Freshwater resources & climate change in delta regions

Global and regional aspects
Rhine-Meuse-Scheldt Delta in the Netherlands

14 January 2013, Jeroen Veraart

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Introducing myself

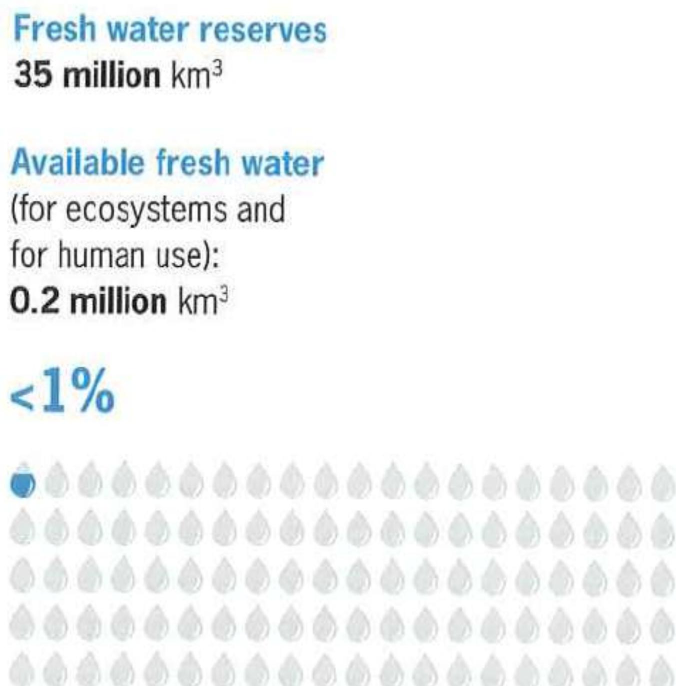
- WU (2000) Environmental Sciences
- Earth System Science & Climate Change Group Wageningen UR (Alterra)
  - National climate change research (KvR/KvK)
  - Fresh water resources management
  - National Delta programma (Southwest Delta)
- Interests: water management, ecosystems/indicators, climate change, science-policy interactions, adaptation to climate change

Contents of lecture

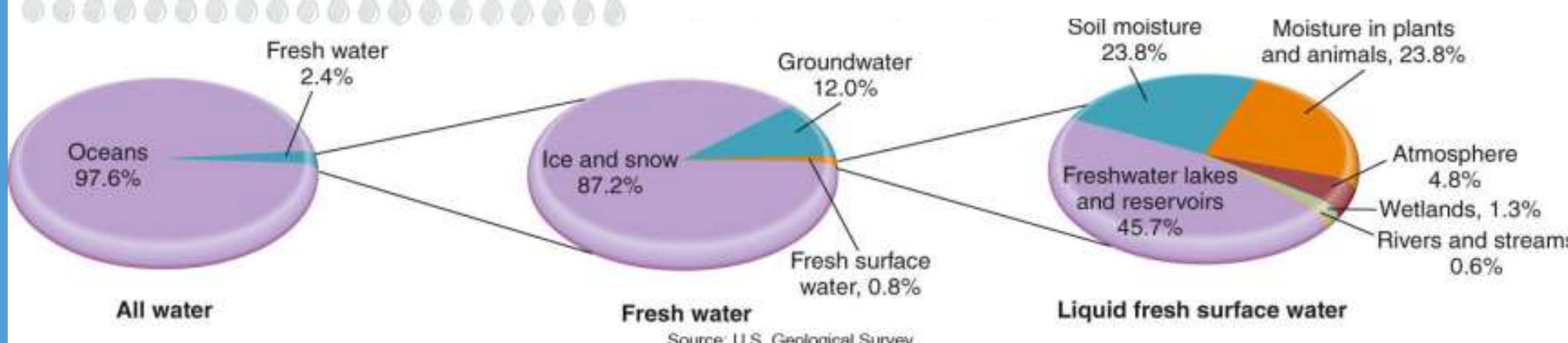
- **Part 1: Global water resources**
- **Part 2: Climate change and water resources**
  - Scenario’s (see also lecture Pier Vellinga)
- **Part 3: Estuarine dynamics & Delta’s**
  - Introduction - general
  - Fresh and Salt: framing the issue
  - Southwest Delta in the Netherlands
- **Part 4: Adaptation to Climate change at regional level**
  - Combat salt
  - Adapt to salt
  - Make better use of rainfall & groundwater


Part 1: Global Water
Resources

Global Water resources



*Less than **1%** of freshwater, and less than **0.02%** off all water, is fresh, liquid surface water on which terrestrial life depends.*



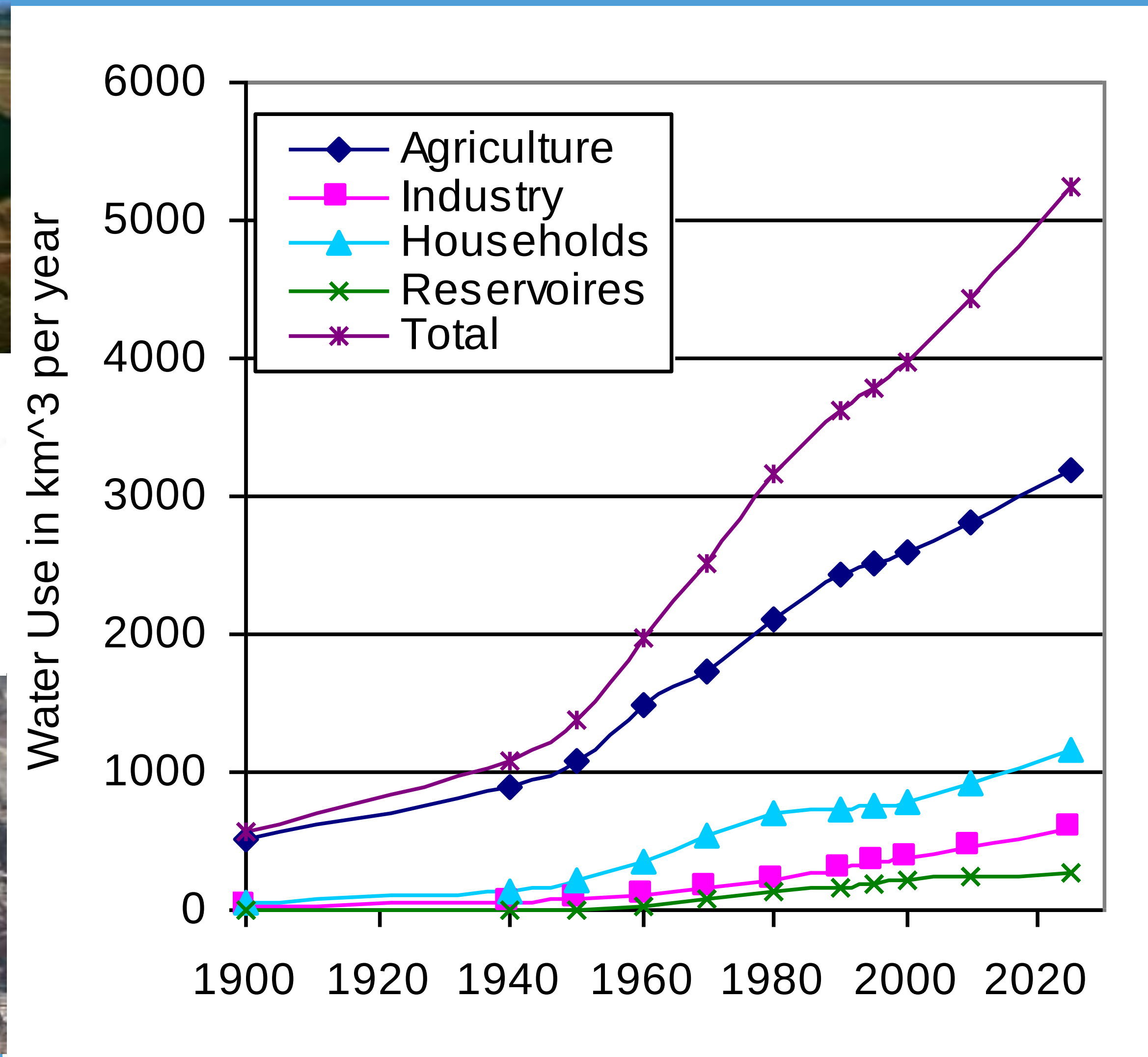
Source: book principles of Environmental Science (chapter 10)

Pressures and challenges for delta's

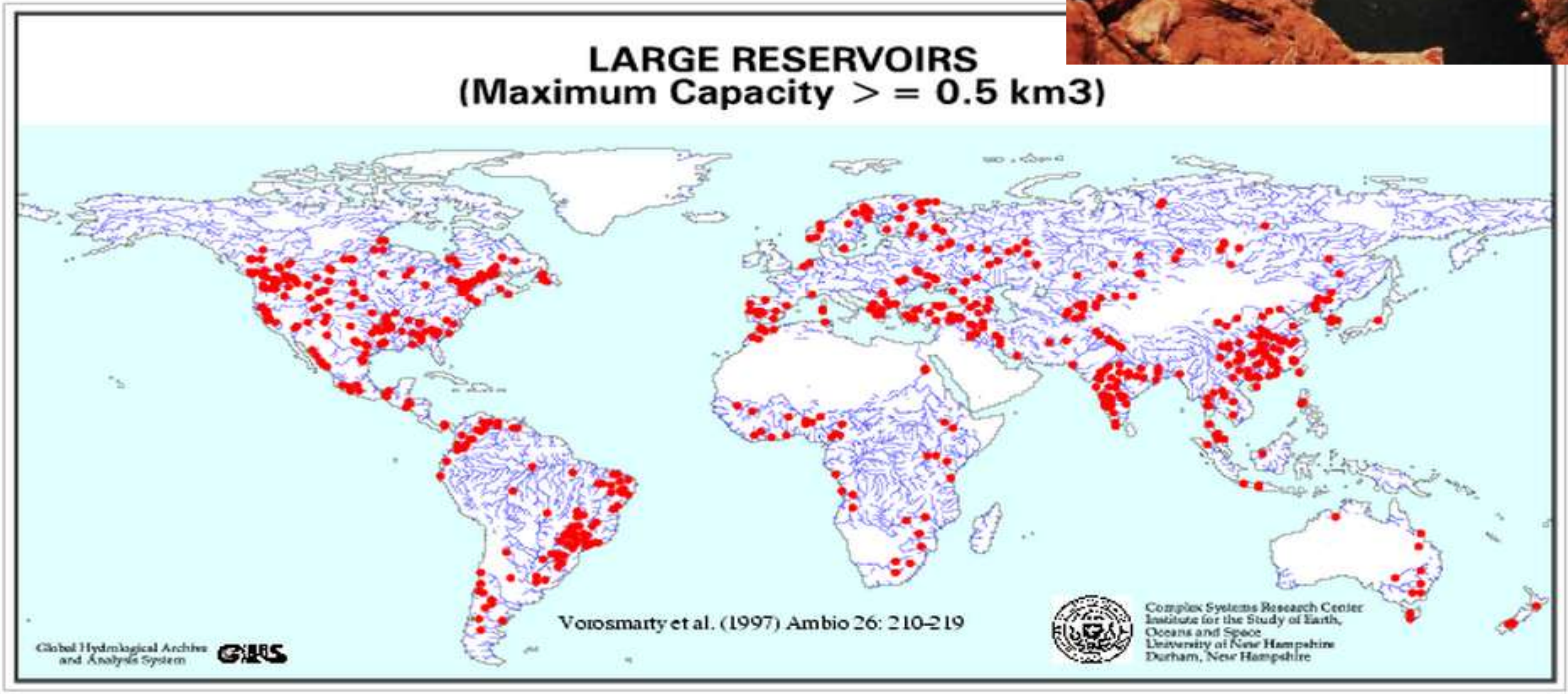
- Population growth
- Urbanisation
- Food Supply
- Soil subsidence
- **Fresh water resources**
- Climate change
  - River run off
  - Sea level rise
  - Precipitation patterns
  - Temperature

