CLIMATIC CHANGE AND URBAN DRAINAGE: STRATEGIES

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KEYWORDS

Climate change, urban drainage, flooding, cso, damage, costs, risk, uncertainty, ….

ABSTRACT

The national study 'Climatic Change and Urban Drainage: Quick Scan', in the Netherlands has shown that climatic change can have a significant effect on the functioning of urban drainage systems, Van Luijtelaar and Dirkzwager (2002).It is important to anticipate on the effects of climatic change knowing the fact that urban drainage systems are realized for a period of 40 years or more.

The follow-up project called 'strategies' is aimed at developing 'strategies' to anticipate on possible effects of climatic change on the urban drainage system. One of the project's main considerations is to set up *cost-effective* strategies, which can be refined from a general to a more specific level. The project aims to bring together the expertise of numerous specialists on the fields like: waste water systems (sewer systems, transport of sewage water, sewage treatment plants); water systems (quality, quantity, nature, ecology); urban environment (spatial planning, traffic and transport, urban development); society (legal and regulatory issues, financing, economic aspects, public perception). Several sessions were organized where experts examined the functioning of urban wastewater systems from various angles.

RIZA, the Institute for Inland Water Management and Wastewater Treatment, has commissioned Tauw Consulting Engineers in cooperation with DHV and ARCADIS, to carry out this project.

INTRODUCTION

In this paper we present an overview of a preliminary investigation to define strategies how to anticipate the possible effects of climate change on urban drainage systems. In this study we have interviewed a number of senior urban drainage experts to sketch various future scenarios.
The UK Foresight project showed that the assessment of flood risk strategies is dominated by uncertainties on important parts of these strategies. Based on these results, recognized in our own practical experience, we felt the need to focus the attention on reducing and communicating these uncertainties in our traditional model based decision processes. We also focused on investing in registering accurate information and the development of innovative knowledge.

QUICK SCAN

The climatic change based on the scenario of a temperature increase of 2 degrees as the central (average) estimate for 2100 and upper limit for 2050, has a considerable effect on the functioning of the sewer systems. According to this scenario, the highest precipitation intensities will increase by an average of 20%. The precipitation volume may increase by approximately 2% in the summer period and approximately 12% in the winter period, Können et al.(1997).

The simulated increase in overflow volume from a sewer system is about 40%. This increase is in the same order of magnitude as the reduction that has been achieved in recent years with measures to reduce combined sewer overflows (cso's). The frequency and duration of flooding occurrences may increase over 50%. These effects are difficult to translate into actual damage because the relationship between a calculated water level above ground elevation and actual inconvenience (damage) strongly depends on local circumstances. In inclined areas and in systems that are operating not optimal, the effects will be visible first and more pronounced.

The assessment of sewer systems has traditionally focused on analyzing the calculated water levels at intersections. However, this is an indirect parameter that is "controlled" by the capacity of the pipelines. Pipelines with an insufficient capacity will result in higher water levels. For a more efficient assessment, the capacity of the sewer system should be assessed, and if necessary modified, on the basis of the capacity of the pipelines, Van Luijtelaar (1999).

In general, the Netherlands are a flat country. The storage capacity of water on street surface is in fact an extra safety factor whose effect is difficult to quantify. We benefit from this additional safety, often without realizing it.

DEVELOPMENTS

In recent years in the Netherlands a substantial effort was made to reduce cso pollution of the open water. Combined sewer overflows are often removed to reduce the number of emission points in a system. Although compensatory measures are taken to guarantee the system has 'sufficient' discharge capacity, the level of safety with respect to flooding is reduced in most systems, simply because the route of the water to the emergency exit (remaining overflows) will be longer.

Sustainable drainage systems are now broadly applied in new developed areas and in urban renewal projects, Van Luijtelaar (1999b) . Nearly all rainwater from newly paved areas infiltrates into the soil or is discharged into open water. On the other hand there is a substantial increase of paved area on the existing combined sewer systems (see Figure 1).

Figure 1 Increase of paved area: parking in the front garden.

