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Third Nordic International Conference on Climate Change Adaptation
Copenhagen 25-27 August 2014

Farmes as water manager:

Extreme runoff and adaptation options in rural areas

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Landmanden som Vandforvalter

Hans Jørgen Henriksen
GEUS

Network project with three case studies

Holstebro
Storå

Silkeborg
Gudenå

Horsens
Bygholm –
Hansted å

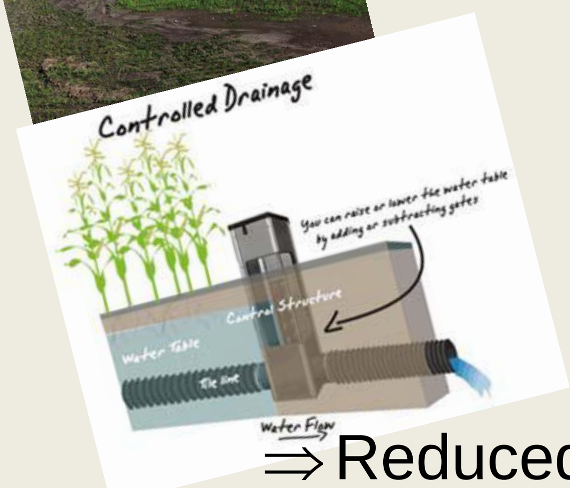
Can adaptation options in rural areas reduce downstream flooding risks in urban areas and create synergies and win-win?