ACCEPTABLE RISK
- Water scarcity
- Salinity

Global freshwater use



Reservoirs



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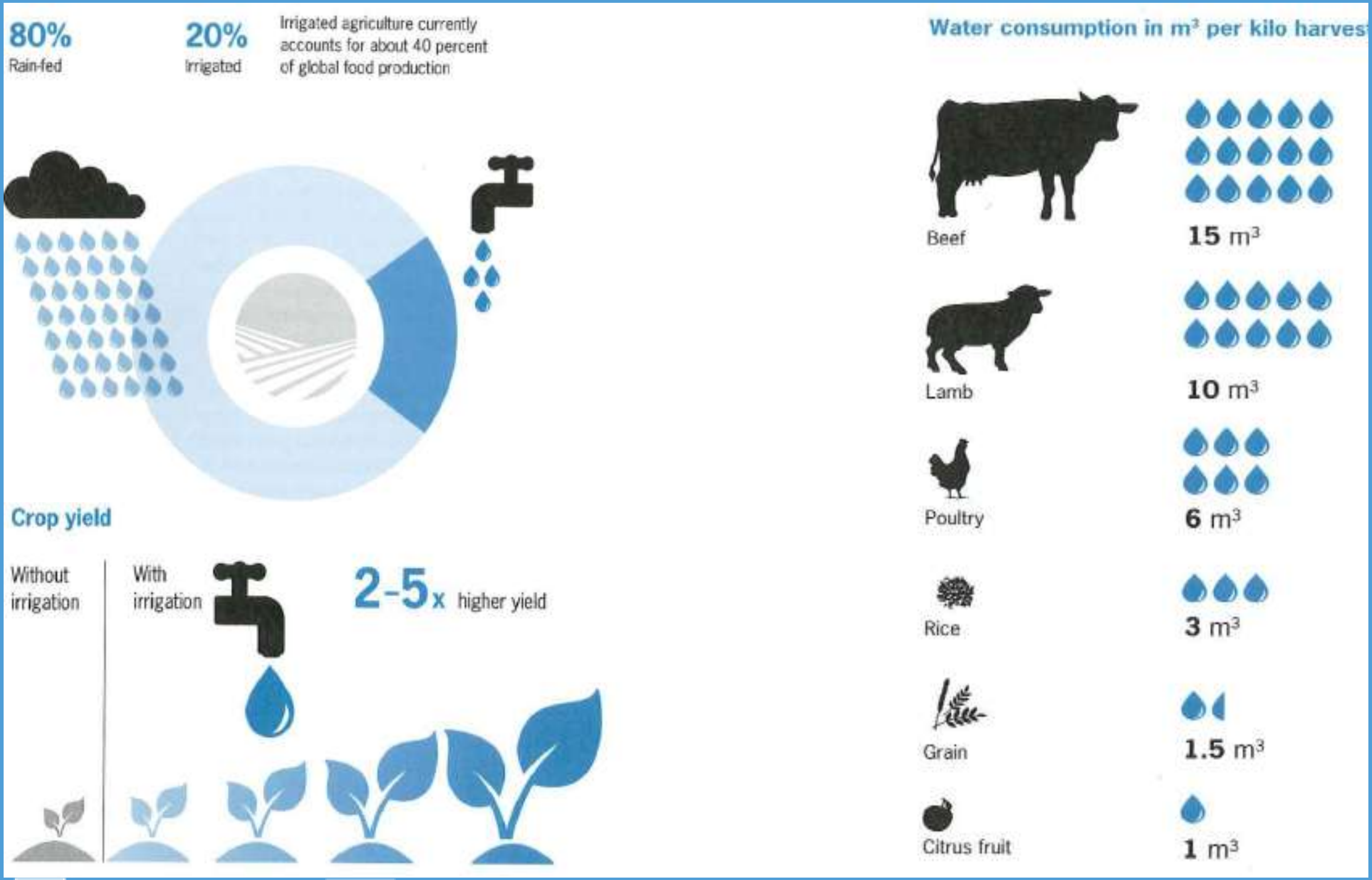
Picture: Hoover Dam, USGS 1984

Water and Agriculture



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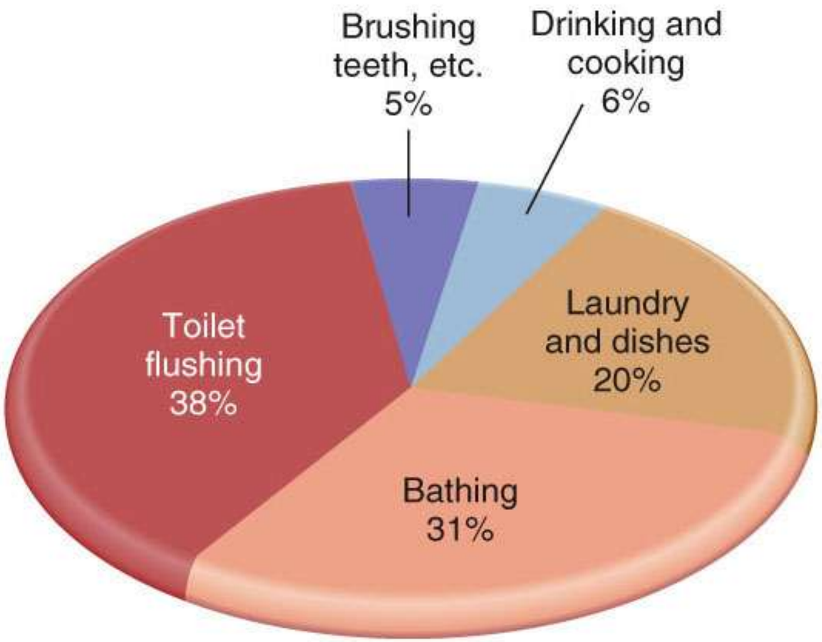
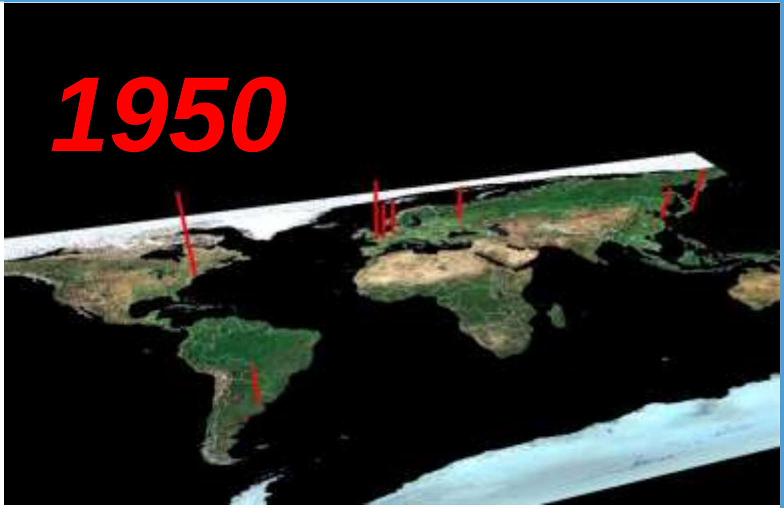
Source: Food and Agriculture Organization of the United Nations (FAO)

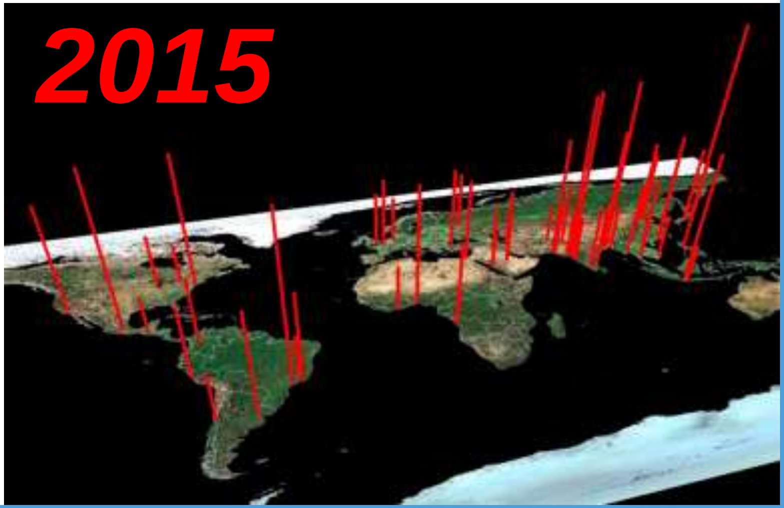
Water and Households

World Cities exceeding 5 million residents



Source: Data from U.S. Environmental Protection Agency, 2004.



