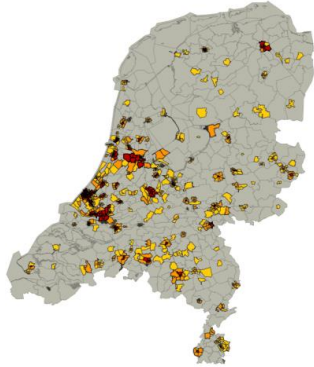


# The influence of active groundwater management on the current and future water demand of urban areas.



Deltas in Times of Climate Change,  
26 September 2014

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Ministry of Infrastructure and the  
Environment



## Introduction

- Objective
- Vision on research approach
- Research questions
- Results
- Recommendations
- Questions



## Introduction



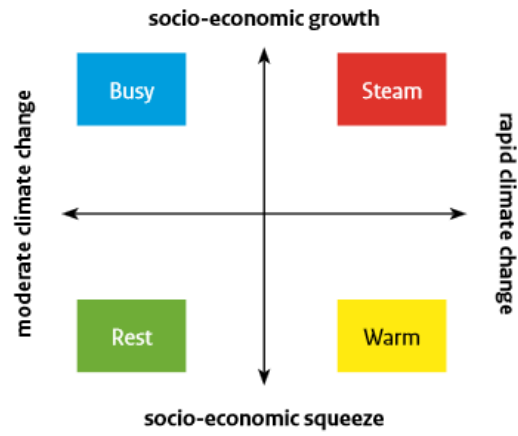
The Delta Programme is a nationwide programme. The national government, provinces, municipalities and regional water boards work together with input from social organizations and the business community. The objective is to protect the Netherlands from flooding and to ensure adequate supplies of freshwater for generations ahead.

## Introduction | Climate scenario's

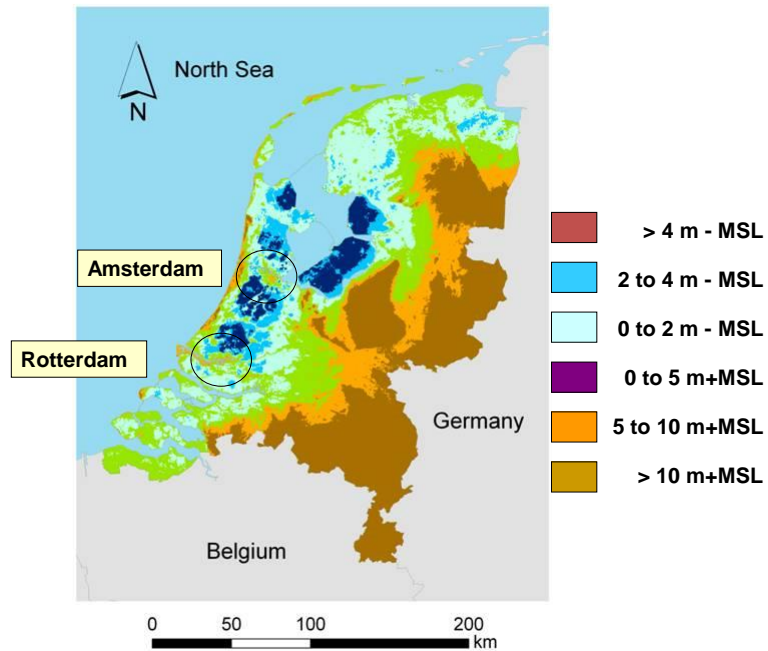
2050		G	G+	W	W+
Winter	Average precipitation	+4%	+7%	+7%	+14%
Summer	Average precipitation	+3%	-10%	+6%	-19%
	Evaporation	+3%	+8%	+7%	+15%
Sealevel rise	Absolute	15-25 cm	15-25 cm	20-35 cm	20-35 cm