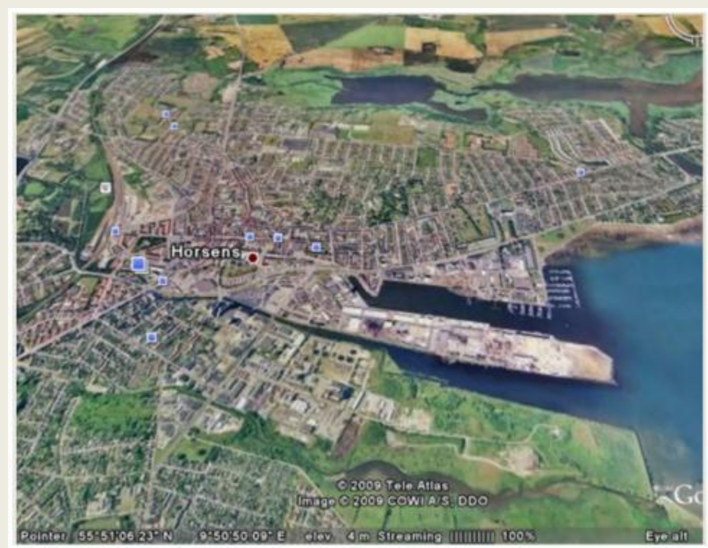




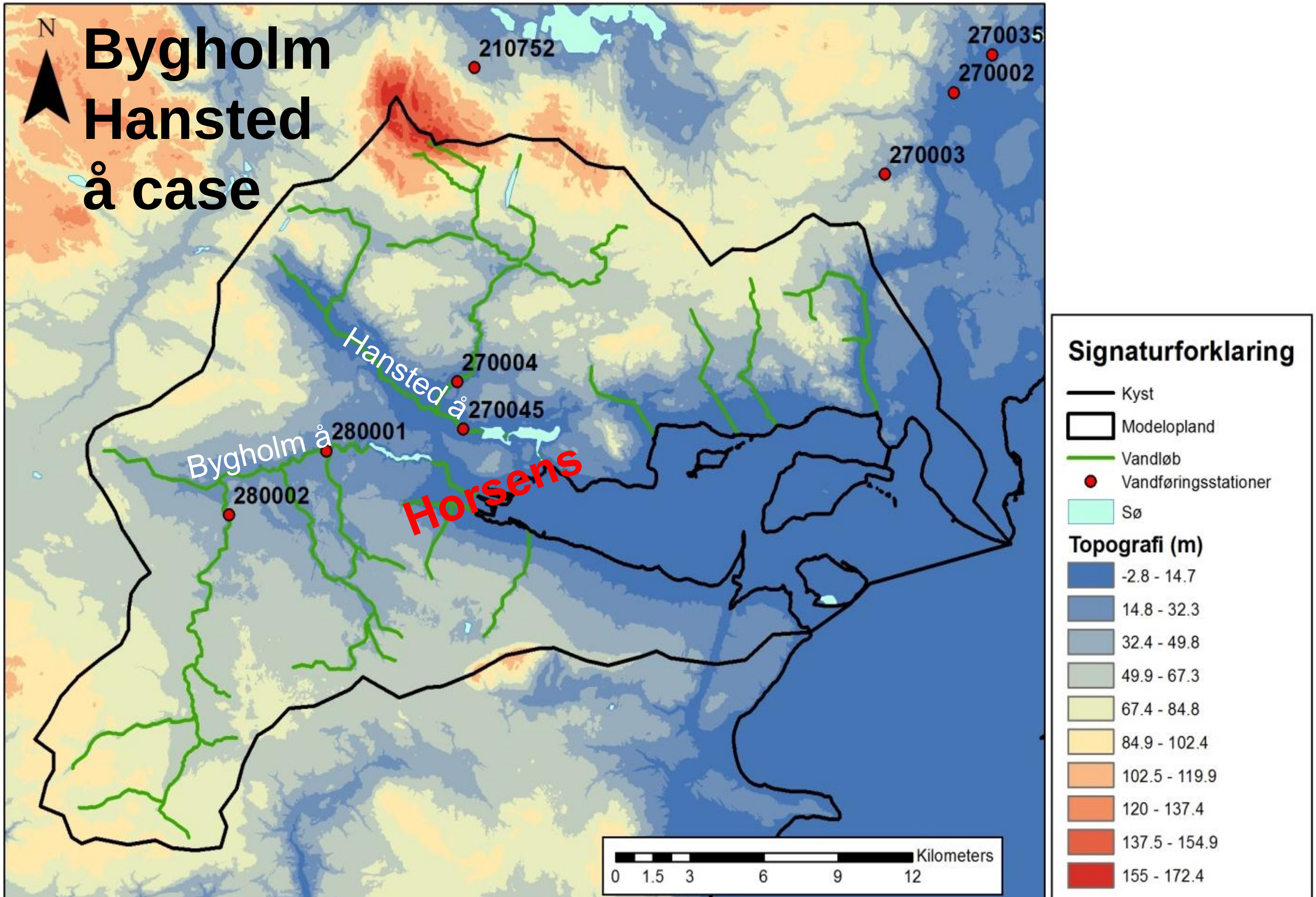



A dusin of adaptatíon options in rural areas (technical–natural–cultivation) was discussed in stakeholder workshops