There is also a trend towards optimizing measures for the lowest social cost. The arguments for these measures are often based on models that at the most can only provide an approximate description of the practical situation, but in which the investments can be compared with a high degree of "accuracy". Aspects such as flexibility and safety are often not properly taken into account because these factors would then make the outcome considerably more complex. The consequence is that safety capacities are gradually being removed from the systems.

In the article we go into the following subjects: the definition of future scenarios, the import role of dealing with uncertainties, strategies, standards and models and the development of an Urban Flood Risk Map.

FUTURE SCENARIOS

The question "Urban Drainage, Quo Vadis ?" also was raised by Wolfgang Schilling in his key-lecture to the XXX IAHR Congress (2003) in Thessaloniki, Greece. In this contribution the following scenarios were presented:

- The **green** scenario (LS^-): sustainable drainage (water harvesting, infiltration, etc.), small scale systems, substantial effort in maintenance, long term risk (wide spread accumulation of pollution);
- The **technocratic** scenario (GS): power to the governance engineers in governmental service, robust systems (no health risks), fundamental knowledge development on universities, political balance on cost effectiveness, danger: development towards privatization scenario;
- The **privatization** scenario (WM): high investments on small risks (drinking water), end-user has no influence on products, research monopoly in business hands, cost cutting on maintenance, decreasing social solidarity;
- The **business-as-usual** scenario (NE): centralized waste water treatment, simple adaptation new environmental standards, big variation in system types, development between technocratic and green scenario, low risk of system failure;
- The **future dream** (LS^+), decentralized waste water treatment, greater individual and community responsibility, combination of source controls and technological development, resource recovery.

In the UK Foresight (2004) project, an interesting classification of future scenarios was presented:

- World markets (WM)
- National enterprise (NE)
- Local stewardship (LS)
- Global sustainability (GS)

There is a certain resemblance between the approaches of Schilling et al. and Foresight.

The Foresight future scenarios embody different approaches to governance (centralised versus localised) and different values held by society (consumerist versus community).

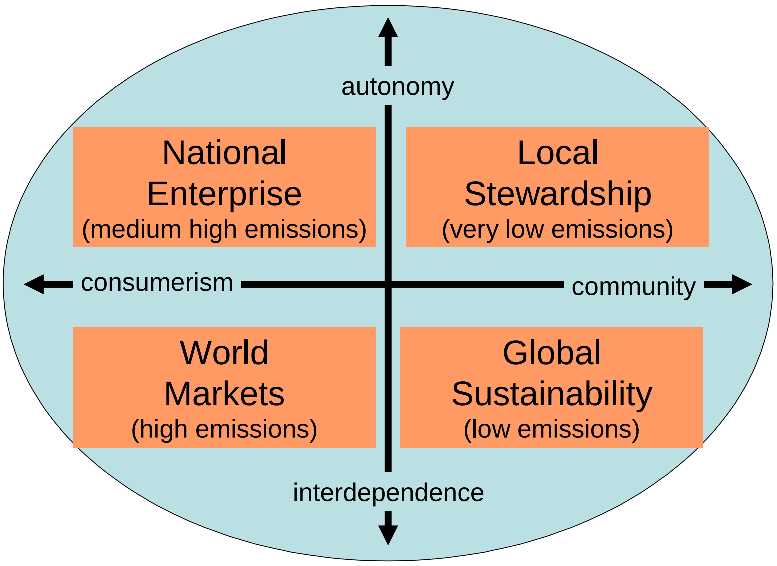

Figure 2 Foresight future scenarios

These future scenarios are investigated on possible risks to people, additional costs and estimated annual damage (EAD). The aim of the project was to use the best available science/knowledge to provide a challenging vision for flood and coastal defense in the UK between 2030 and 2100 and so inform and shape long-term policy. The future is very uncertain and cannot be predicted. It is therefore important to develop policies that can cope with a range of different outcomes – and which can adapt flexibly as the situation evolves. *The greater the uncertainty, the greater the need for flexibility.*

UNCERTAINTIES

The road to the future is paved with many different kinds of uncertainties in relation to social economic, technological, political developments. In the Foresight project it is recognized that uncertainties are a major factor in the outcome of the project. "Many of the responses that were the most effective at reducing intra-urban risk were also the most uncertain."

