process it could well be that data collection and model analysis of alternative options are to be made several times, in particular during and after the next step, the adaptation planning workshop.

12. Workshop adaptation planning

During this workshop, or series of workshops, parties formulate concrete plans for adapting the urban environment. This includes selecting adaptation measures, their spatial planning and design, assessing the added value they create and development opportunities and formulating the role of the parties in the realization, operation, maintenance and funding of the measures. Planning support systems can be used to facilitate and accelerate integration of creative design, effectiveness assessments and a constructive dialogue amongst the stakeholders.

13. Adaptation plan

The result of this iterative procedure is not only an adaptation plan. Results should reach out to influence other day-to day practices, internal guidelines for purchasing and operations. The new measures have an impact on the distribution of roles and responsibilities between organizations as well as on the skills and capabilities of their staff. Climate adaptation starts with an analysis of vulnerabilities and an adaptation plan, but it can lead to new tasks and a more valuable contribution to urban society.

Because of these potential consequences a solid adaptation plan is required, a plan that has wide political and social support. Pilot projects can help to create this support, as well as (small) disasters in case of extreme weather.

14. Implementation

Most of the adaptations measures are relatively cheap to realize when retrofitted synchronically with other reconstruction activities. Any opportunity for climate adaptation that we miss now can create costly adaptation requirements in the future; for a next low cost opportunity we have to wait for at least another 50 years, when the next large scale reconstruction is scheduled. Climate change may not be an acute problem, adaptation is nevertheless urgent as we have to use every retrofitting opportunity that comes along from now on.

Conclusion

Creating a climate resilient urban environment contributes to the liveability of the city, to economic and social development, to the competitive position of a city and to the sustainability and durability of the urban systems. If we use all emerging opportunities for retrofitting adaptation measures from now on large benefits can be obtained at low costs. These benefits not only include avoided damage but, equally or even more important, minimized damage in case the regular protection system against flooding, drought and heat stress fails. And there is also the maximized additional social and economic benefits and co-benefits of adaptation measures.

To minimize damage in case of a failing regular protection system we have to pay extra attention to all the vulnerable and/or vital objects, networks and population groups in the urban environment. Providing these with extra protection often pays off extremely well. It is not the responsibility of the municipality, nor the water authority, to provide such adaptation measures at this very local scale. That is why many private stakeholders are to be involved actively in the adaptation planning process; they have to understand the hazards and risks of climate change and they have to learn how to protect themselves by retrofitting adaptation measures. Moreover, they have to learn and see how adaptation can create additional added values to their properties.

Retrofitting adaptation measures to create climate resilience is an intensive transition process. Even though many measures are not expensive in themselves the realization requires substantial changes in stakeholder's roles, and in practical skills of all the people involved. The substantial benefits of adaptation however are the most convincing argument to start adapting our urban environment from today on.

Annexes

The Dutch version of the Guideline for Stress Testing the Climate Resilience of Urban Areas includes four annexes:

1. Overview of political and institutional arguments for stress testing the climate resilience of your urban area.
2. Inventory of parties to be involved in the climate adaptation planning process.
3. Inventory of vulnerable objects networks and groups in the project area.
4. Data required for stress testing the climate resilience of an urban area.