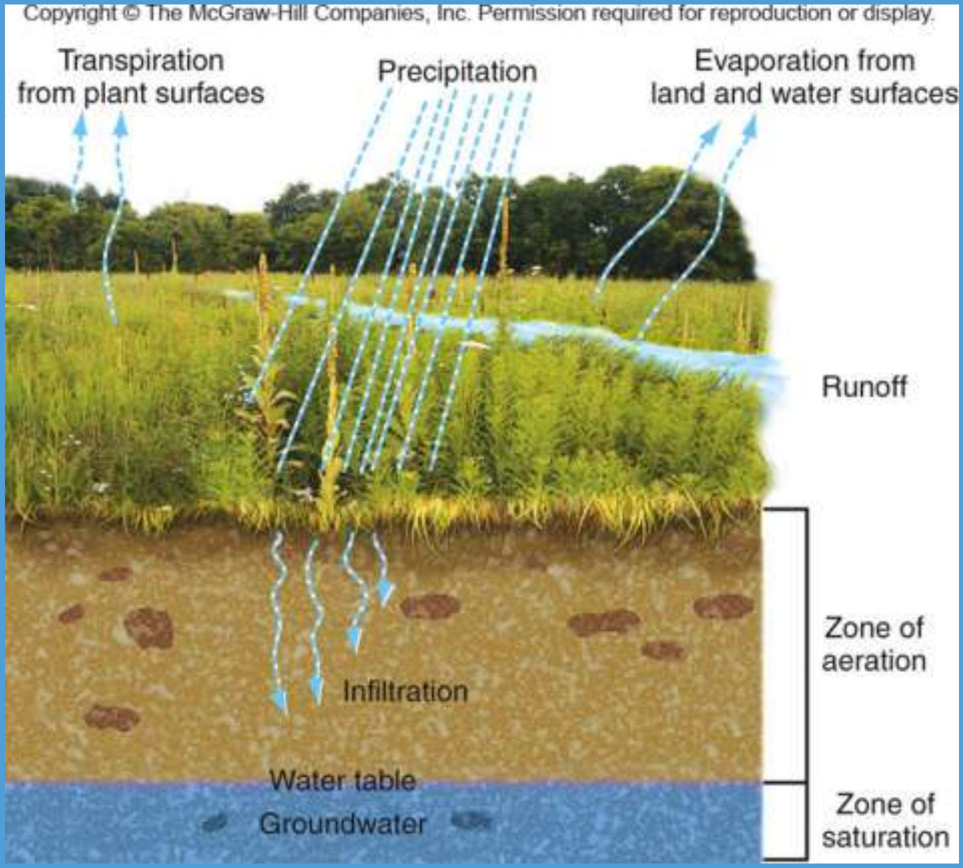


Source: Analysis by Munich Re Data: U.N. Population Division

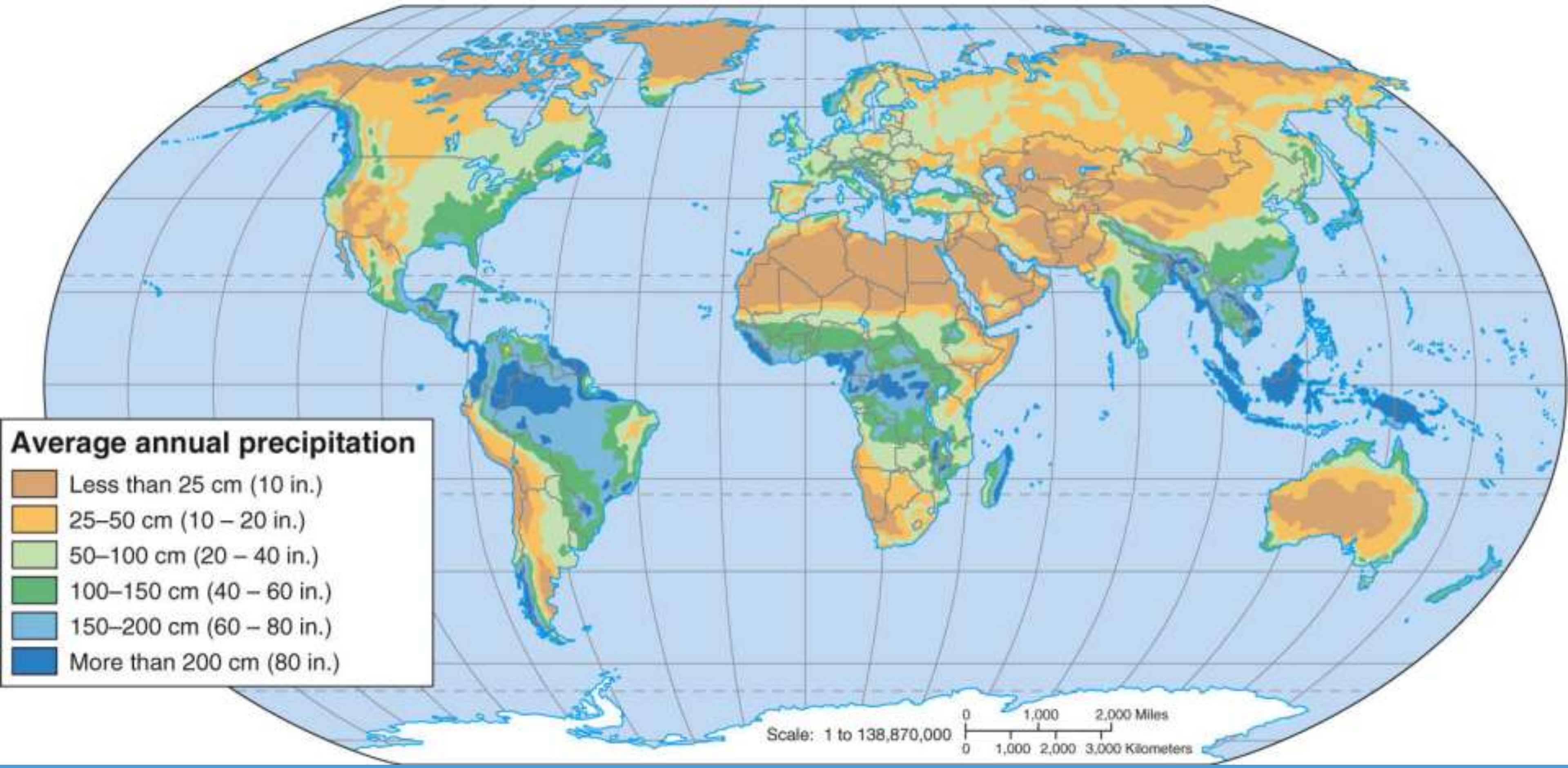

Part 2:
Climate change & Global Freshwater

Climate change & hydrological cycle

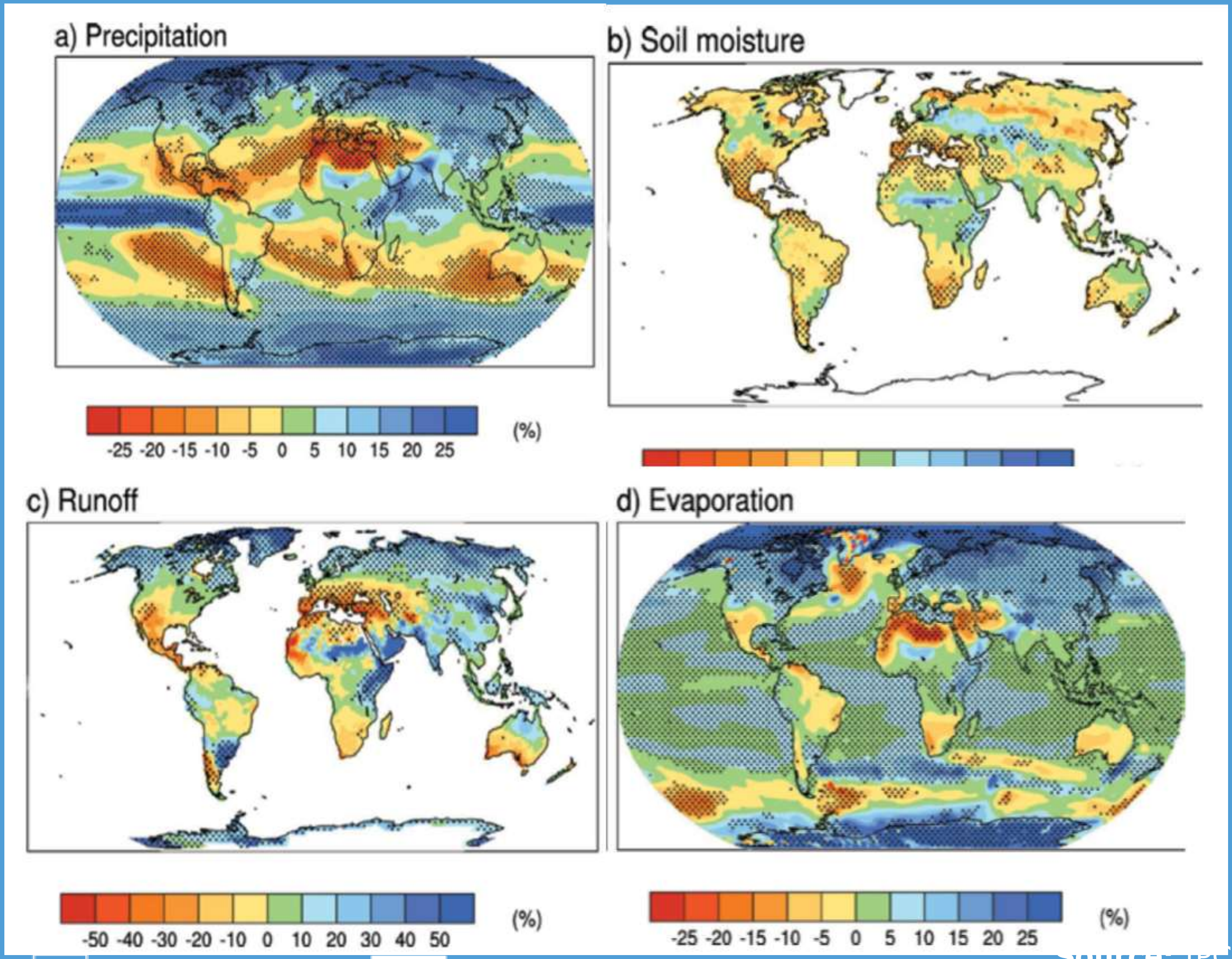
- Precipitation
- Evaporation/Transpiration (land, water, biosphere)
- Soil moisture
- Runoff
- Groundwater (infiltration)
- Sealevel rise (salt)



Average annual precipitation on Earth



Climate change and hydrological cycle



Mean annual precipitation for the scenario SRES A1B for the period 2080–2099 relative to 1980–1999

Source: IPCC, 2007

Summary of future changes of the hydrological cycle

- **Rainfall:** rainfall will increase near the poles and in the tropics but will decrease in the mid-latitudes
  - Increased variability – more heavy precipitation events and longer dry spell
- **Evaporation:** potential evaporation will increase almost everywhere – changes in actual evaporation over land depends largely on changes in rainfall
- **Storage** – soil moisture projected to decline in more areas than what would be expected from rainfall alone
  - Droughts (long periods with low soil moisture) will increase
- **Run-off** – will increase in the high latitudes and tropics and decrease in the mid latitudes
  - Especially in dry regions small changes in rainfall can cause large changes in run-off

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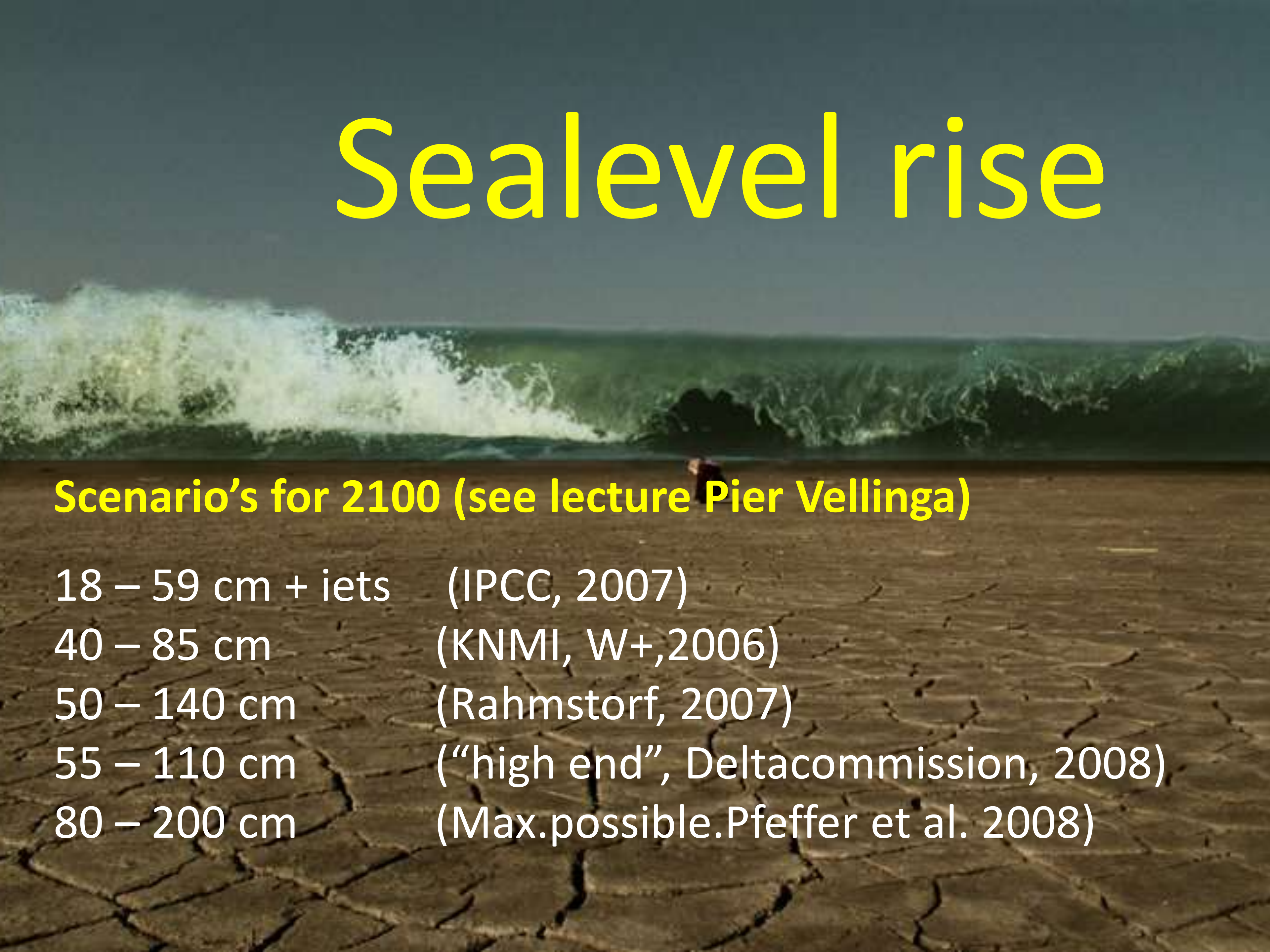
Source: Fulco Ludwig

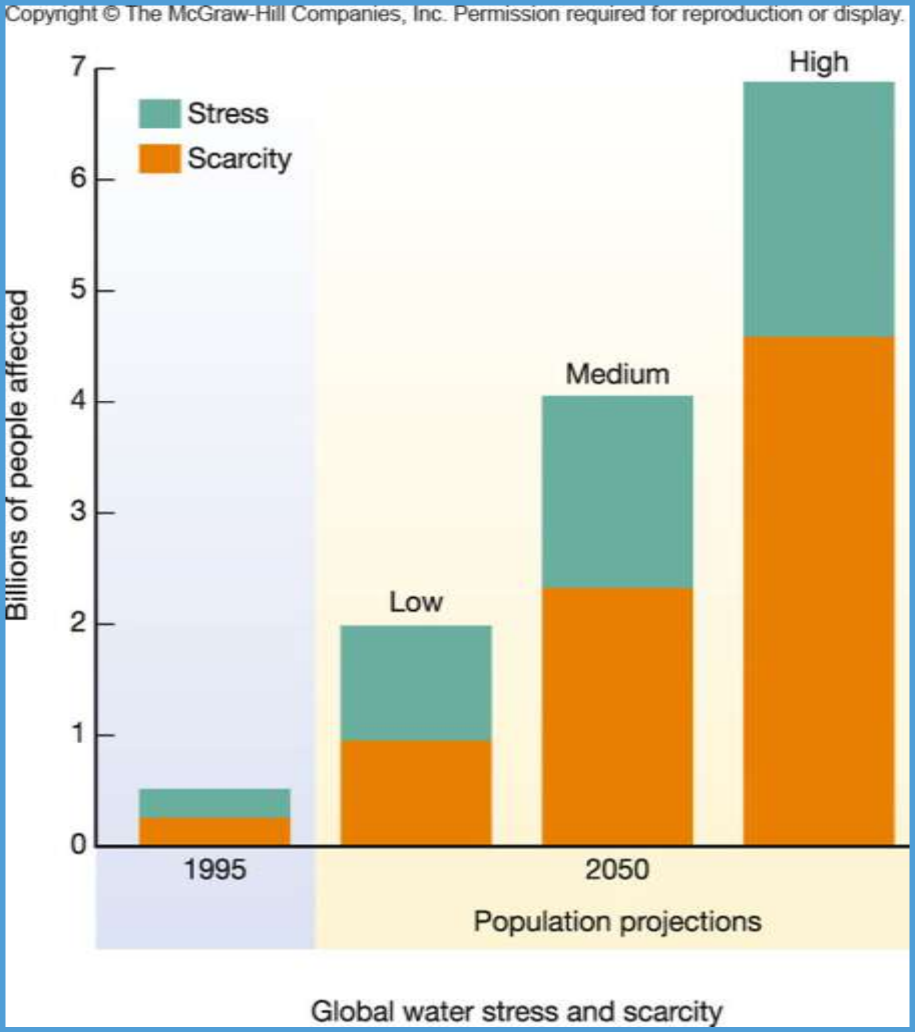


Sealevel rise

Scenario's for 2100 (see lecture Pier Vellinga)

18 – 59 cm + iets	(IPCC, 2007)
40 – 85 cm	(KNMI, W+,2006)
50 – 140 cm	(Rahmstorf, 2007)
55 – 110 cm	("high end", Deltacommission, 2008)
80 – 200 cm	(Max.possible.Pfeffer et al. 2008)