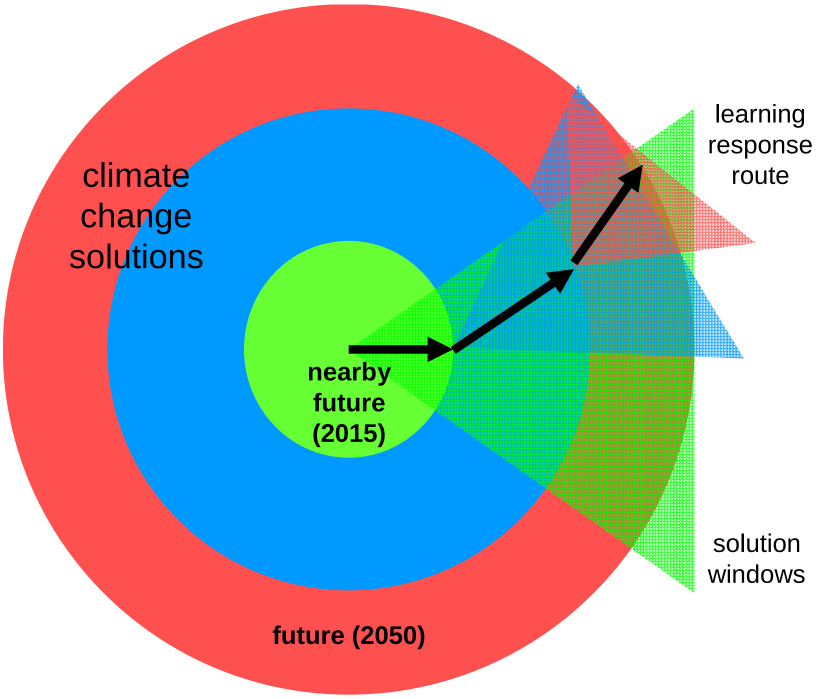

Figure 3 The road to the future will not be a linear extrapolation of our present experience

Uncertainty is not simply the absence of knowledge. In a paper with a contribution of the late Paul Harremoës, a conceptual model was presented to define uncertainty in three dimensions: location (process), level and nature of uncertainty. In this model 4 levels of uncertainty are distinguished:

- Statistical uncertainty (measurement uncertainty, …..),
- Scenario uncertainty (future developments,……),
- Recognized ignorance (climatic change,….),
- Total ignorance (we do not even know what we don't know, for example the occurrence of hurricanes in the Netherlands, ….

It is increasingly a requirement in model-based decision processes that uncertainty has to be communicated in the science-engineering/policy-management interface.

STRATEGIES

Strategies on managing the effects of climatic change on urban drainage systems can be directed on both water quantity and quality aspects. In our project the attention is primarily focused on flood risks in relation to asset damage and health risks. In the context of no-regret responses this may be the subject where an early future strategy is needed most. Effects on water pollution and drought effects should be taken into account in designing robust water systems.

A general estimate is that the number of systems where more intensive rainfall will lead to substantial damage or health effects is relatively small. The Netherlands are a flat country where large quantities of water can spread out over large areas with only temporary inconvenience. A very import strategy is keeping the building level of houses significantly higher than the roads. (see Figure 4).