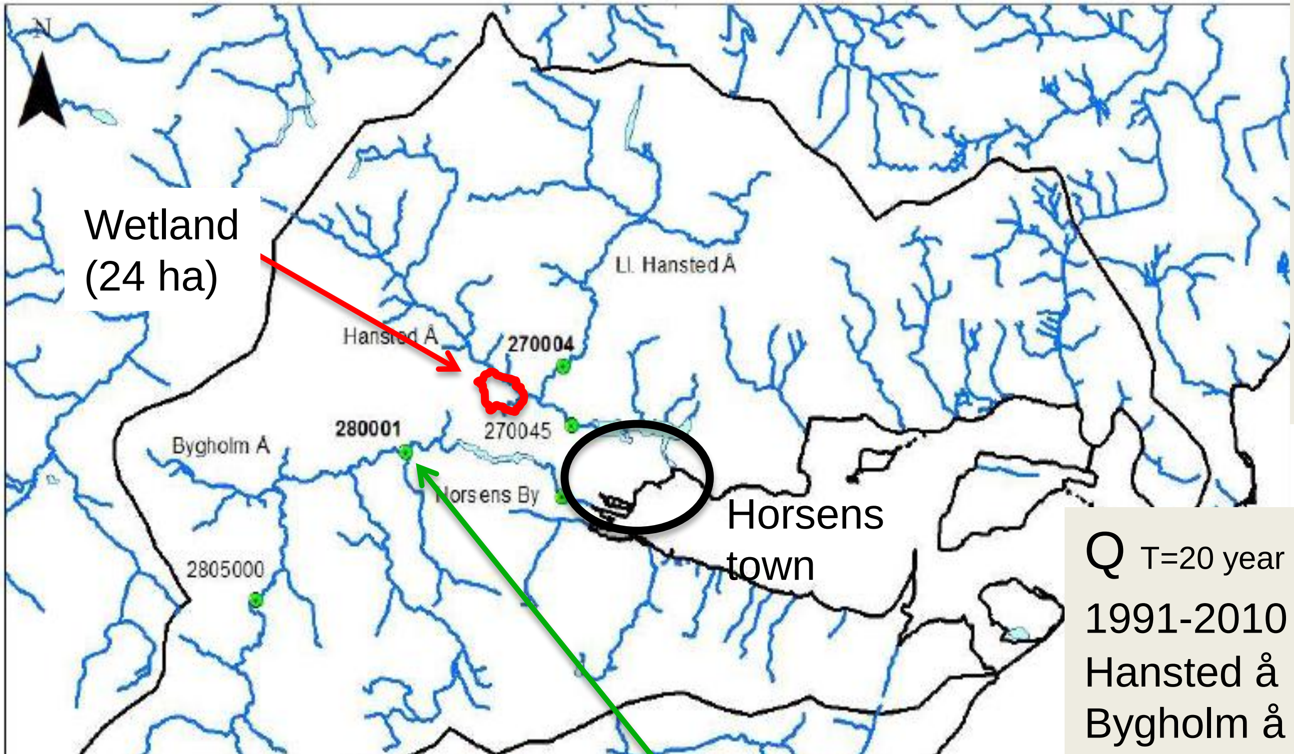




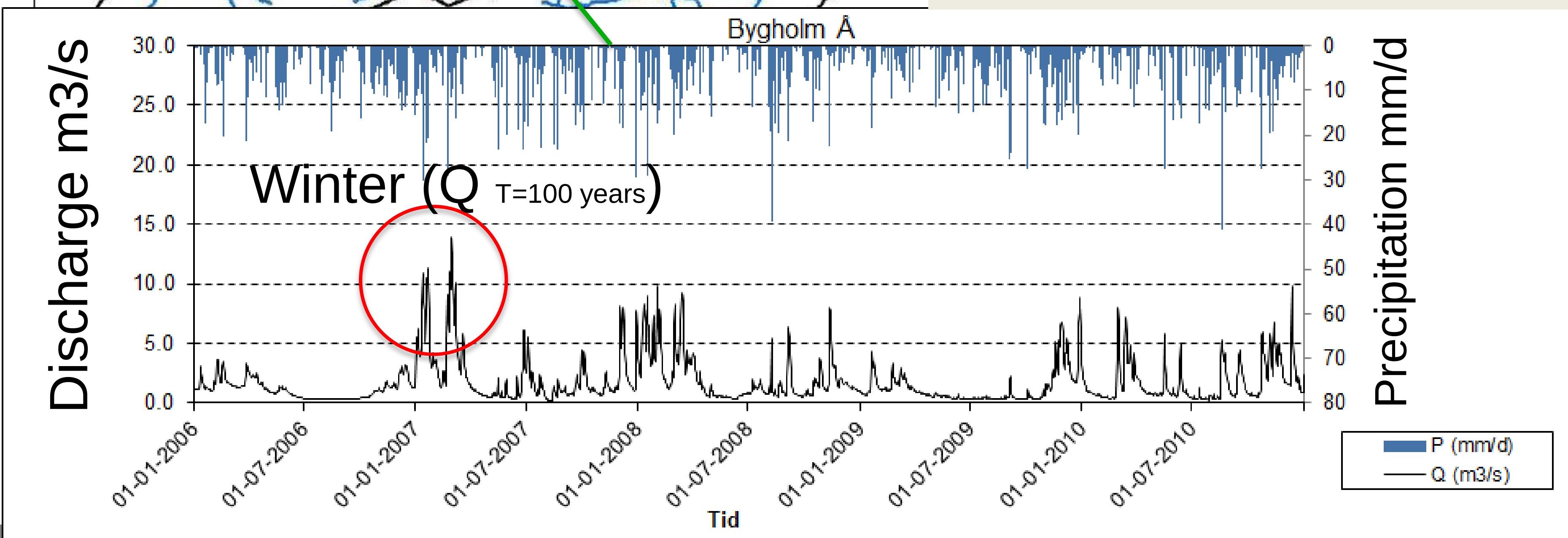
⇒ Reduced flooding risks in **Horsens town** and possible other synergies