Water scarcity and water stress

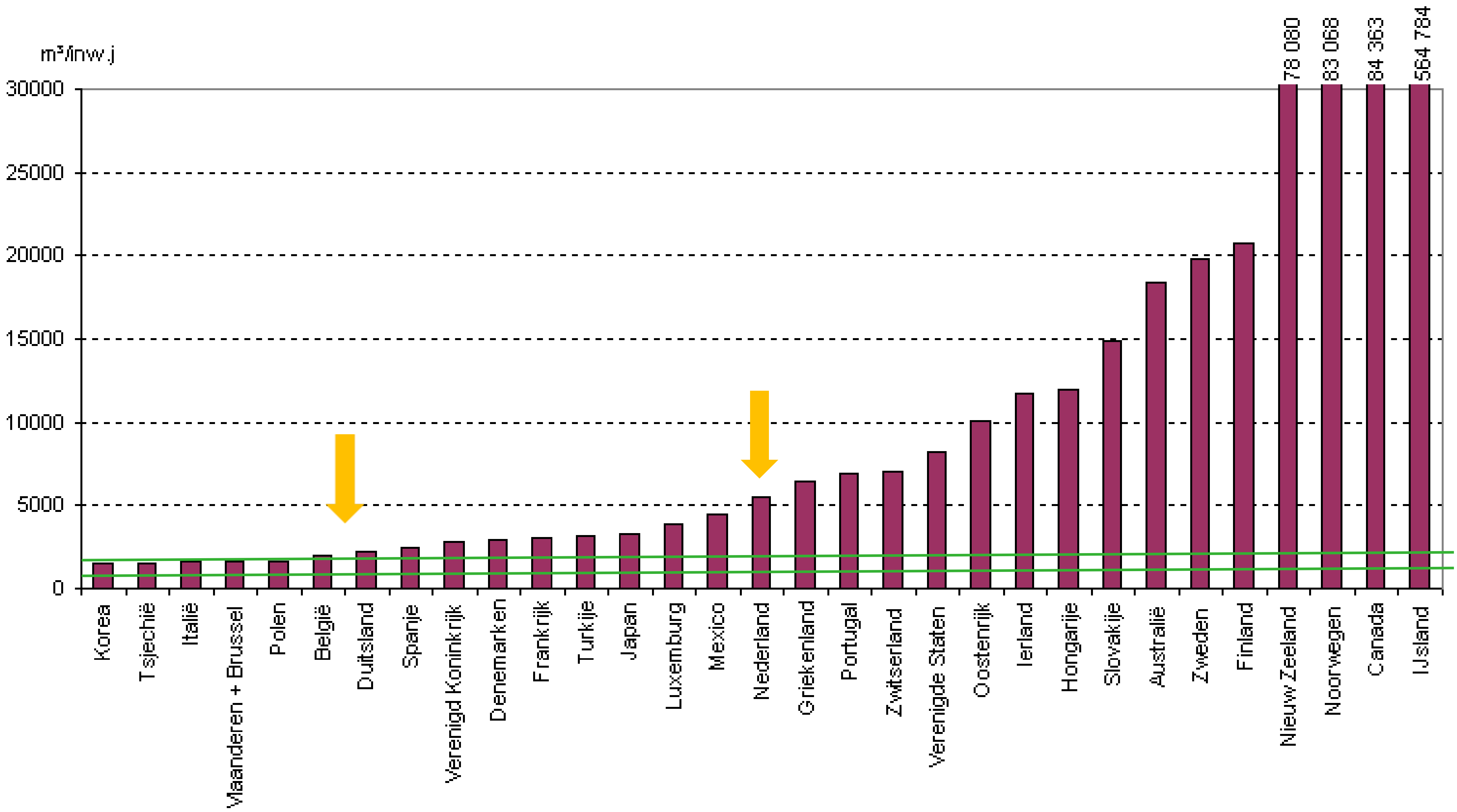


Water stress is when annual water **supplies** drops below **1,700 m3** per person (e.g. 4660 litre/d) and

Water scarcity when supplies drops below **1,000** m3 per person (2740 litre/d) (definition UN) .

Average water use per person in the Netherlands: **120 l/d** and an annual water supply of **5000 m3** per person

Water availability per Capita (OESO)



Source: OESO

Part 3: Delta’s

Characteristics of delta areas

"A low triangular area of alluvial deposits where a river divides before entering a larger body of water."

"naturally shaped by a combination of river, wave and tide processes."

"Ideal settling areas for society because of fertile soils, available water resources etc."

"Vulnerable to natural hazards such as storm surges and river floods"

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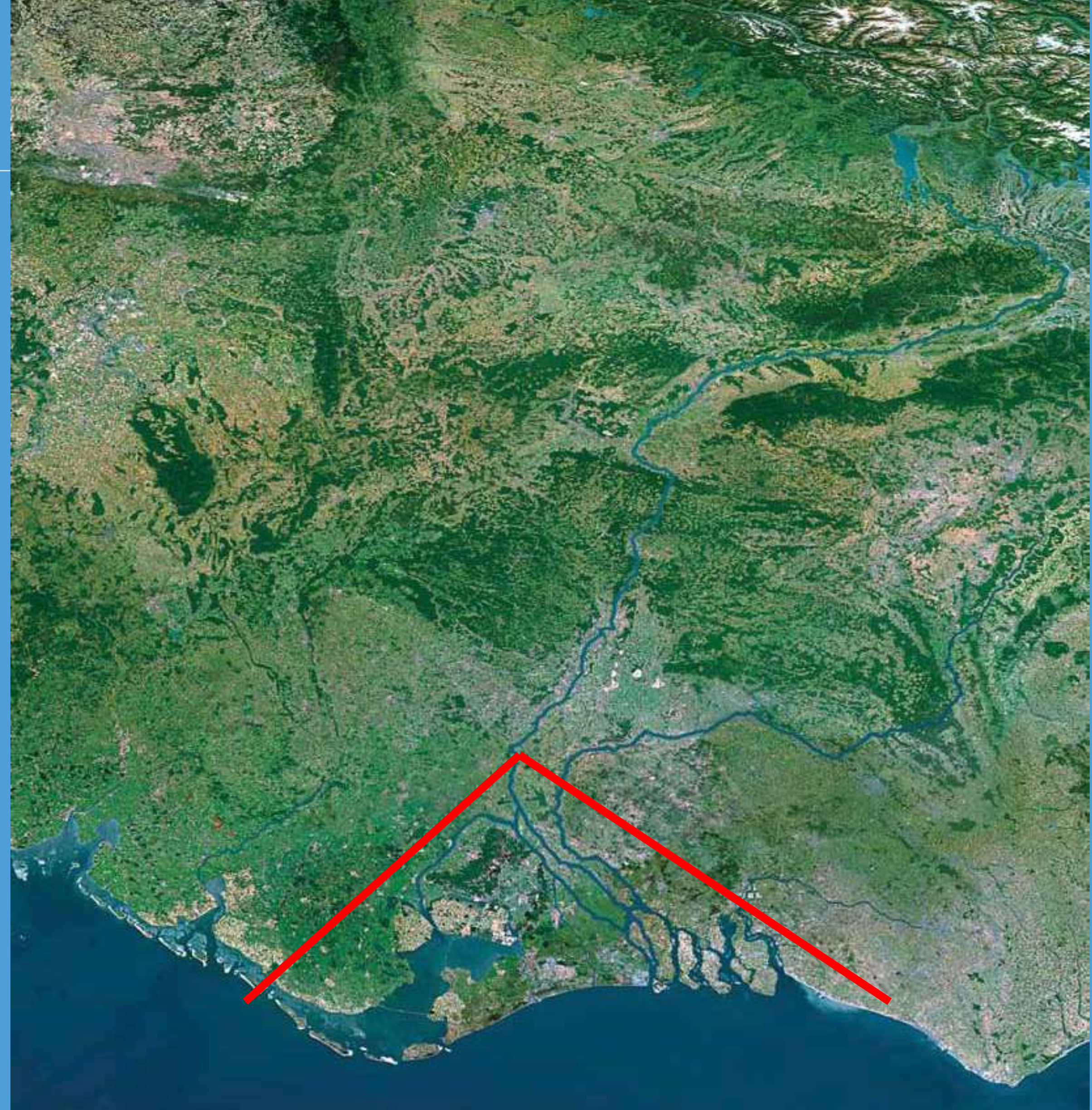
Estuarine dynamics

- Tidal dynamics
- Morphology dynamics (sedimentology)
- River discharge – sea influence
- **Salinity gradients**
- Nutrient gradients

Baptist e.a. (2007)

Dutch Delta

The term 'Dutch Delta' in policy doc's is more a ***'pars pro toto'****, referring to the lowland setting (rather than a mere fluvial subsystem)*



Picture: Ontwerp Nationaal Waterplan (2008)

http://www.youtube.com/watch?v=a8mcwbgW7IM

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Delta works and drawbacks

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Delta Programme about lake Volkerak

- Temporary **retention of river water** during peak discharges
- Estuarine dynamics, under the condition that alternative **freshwater supply is guaranteed**!

Climate proofing:

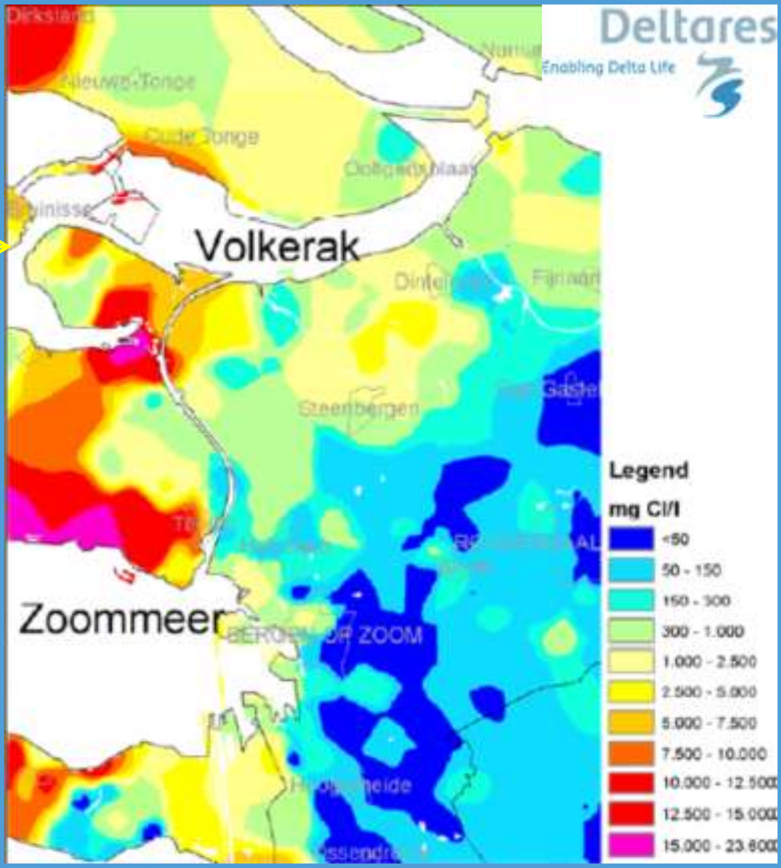
- coastal protection
- nat. fresh water resources

- Land use (regional development)
- Ecology & Economy

Causes of salinisation in West part of the Netherlands

- Land subsidence / land use
- Climate change
  - Sealevel rise
  - Precipitation
- Autonomous salinisation
- Water management