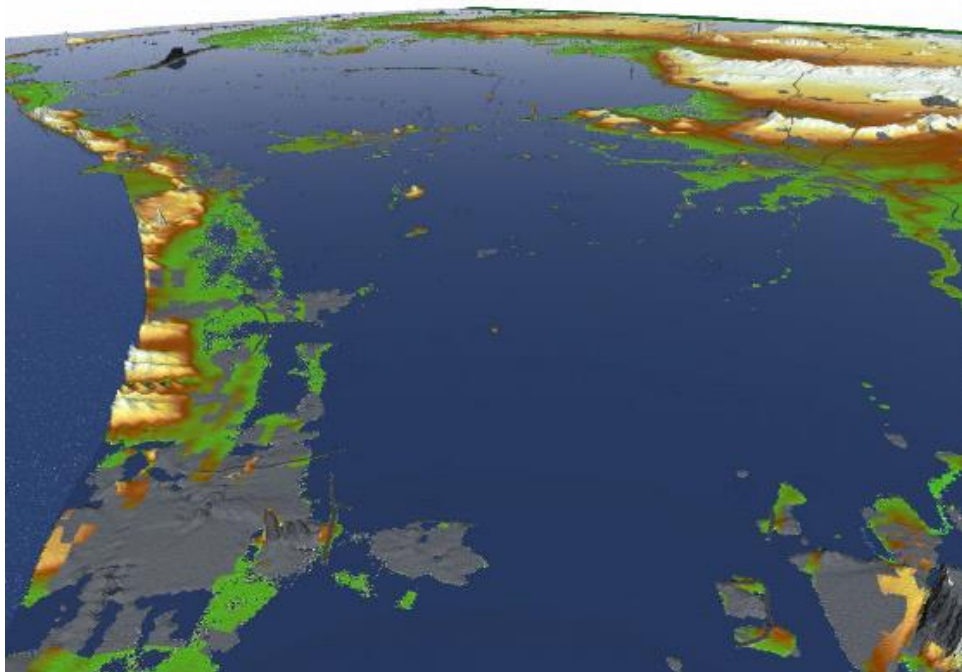
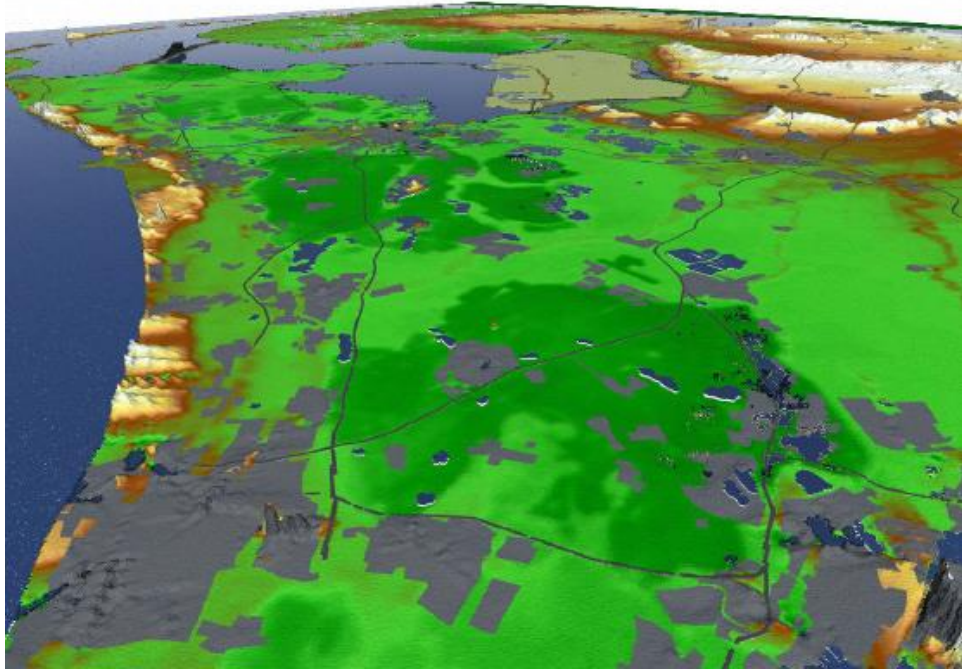
(KNMI, 2006)