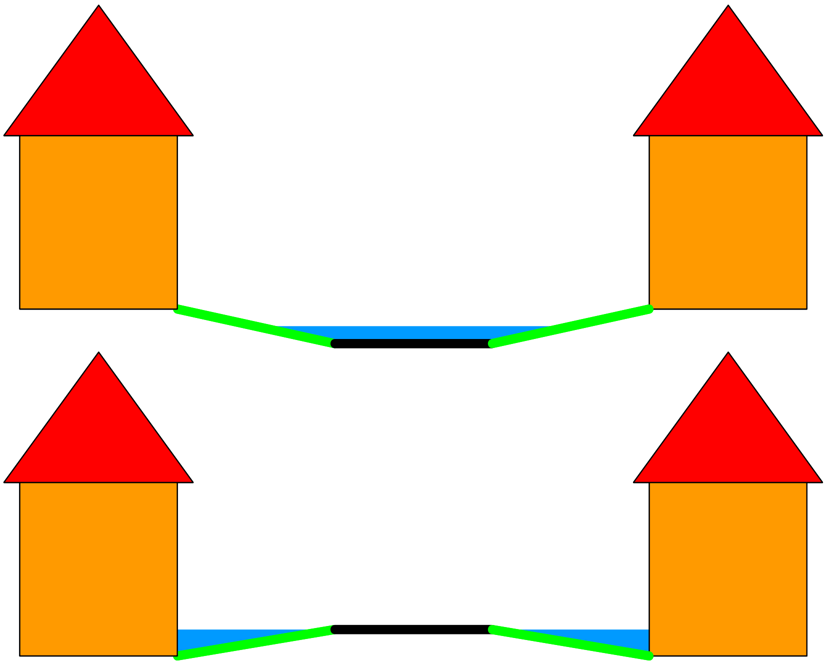

Figure 4 Keeping the housing level well above the street level.

An increase of health risks is expected from the flooding effects of combined systems. Due to extending flooding durations and special hydraulic conditions there is an increasing chance that waste water will flow over street surface.

Our national dogma is to retain rainwater , and store it before discharging it very slowly. It is important to refill our groundwater reserves and to prevent the peat soils from sinking lower (further below sea level). From an ecological point of view the creation of wetlands is also stimulated.
The dilemma is that we also need to create storage for extreme water quantities. Slower water systems will suffer greater from climate change effects, especially during long periods of rainfall.

On an urban scale we see a major development (sustainable drainage) in separating waste water and storm water flows and the disconnection of impervious areas. This is a 364 day per year solution mainly meant to reduce the discharge to the treatment plant and to improve the quality of the open water system. Sustainable drainage often means that the system scale is much smaller than the traditional sewer systems. The hinder and nuisance of excessive rainfall may come out as a very local and individual effect.

The renewal of traditional combined systems in the next 20 years offers opportunities to transform them into separate systems. This may be accompanied by the creation of new open water space in the urban areas, to store and to transport water due to excessive rainfall. The use of multifunctional sewer systems can now provide reduction of flood risk in realizing extra discharge capacity in existing combined systems and can provide extra storage capacity to reduce pollution by combined sewer overflows. The extra combined sewers in the future maybe changed to sustainable drainage.

STANDARDS AND MODELS

To assess the vulnerability of urban areas to flood risks and the possible effects of responses, the traditional hydraulic sewer models only give a rough indication of possible impacts. In most cases only the minor system (below ground level) is described in the hydraulic model. The major system needs to handle the water that exceeds the capacity of the minor drainage system.

Over the last ten years attention was concentrated on meeting environmental standards to reduce the water pollution effects of combined sewer overflows. To prove/asses the effects of measures, model simulations play a major role and incidentally systems are monitored. In an environment where decisions are purely model based the communication of uncertainties is very important (Walker et.al, 2004).

An important mechanism of the present model based decisions making culture is that the role of practical know how and know why is decreasing. The urban drainage field is more and more dominated by communicators, managers and general standards. In his article "From Socrates to Expert Systems" professor Dreyfus (1985) creates a very powerful image of the important role of knowledge in making the right decisions. Especially with more complex questions like strategies to control the possible effects of climatic changes we need expertise in stead of general standards.

An interpretation of the Dreyfus learning stages (from novice to expert) is given in Figure 5. This interpretation is given in three levels in stead of five, the original approach of Dreyfus.