Internal salinisation



Exernal salinisation

Source: Beijk et al., 2008

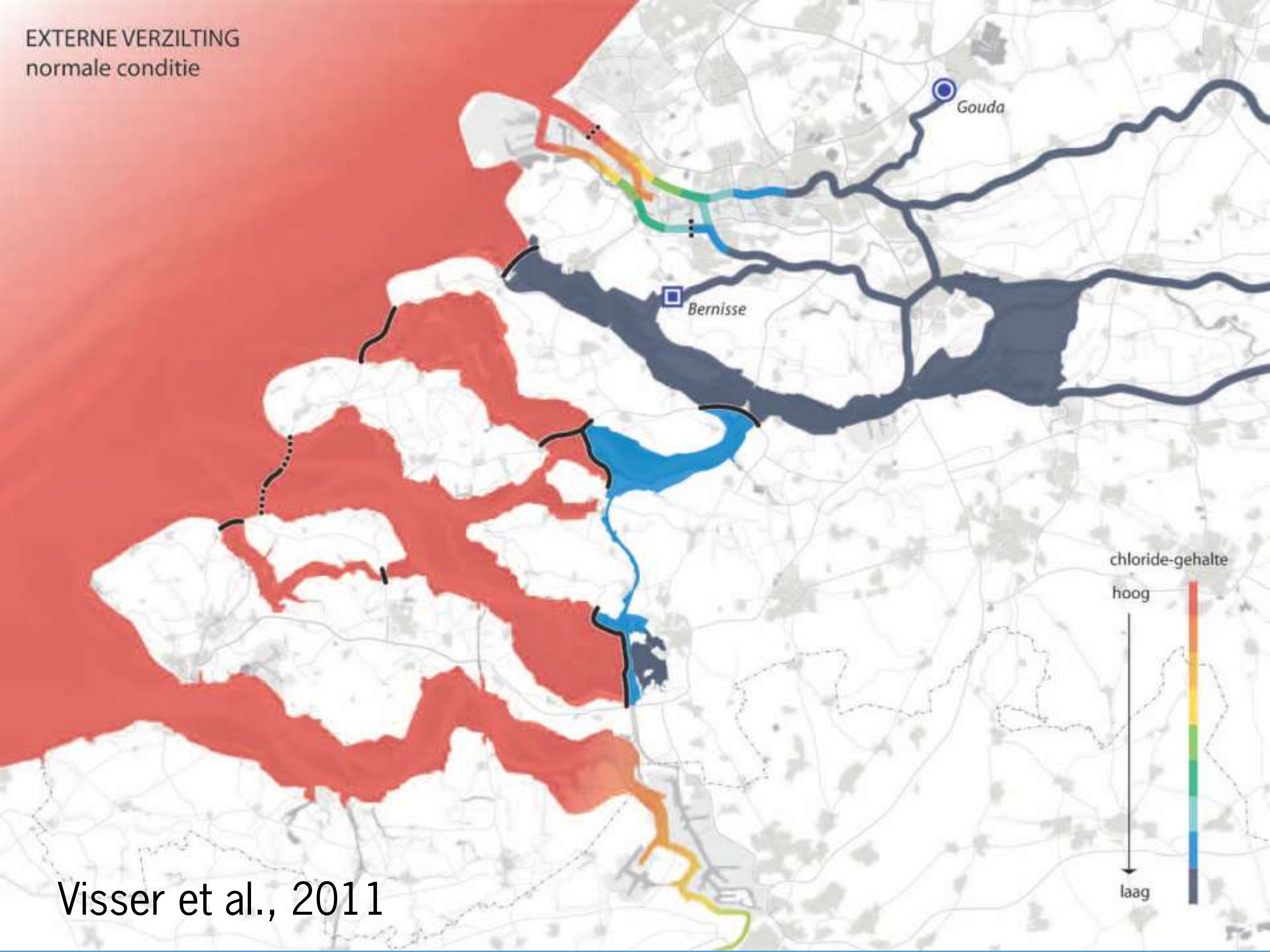
Salinisation & climate change impact

- Estimation of probabilities that chloride conc. thresholds are exceeded
- Estimation number of frequency of days that thresholds are exceeded

Dealing with uncertainties, under different:

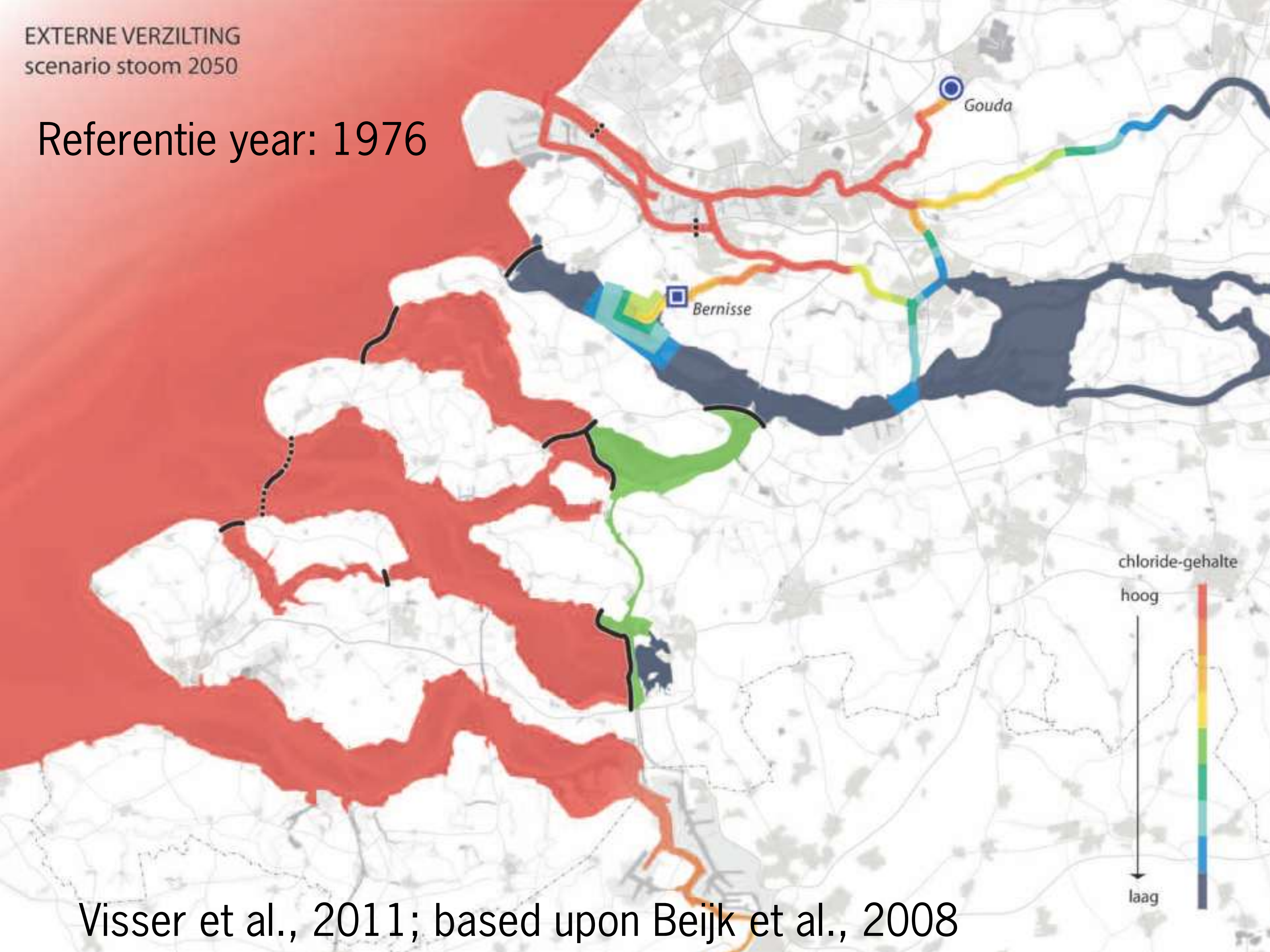
- Scenario's (KNMI, Hydrology)
- Locations in the delta
- Types of salt years

Beijk, 2008; Rijkswaterstaat



Visser et al., 2011

Referentie year: 1976



Visser et al., 2011; based upon Beijk et al., 2008

Indicative CL- values in Dutch water management

	CL^- (mg l^{-1})	Source
North Sea:	16000-18000	Cult. Tech. Vadaceum (1988)
Lake VZM (currently)	200 - 1000	Plan-MER (2010)
Current management objective Lake VZM	450	Peilbesluit (1996)
Lake VZM (future)	8000-10000	Plan-MER (2010)
Drink water threshold (law)	150	RIVM/WHO
Landbouwkundig zoet	1000	Province Zeeland (2006)
Greenhouse horticulture	50-200	Rijkswaterstaat
Arable farming	1000	Rijkswaterstaat
Freshwater dependent nature	300-1000	Rijkswaterstaat

Fresh and salt water

Indicators:

- Chlorinity ($[CL^-]$),
- Natrium ($[Na^+]$),
- Conductivity (Ms/cm)

Uncertainty in research:

- Scientific disciplines use different indicators
- System looked at? (ground/surface/soil moisture)

Uncertainty in policy:

- Stakes
- Scientific sound risk thresholds

Classification systems fresh and salt water

- Geohydrology : Stuyfzand (1993)
- Ecohydrology : Wamelink and Runhaar (2000)
- Marine ecology :Venice System (1959)

Venice System (1959):

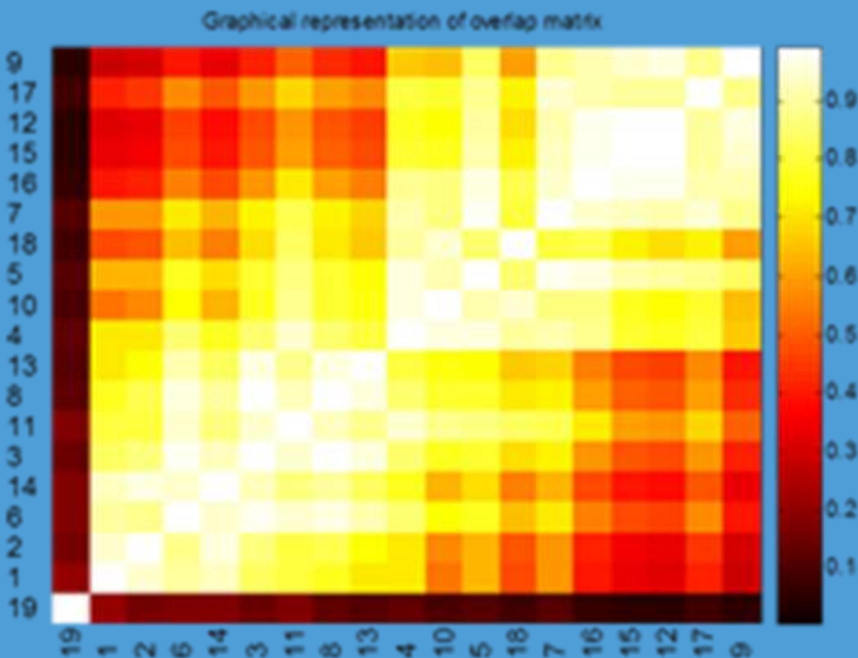
Legend	**salinity (g/l)**
Fresh	<0.5
Oligohaline	0.5-5 (Brak)
Mesohaline	5-18
Polyhaline	18-30
Mixohaline	0.5-30
Euhaline	30-40

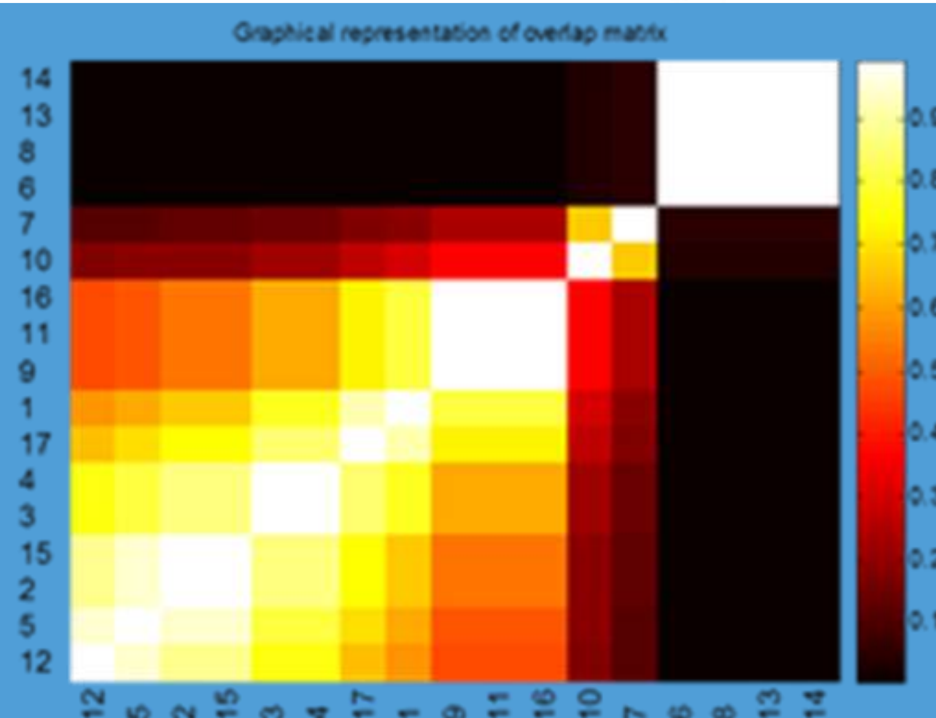
	Stuyfzand (1993)	Wamelink & Runhaar (2000)
Klassen	mg NaCl/l	mg NaCl/l
Zeer zoet (oligosalien)	0 - 5	0 - 150
Zeer zoet - Zoet	5 - 30	-
Zoet	30 - 150	150 - 300
Zoet - Brak	150 - 300	300 - 1000
Brak	300 - 1000	1000 - 5000
Brak - Zout	1000 - 10000	5000 - 10000
Zout	10000 - 20000	>10000
Hypersalien	> 20000	