## Introduction | Climate scenario's

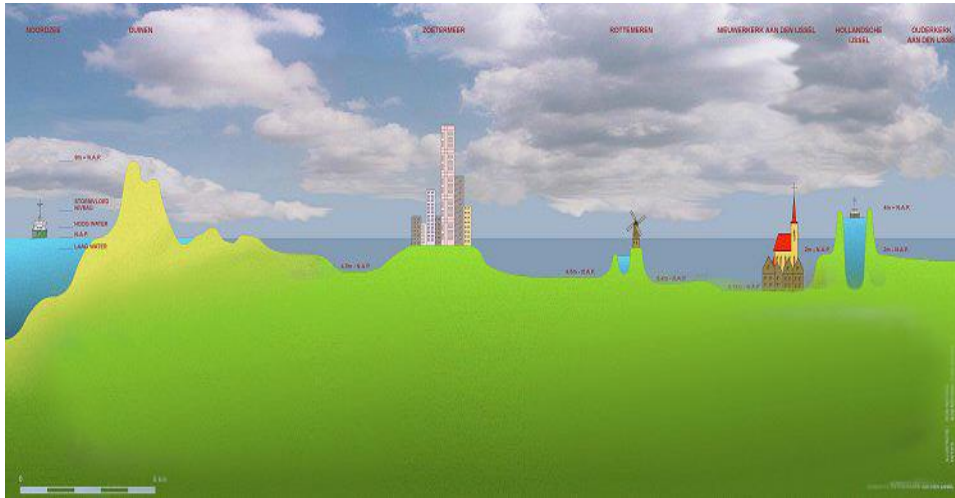


(Deltaprogram, 2012)