Bygholm
Hansted
å case
N
210752
270035
270002
270003
270004
270045
280001
280002
Hansted å
Bygholm å
Horsens
Signaturforklaring
Kyst
Modelopland
Vandløb
Vandføringsstationer
Sø
Topografi (m)
-2.8 - 14.7
14.8 - 32.3
32.4 - 49.8
49.9 - 67.3
67.4 - 84.8
84.9 - 102.4
102.5 - 119.9
120 - 137.4
137.5 - 154.9
155 - 172.4
Kilometers
0 1.5 3 6 9 12

Extreme event analysis of Q max



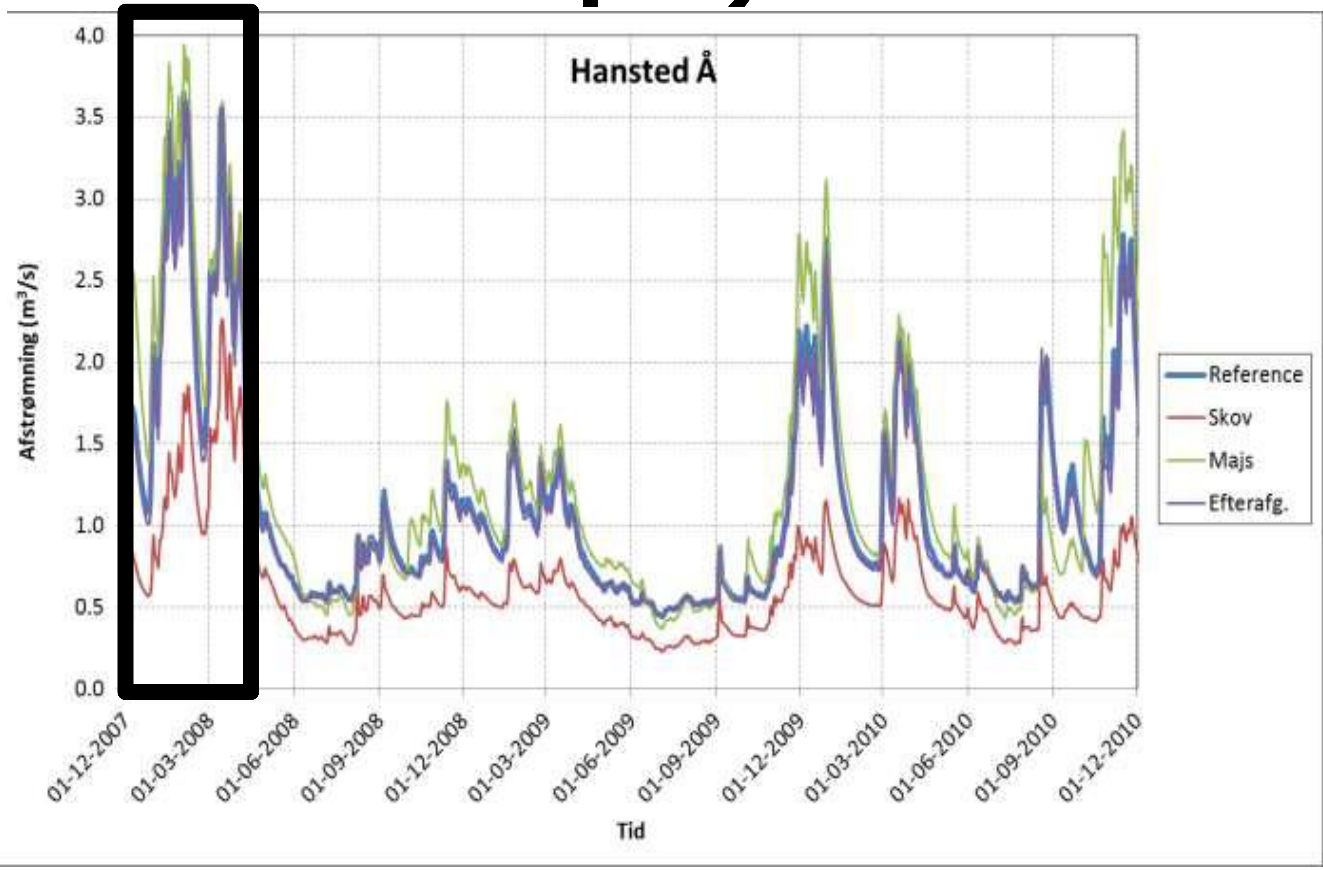
$Q_{T=20 \text{ year}}$ flooding events (m3/s)		
1991-2010	winter	summer
Hansted å	7,6	2,7
Bygholm å	11,7	3,7