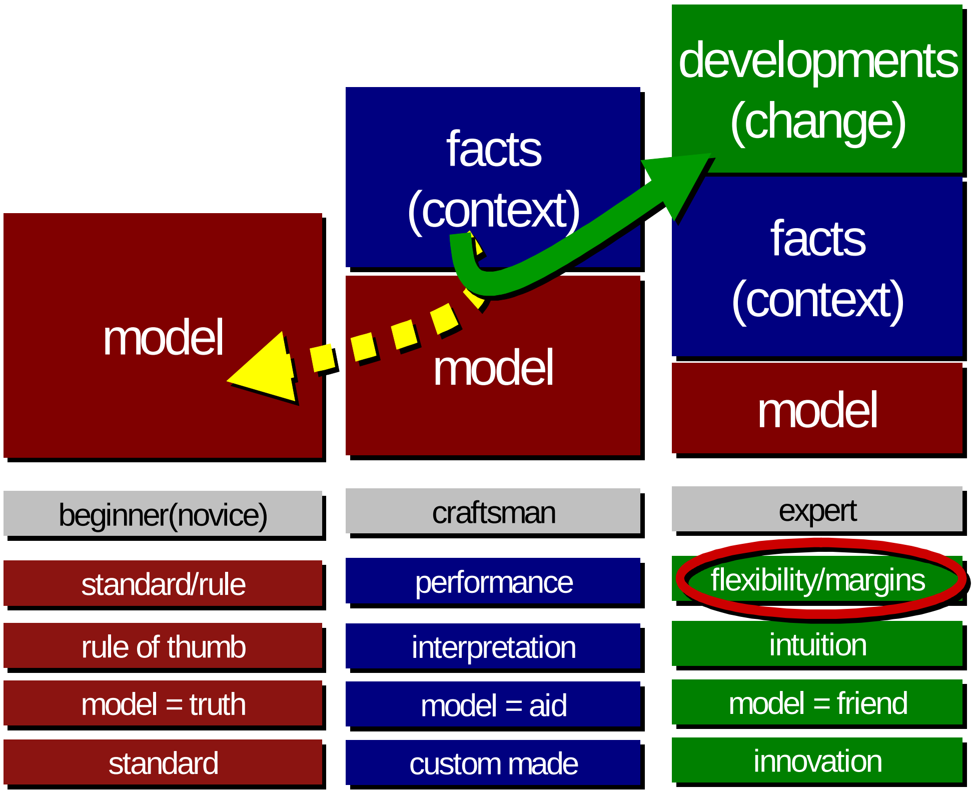

Figure 5 Interpretation of the learning stages of Dreyfus

It is broadly recognized that the role of craftsmen and experts gradually is taken over by the computer (movement from craftsman to novice). In a decision making environment purely based on model simulations and standards often there is no or little room to communicate and discuss uncertainties.
It is also recognized that we need to stimulate a movement from a model approach towards reality , resulting in monitoring urban drainage systems to gain more facts. A step further is that we seek an innovative approach to control our urban drainage environment (movement from craftsman to expert), in way it is less vulnerable to the effects of climatic change.

A general approach based on new safety standards will lead to huge investments because unnecessary money is spent to prevent problems only observed in model results. On the other hand problems not seen (or underestimated) in model simulations may cause unexpected discomfort. This can be painful when big amounts of money are invested to improve a situation.

URBAN FLOOD RISK MAP

The first step in gaining more insight into the relationship between the theoretical and practical functioning of urban drainage systems is the use of all of the available data. The value of independent and accurate information will play a more and more important role in our society. In his investigation of noise nuisance around the Schiphol Airport, Prof Berkhout stated (2003) that people who suffer from noise nuisance during the night sleep better when the Government provides them with accurate facts about their present and (future) situation. He invented the Noise (Nuisance) Landscape to communicate the facts and developments to the citizens in the Schiphol area.

An analogous approach can be chosen to develop an Urban Flood risk map. People, who want to live in a beautiful environment with a recognized risk of flooding based on accurate information, can make a deliberate decision as to their own responsibilities They also might have to pay more premium for an insurance policy.