Different regional perspecives

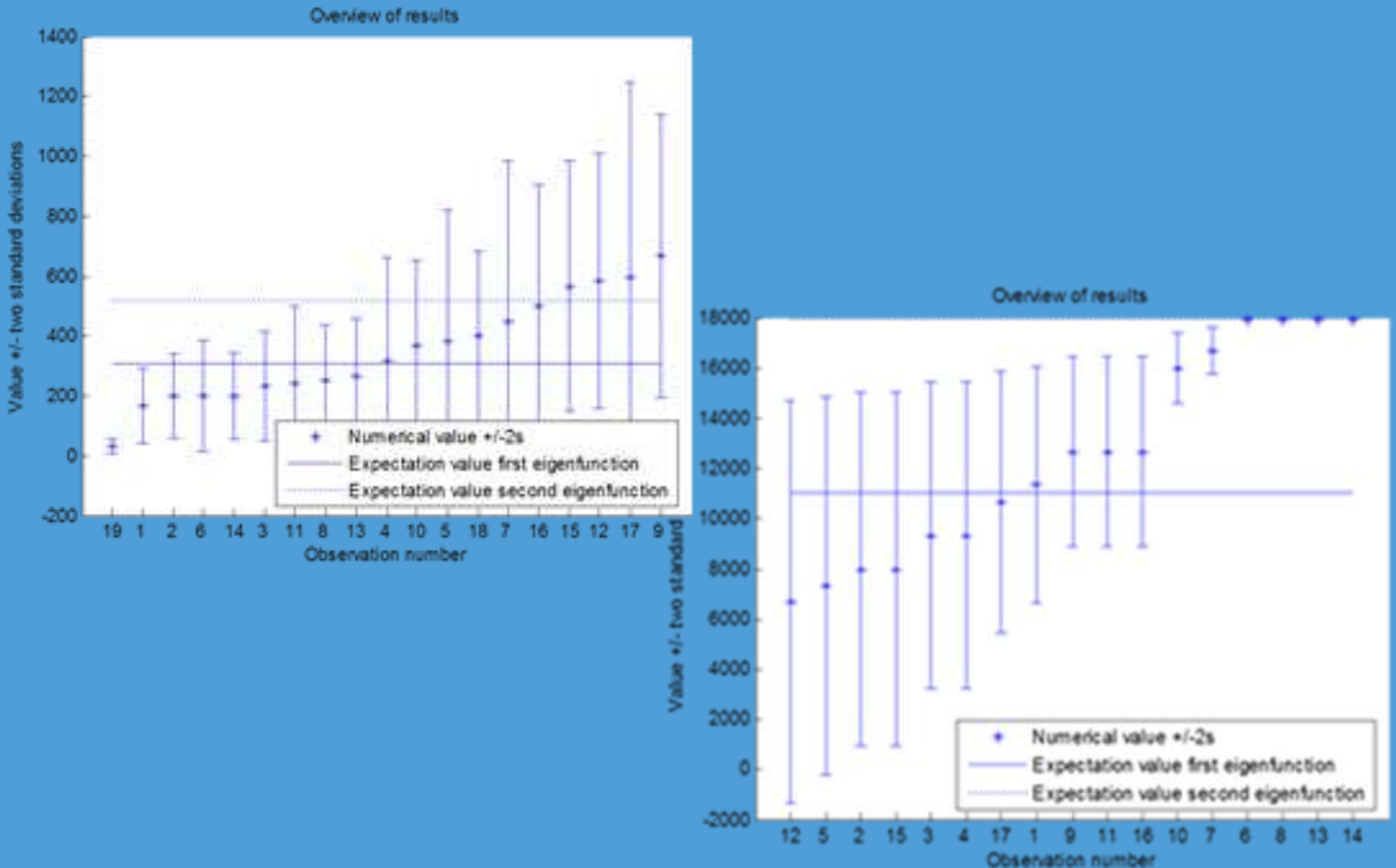
Salinity surface water at this picture (2008): 2.5-3 g/l (≈ 750 -1000 mg/l Chloride) the Mallorcan water manager calls this water ‘fresh’, while Dutch water managers would qualify this water as ‘brackish’.

Fresh and Salt (1)





Freshwater around VZM: framing the issue



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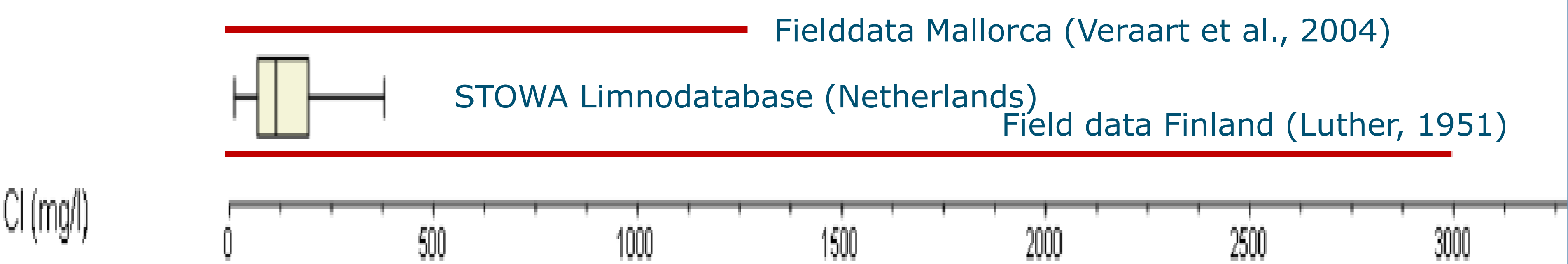
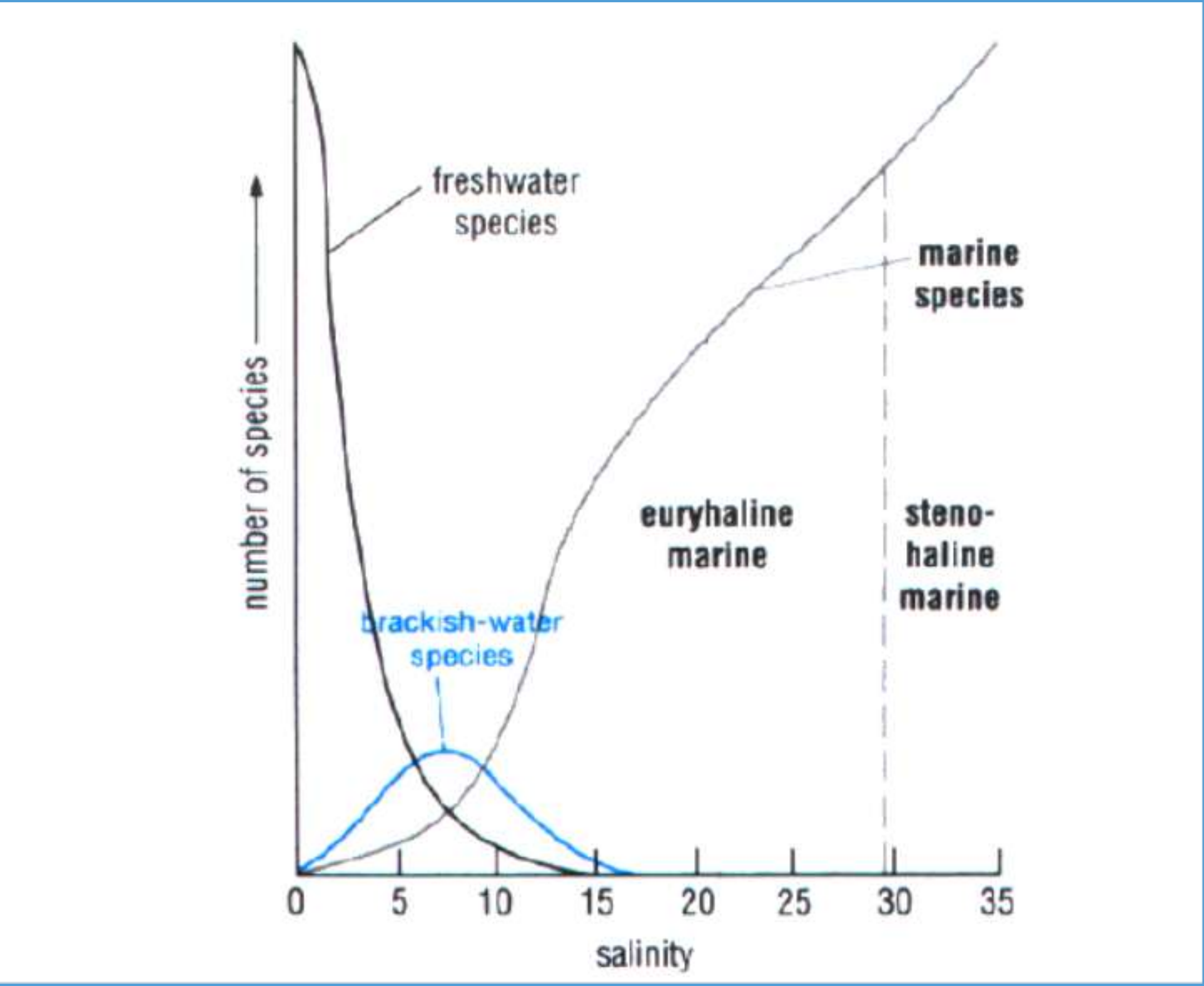
Source: Klostermann & Veraart, in prep.

Differences in field data salt tolerance

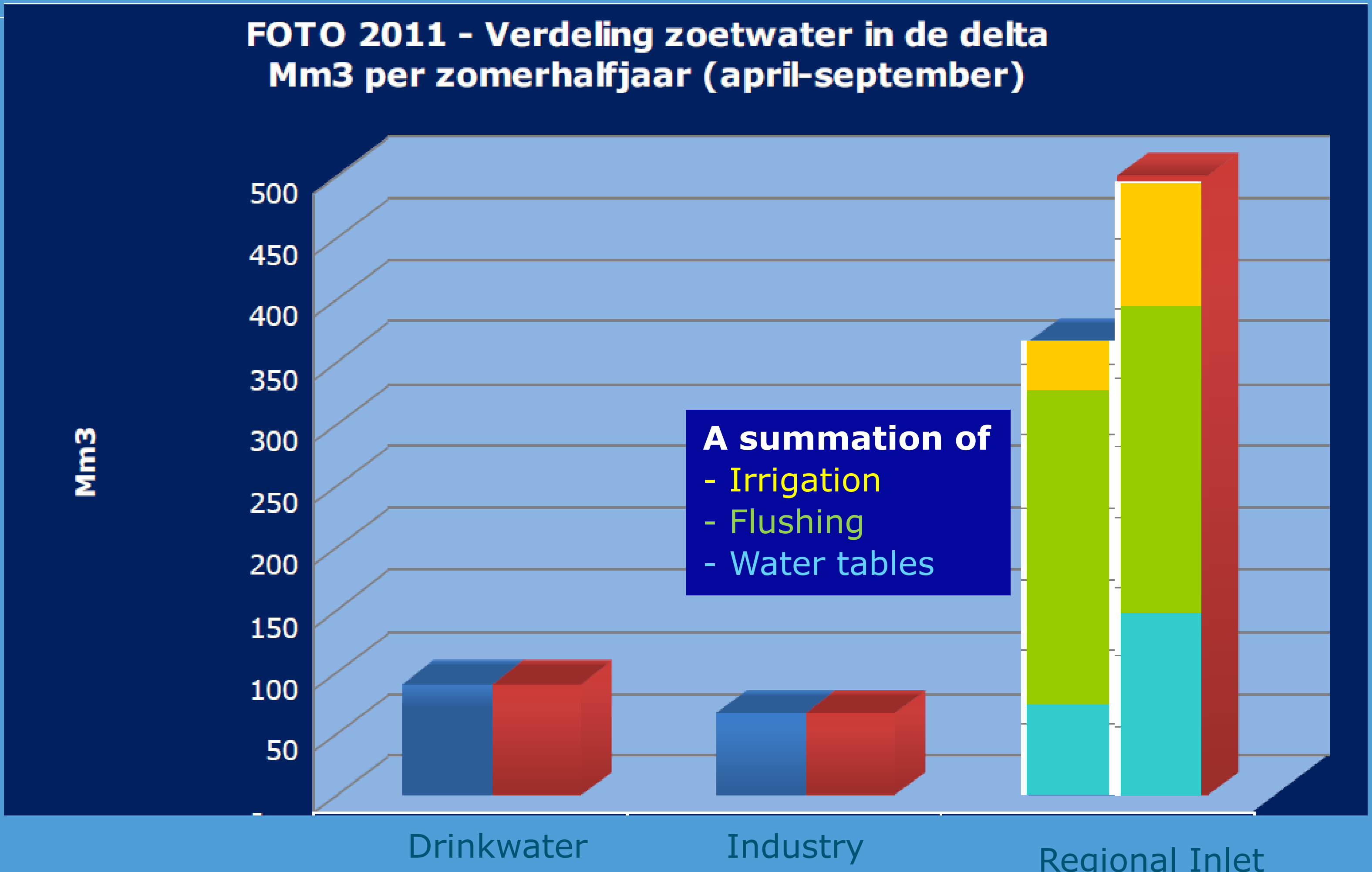


Grof hoornblad
(Ceratophyllum demersum)