Peak flow faktor ~ evaluation of change in max flow due to change in land use etc in the catchment (winter example)

Analyse: Peak Flow Faktor

- T-års hændelse estimeres, Q_T
- PFF = $Q_{T,tiltag}/Q_{T,ref}$
- PFF = $Q_{10,tiltag}/Q_{10,ref}$
- PFF ≠ 1: Ændring af maksimums-afstrømning



Workshop in Horsens march 2014

25 invited participants:

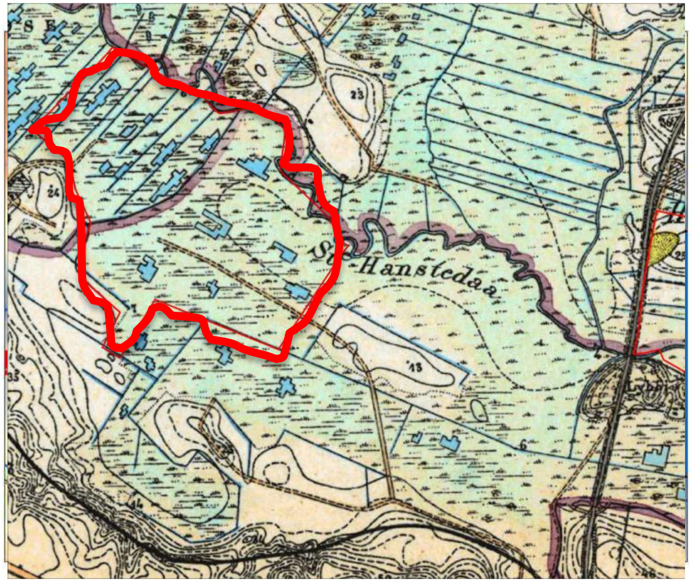
- municipalities
- water works
- researchers / network
- Regions
- farmers
- farmers consultants

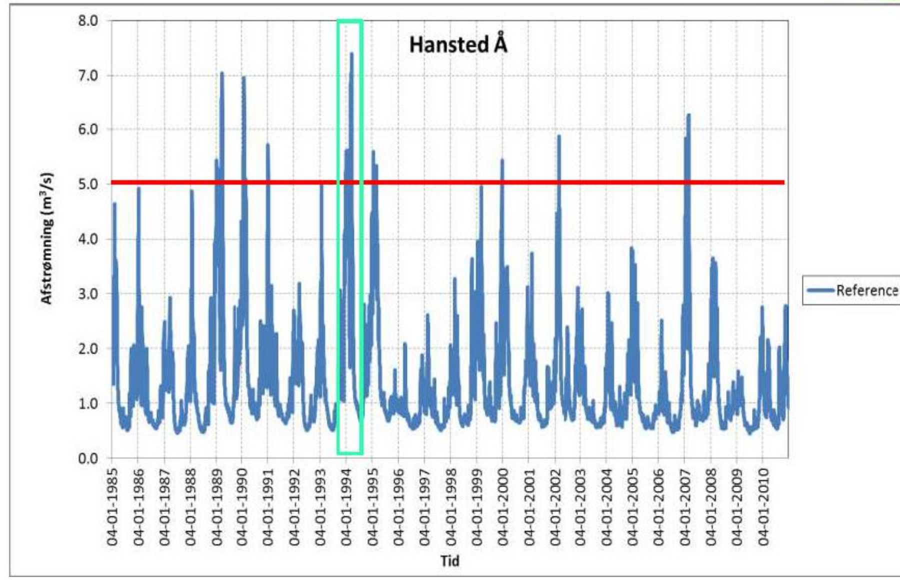
Purpose: Participatory Integrated assessment and Scenario Analysis
(land use model learning)