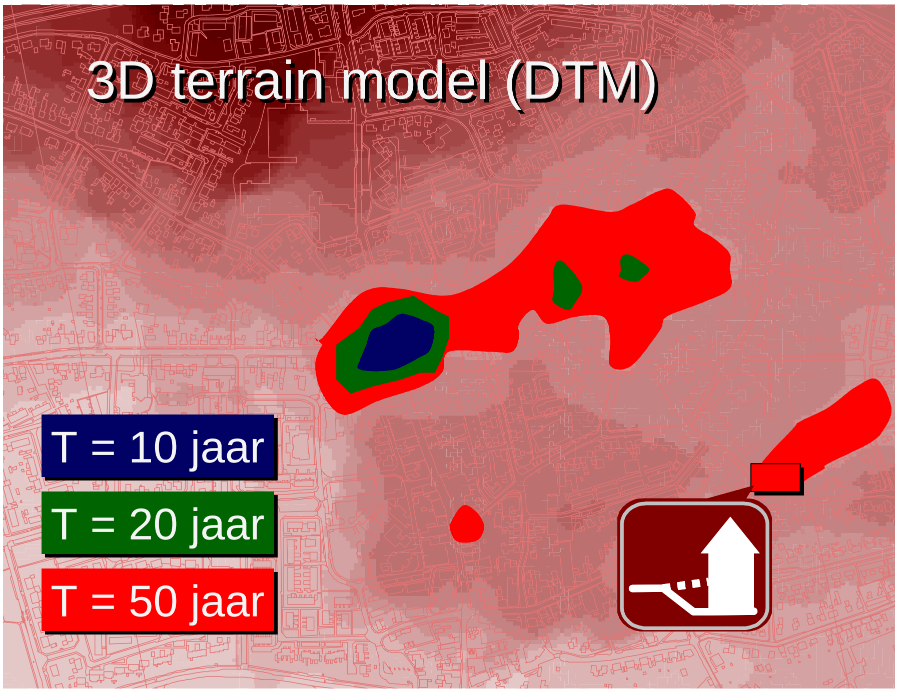

Figure 6 Urban Flooding Risk Map (landscape)

GIS and DTM can be used as a very powerful tools:

- to analyze the course of natural flood pathways in relation tot vulnerable depressions in the ground levels;
- to register properties with extra vulnerability to flood risks, based on specific circumstances or empirical facts (for example historical information) ;
- to communicate flood risks to citizens and to stimulate the water-awareness;
- to show and communicate the effects of decisions on investments in flood protecting measures, in stead of hiding behind a standard only related to a statistical figure;

In a flat country like the Netherlands the flooding effects due to excessive rainfall in an urban area may be relatively small but therefore also harder to recognize. A digital terrain model can be used to analyze the course of natural flood pathways in relation tot vulnerable depressions in the ground levels.

In the long run the development of fully integrated model of the major system (above ground level) and the minor system (below ground level) will be used to asses the hydraulic behavior under extreme rainfall conditions. The lack of accurate data is a major restraining factor for perhaps many years to come. In the mean time we can focus on historical an practical information based on local experience and historical data. Dealing with complaints of citizens we must try to derive and register the useful information on the digital Flood Risk Map. People involved, can check and comment on the presented information resulting in gradual improvement of the quality and level of detail.

CONCLUSIONS

General conclusions of our study :

- Define hinder, nuisance en damage to improve communication on flood risks;

- Accept a greater degree of nuisance, a simple method of gaining extra storage capacity on the ground level, be aware of the effects in more vulnerabale situations;
- Show uncertainties in model based descision processes, traditional hydraulic sewer models are not equipped to make an accurate prediction of flood risks;
- Expertise is more important than standards (invest in human knowledge), when dealing with specific problems and future developments, where dealing with uncertainties is important;
- Develop an Urban Flooding Risk Map to use as a communication tool to citizens and a registration of valuable (historic) information.

Recommendations for the system (developments)

- More natural urban drainage systems
- More attention for water in the spatial development in the urban area
- Smart over dimensioning in systems for new housing and in large scale adaptations in existing areas
- More robust techniques, small details can be very important

This project was aimed at developing various *cost-effective and no regret* strategies to anticipate the effects of possible climatic developments in the urban (waste) water system. To look into the future we could investigate 3 different scenario's:

1. business as usual, moderate technological developments (wait and see, pay the damage);
2. advanced approach, with stronger impulse to reduce the risk of urban flooding by creating more space for water en substantial conveyance of water outside the urban boundaries;
3. breaking trend using a strong technological development i.e. disconnecting the waste water from the combined systems.

Working out these strategies would lead to a project similar to the Foresight project. The question is if a Dutch version of this investigation can lead to more useful results. The uncertainties in future strategies are so big that a longterm analysis of a future scenario is not yet recommended.

The appreciation and development of innovative knowledge to handle uncertainties translated in to a transparant and understandable approach to analyze and show the effects of floodrisk responses may lead to well-considered and sustainable solutions.

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