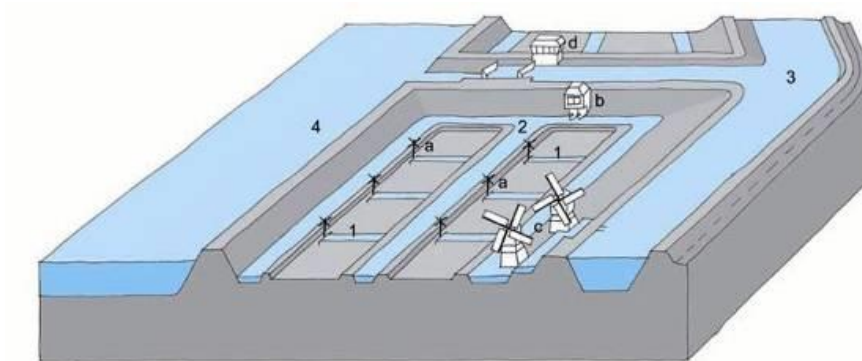




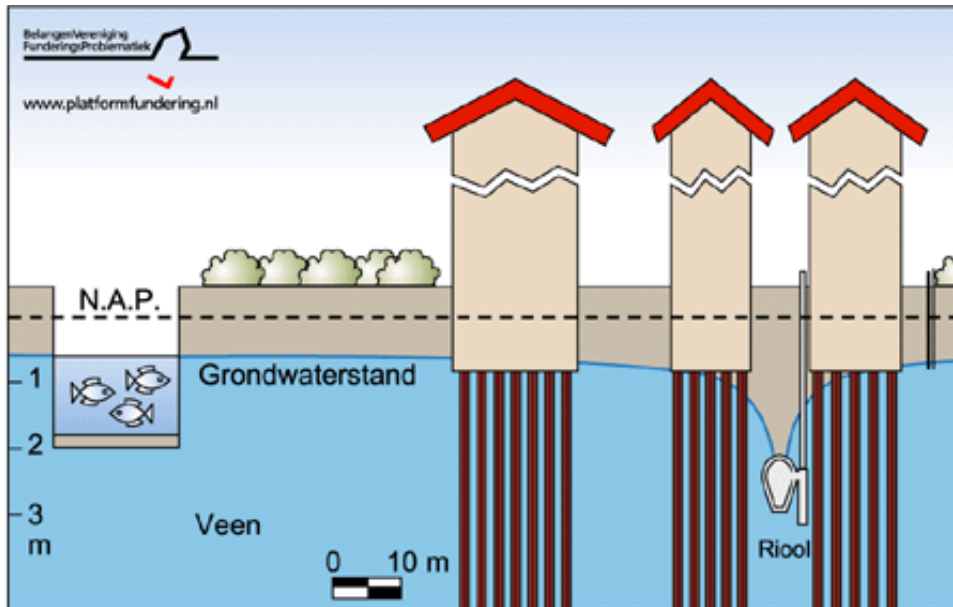
# Introduction



# Introduction



## Introduction



## Introduction





## Introduction | Objectives

- Achieve general insight in the water demand of urban areas in the Netherlands
  - Now
  - With active groundwater management
  - In the future (climate scenarios)
  - High and Low Netherlands
- Using current available knowledge
- Goal is not: describe urban hydrology as accurately as possible

## Introduction | Vision on research approach

- Looking for an overarching question for a societal problem
  - Approach as simple as possible, but not more simple
  - General answer means theoretical approach
  - As few area specific characteristic as possible, but show the influence of characteristics
- Think from a city system perspective

## Introduction | Research questions

### **Main questions**

- What is the water demand of urban areas in the Netherlands, now and in the future (delta scenarios)
- How large is the additional water demand if active groundwater management would be introduced?



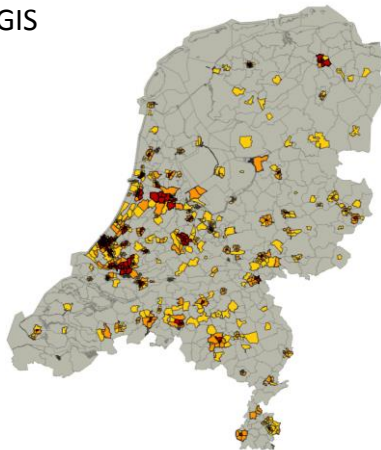
## Introduction | research questions

1. What is a city?
2. What is the water demand of the urban areas in the Netherlands
3. What is the minimum external water demand?
4. What is the maximum external water demand?
5. How does the external water demand depend on groundwater storage capacity?
6. What is the influence of climate scenarios?
7. What should we take into account nationally?

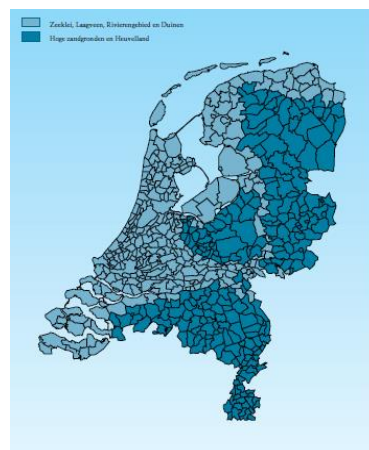


## Question 1 | What is a city?

TOP10NL CBS wijkenbestand  
GIS



High en Low NL



## Question 1 | What is a city?

- Collection of neighbourhoods of class 1,2 and 3
- 14% of the country
  - 7.8% in low NL, 6.2% High NL
- 66% of the population

## Question 1 | What is a city?

Land use average Dutch city

<b>Terrain type</b>	<b>Percentage</b>
<b>Paved</b>	<b>32,6%</b>
Roofs	9,9%
Asphalt roads	5,1%
Pavement	6,0%
Private paved	11,6%
<b>Unpaved</b>	<b>61,6%</b>
<b>Water</b>	<b>5,8%</b>
<b>Total</b>	<b>100%</b>

## Question 2 | What is the water demand of the urban areas in the Netherlands

**Urban water demand = the water that leaves the city:**

- Urban evaporation
- Drainage of rainwater runoff to the sewer treatment
- Drainage of used drinking water to the sewer treatment
- Drainage of industry wastewater to the sewer treatment