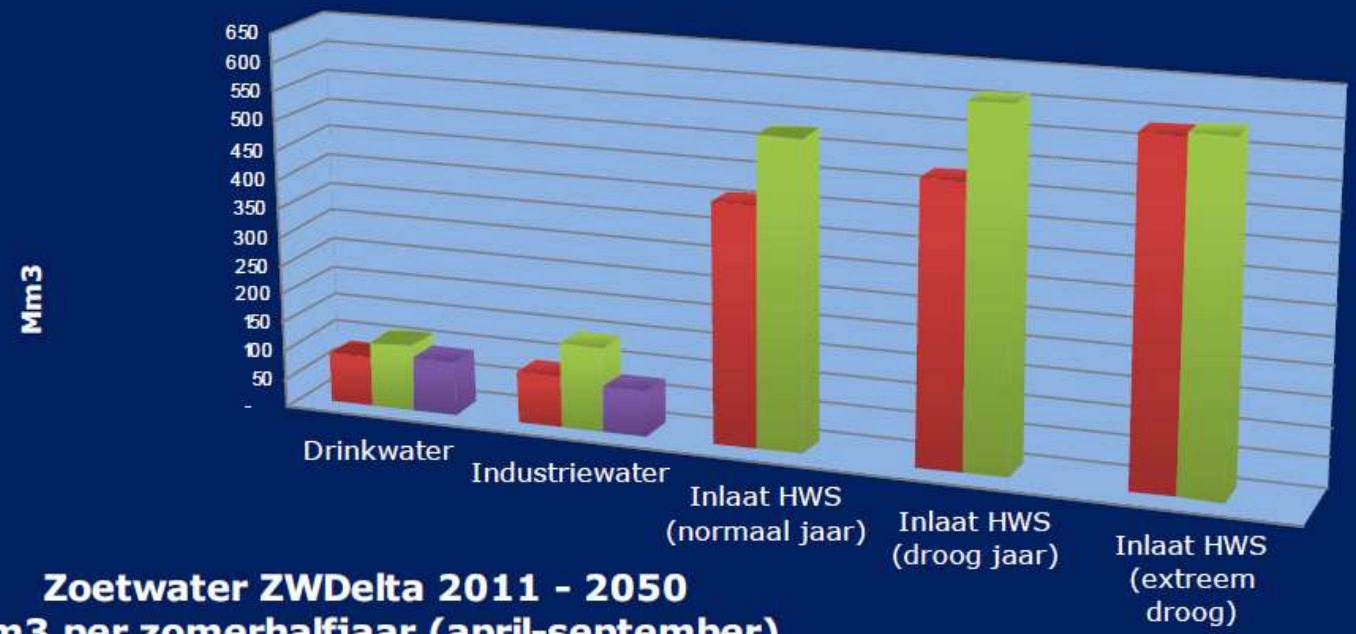
Remane & Schiepler, 1971)

Water demand per sector in a normal and extre dry year (1976) in the Southwest Delta



Van Tuinen & Visser, 2012

Scenario's



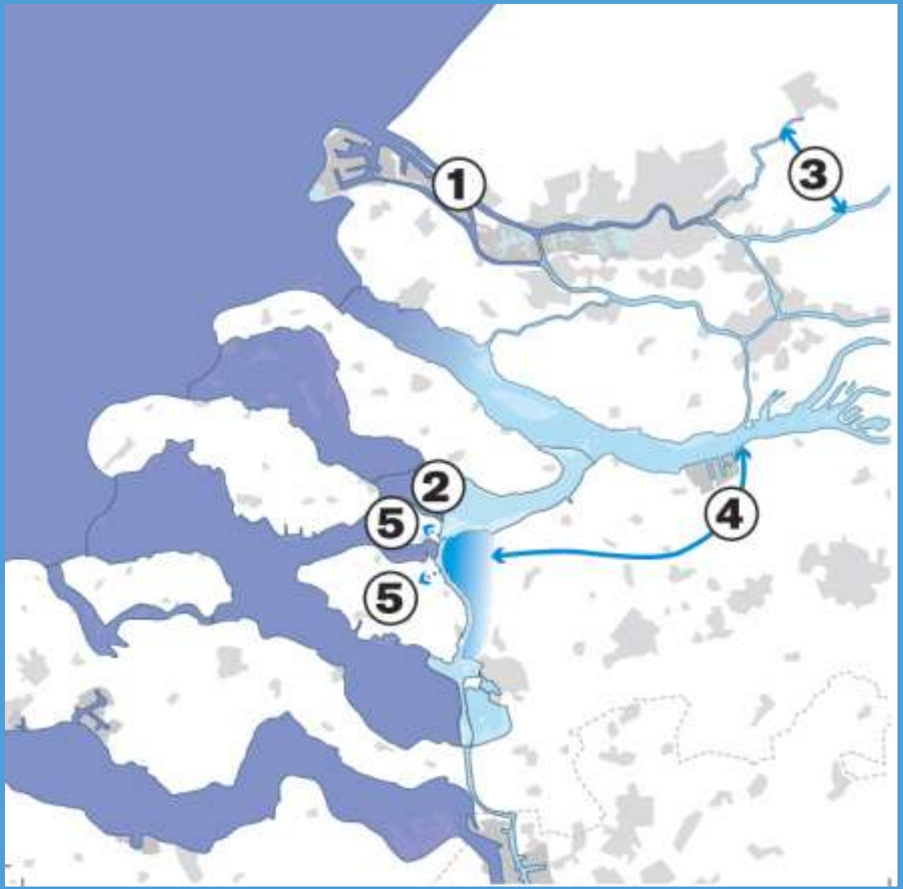
Zoetwater ZWDelta 2011 - 2050
Mm3 per zomerhalfjaar (april-september)

	Drinkwater	Industriewater	Inlaat HWS (normaal jaar)	Inlaat HWS (droog jaar)	Inlaat HWS (extreem droog)
HUIDIG	84	87	411	481	583
STOOM (2050)	112	145	529	611	589
SECTOR PROGNOSE	92	77			

Van Tuinen & Visser, 2012

Recent history water management VZM

- 1987: Lake became Fresh
- .... : Water Quality issues
- 2002: Strategic Env.
  Impact Assessment
- 2003: 'De brede discussie'
- 2008: Delta Commission
- 2009: Delta programme
- 2010: National Water Plan
- **2012: RSV VZM-Grevelingen**
- 2015: decision: fresh/salt?



Map: Programmabureau Zuidwestelijke Delta

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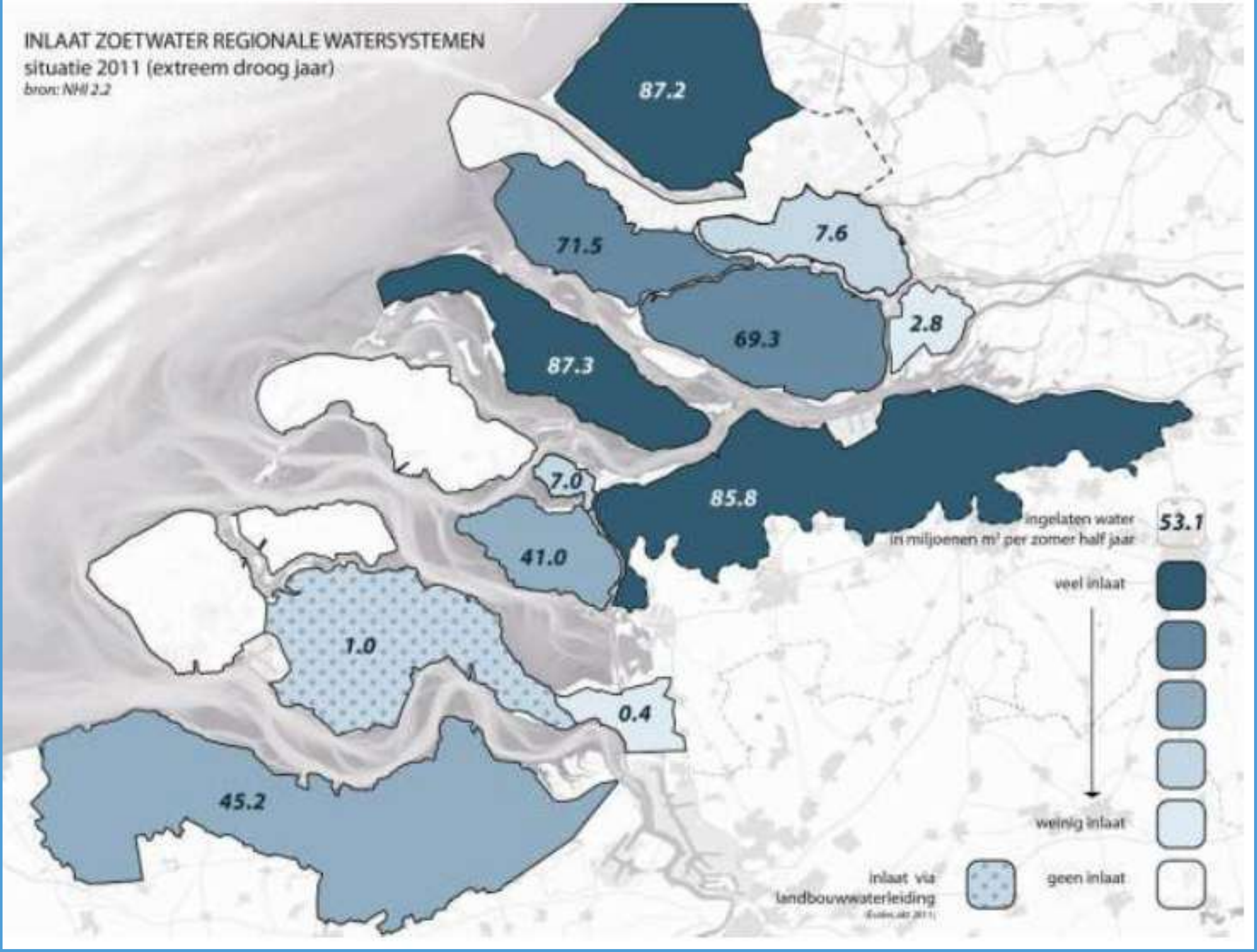

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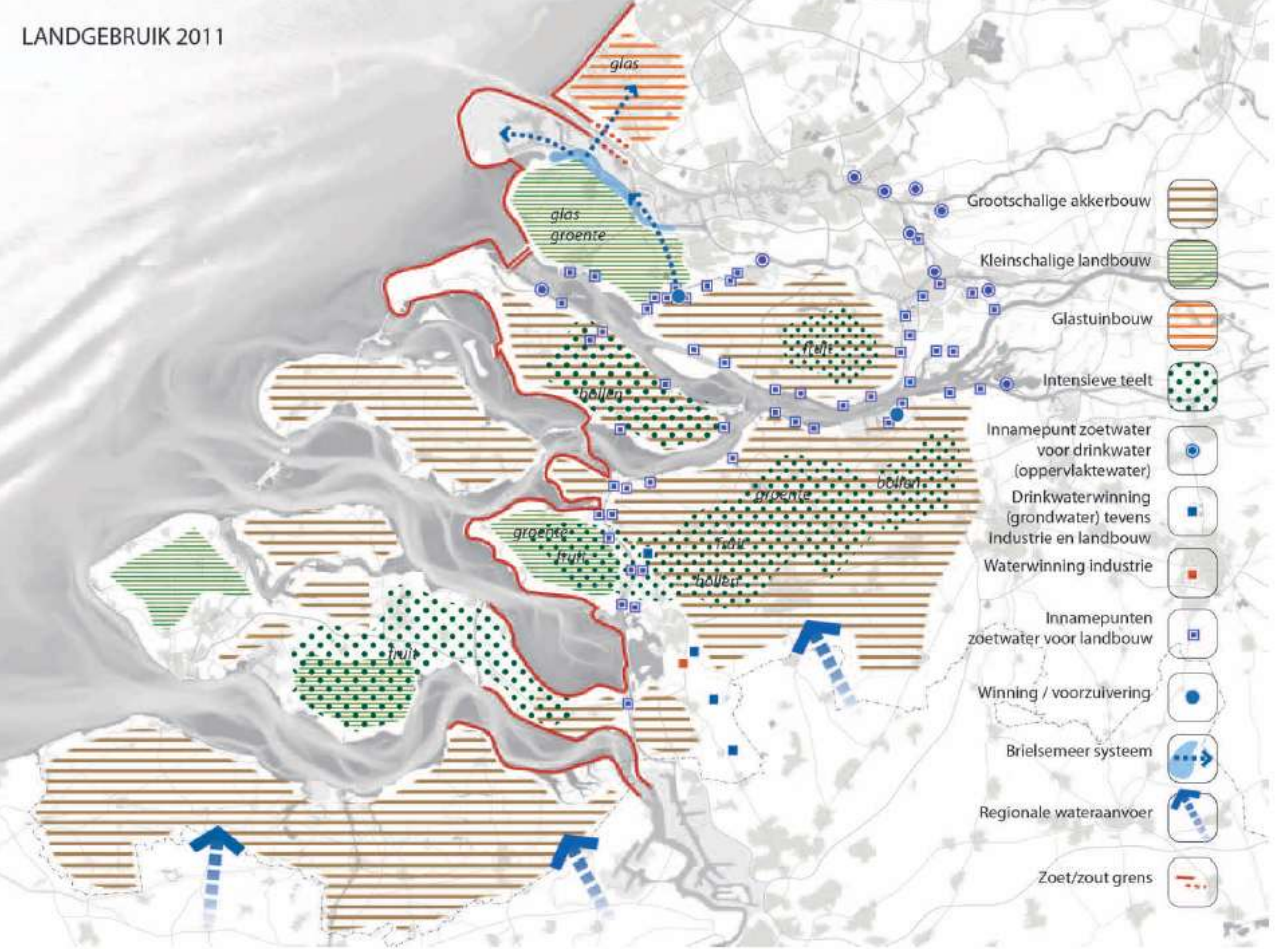
Van Tuinen & Visser, 2012