## Question 2 | What is the water demand of the urban areas in the Netherlands

	Total demand(km <sup>3</sup> )	Total demand (mm)	%
<b>Urban evaporation</b>	<b>1.91</b>	<b>370</b>	46%
<b>Drinking water use</b>	<b>0.83</b>	<b>160</b>	20%
<b>Industrial water use</b>	<b>0.47</b>	<b>91</b>	11%
<b>Rainwater runoff</b>	<b>0.99</b>	<b>192</b>	24%
<b>Total</b>	<b>4.2</b>	<b>812</b>	100%
Rural area	18.8	595	Nvt
<b>Total Country</b>	<b>23.0</b>	<b>625</b>	<b>Nvt</b>

### Question 3 | What is the minimum external water demand of urban areas?

	Water demand (mm)	Water supply (precipitation) mm	External water demand (mm)
Average (1967)	573	853	0
Dry (1989)	562	661	0
Very dry(1976)	539	536	0

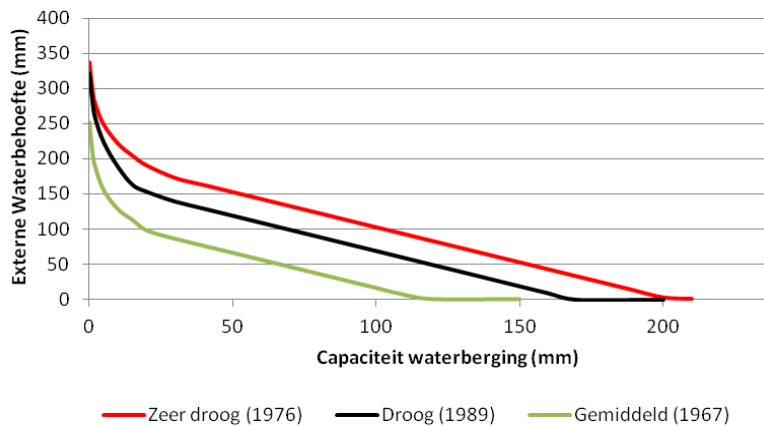
### Question 4 | What is the maximal external water demand of urban areas?

- No storage
- Perfect target level management on daily basis of both groundwater and surface water
- Water excess is drained immediately
- Water shortage is supplied immediately
- Calculation based on daily time series

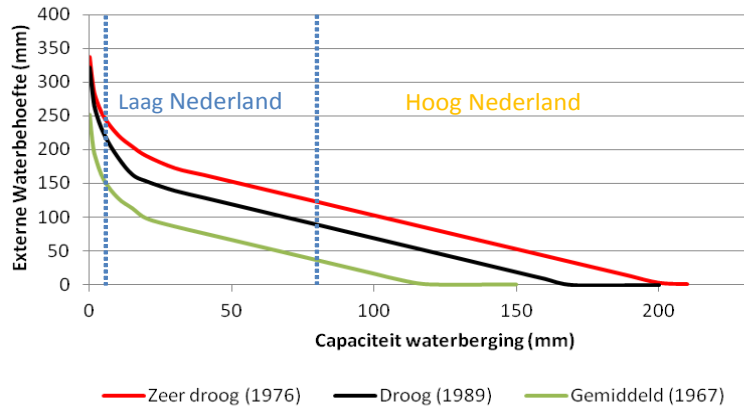
Question 4 | What is the maximal external water demand of urban areas?

	Maximal external water demand (mm)	Maximal external water demand total country (km <sup>3</sup> )	Maximal external water demand only low NL (km <sup>3</sup> )
Average (1967)	252	1.28	0.73
Dry (1989)	321	1.65	0.92
Very dry(1976)	337	1.74	0.97

Question 5. How does the external water demand depend on groundwater storage capacity?



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## Question 5. How does the external water demand depend on groundwater storage capacity?

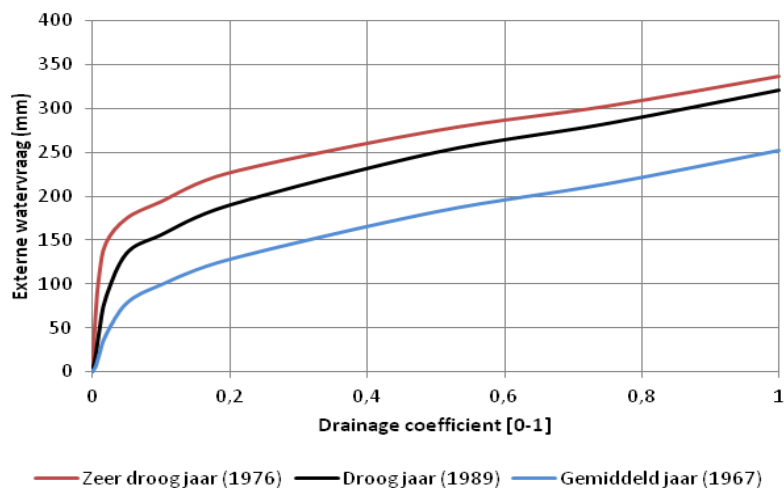
- External water demand of an average city in Low NL is 36-147 mm in an average year.
- External water demand of an average city in High NL is 0-36 mm in an average year

## Question 5 | How does the external water demand depend on groundwater storage capacity?

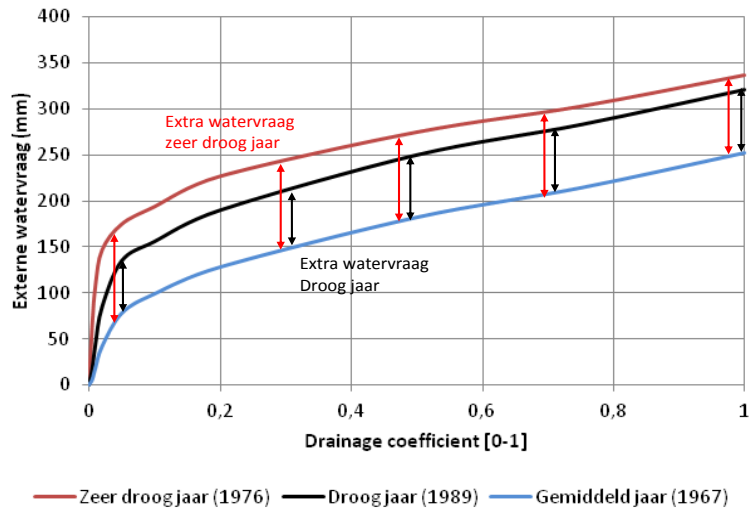
### External water demand without groundwater management

- Only storage in groundwater
- Interaction between groundwater and surface water is very important
  - Interaction is governed by level difference and drainage coefficient
- Drainage coefficient is function of permeability, drain distance, and boundary area surface water and groundwater

## Question 5 | How does the external water demand depend on groundwater storage capacity?



## Question 5 | How does the external water demand depend on groundwater storage capacity?



## Question 6 | What is the influence of climate scenarios?

Strategy: Additional water needed if water level fluctuation average year is not allowed to increase in very dry year in the climate scenarios

- 107 mm in very dry year in G scenario
- 156 mm in very dry year in W+ scenario



## Question 8 | What should we take into account nationally?

	Dry year (km <sup>3</sup> )	Very dry year (km <sup>3</sup> )	Very dry year W+ (km <sup>3</sup> )
Active groundwater management in 50% of urban area Low NL	0.08	0.15	0.23
Active groundwater management in 25 % of urban area Low NL	0.04	0.07	0.11

## Conclusions & recommendations

- On a national and yearly scale the additional urban demand for active groundwater management is relatively limited
- Locally take into account very high relatively increase of external water demand in very dry years if active groundwater management is introduced
- Water demand of urban areas cannot be neglected
- More research on urban evaporation is needed
- More insight in urban groundwater storage capacity is needed
- To encourage the development of technologies for active groundwater management

## Questions?

- Full report available on:  
<https://deltaprogramma.pleio.nl/file/download/23579342>