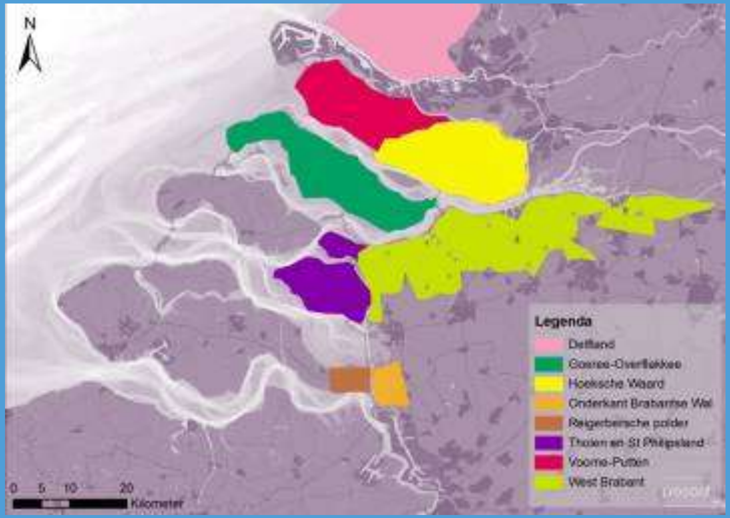
Bron: Zoetwater Advies, Stuurgroep Zuidwestelijke Delta, 2009

Part 4: Adaptation of freshwater resources management to climate change

Expert judgment about adaptation

- Before designing regional interventions to cope with future water scarcity make a well considered choice of a policy strategy, e.g.:
    - **Combat the impacts (resisting strategy)**
    - **Cope with the impacts (adaptation)**

Both can be made climate proof!



Source: De Vries et al., 2009)

Knowledge for Climate

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Deltares Enabling Delta Life

Acacia Water Solutions in Groundwater

KWR

TNO

Combat the impacts (resisting strategy):

Supply freshwater to keep salt sensitive crops in production in a estuarine delta

Regional stakeholders:
' Zout hoort in de zee
Niet op Flakkee…'

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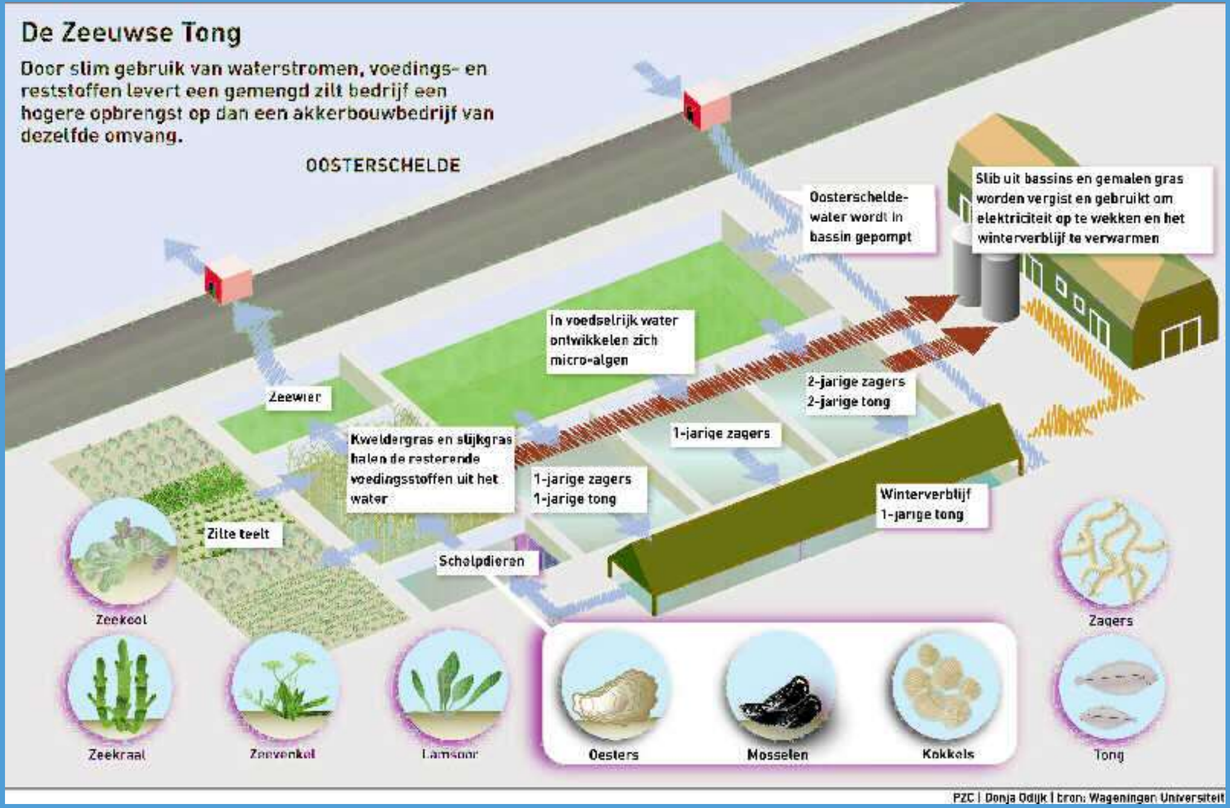
Cope with the impacts (adaptation):

From agriculture to aquaculture (example Zeeuwse Tong)



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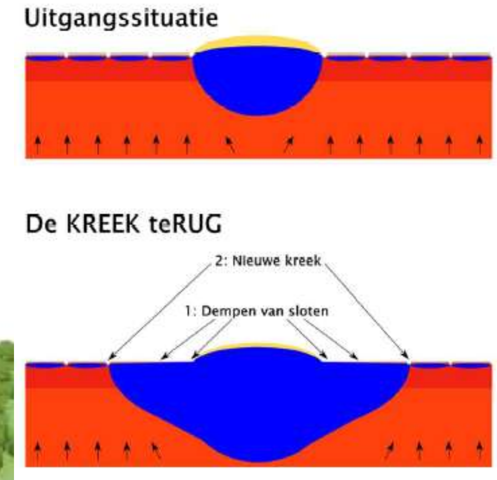
More efficient use of rainwater and groundwater

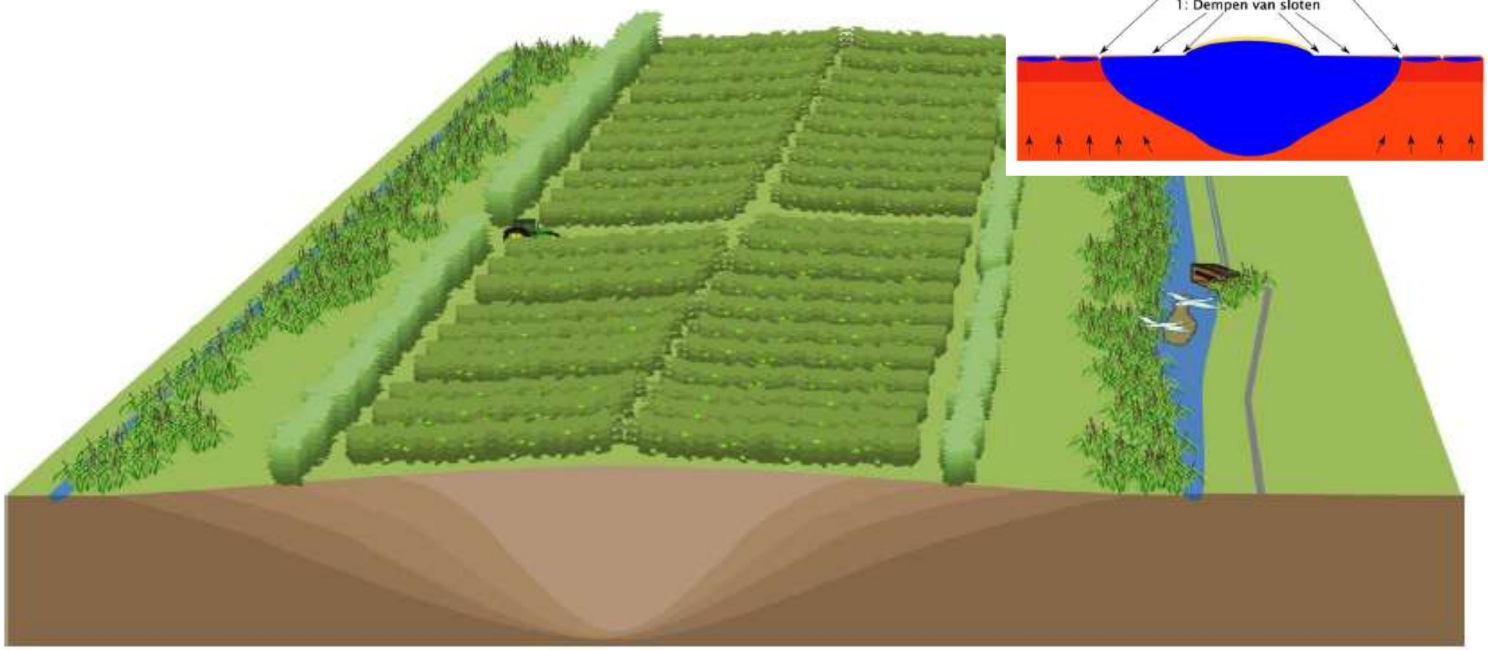
Deltares
Enabling Delta Life

IMARES
WAGENINGEN UR

De KREEK teRUG

More efficient use of rainwater from winter (increase storage freshwater with drainage techniques)





Adaptation to salinisation (aquatic system)

1. **Become more tolerant** (osmoregulation or active secretion of salt)
2. **Avoid salt** (dispersion, (re)colonisation, survive as a seed or as a propagule.

James, 2003; Skinner et al., 2011

Seed & flower Potamogeton pectinatus

Propaguels *of Zanichelia palustris (pictures: Veraart, 2007/2008)*

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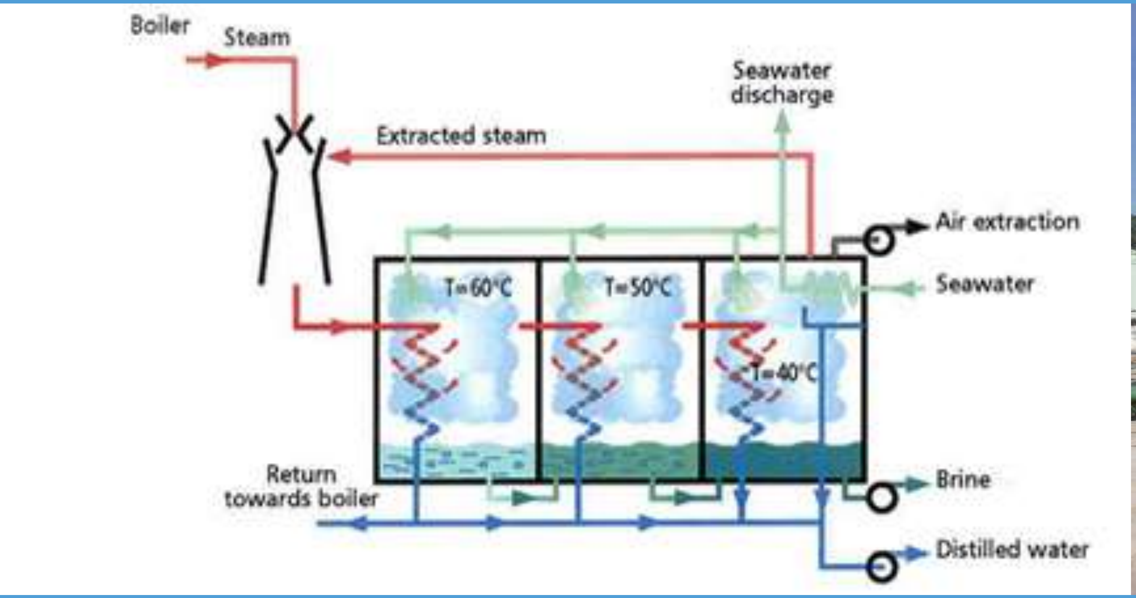
Desalinisation Plant Alcudia



Freshwater production	:	1 500 m3/day
Energy use	:	9 kWh/m3

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Source: www.entropie.com

Sewage treatment water coastal zone

Acknowledgements

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- Programmabureau Zuidwestelijke Delta
- Provincie Zeeland
- Deltaprogramma
- Others.

Possibility for Internship at Alterra

Climate change, Water management, Water framework directive and Natura2000 in West-Nederland

When: first half of 2013 (5 months)

Supervisors:

- Jeroen Veraart
- Claire Vos
- Erik de Haan (Province of South Holland)

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Thank you
Jeroen Veraart