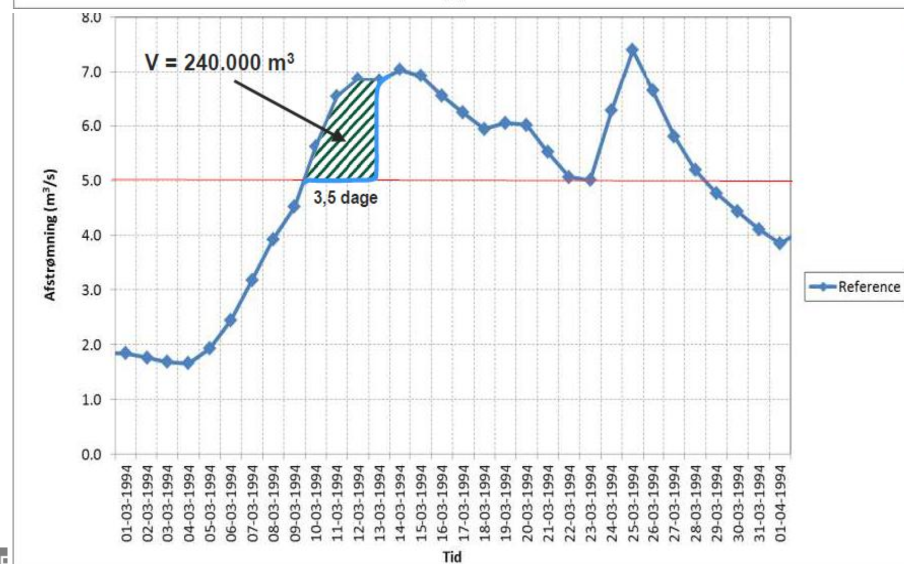
Bygholm enge
N - wetland

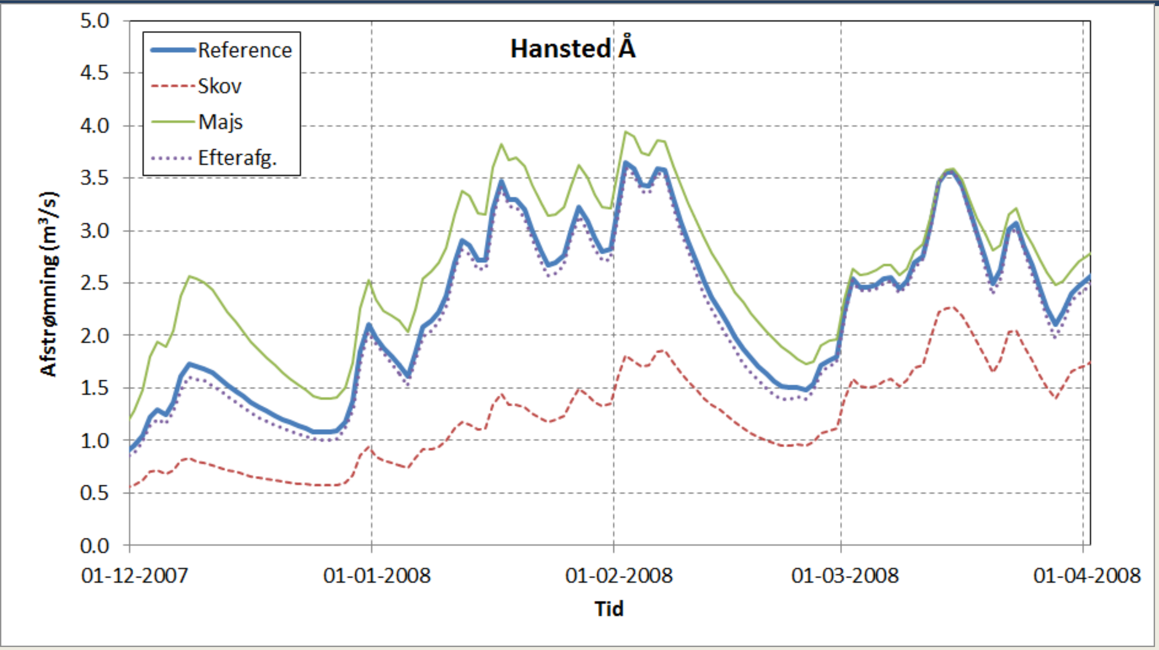
Flooded area: 24 ha
Water depth: 0,5 – 1,0 m
Volume: 120.000 – 240.000 m3

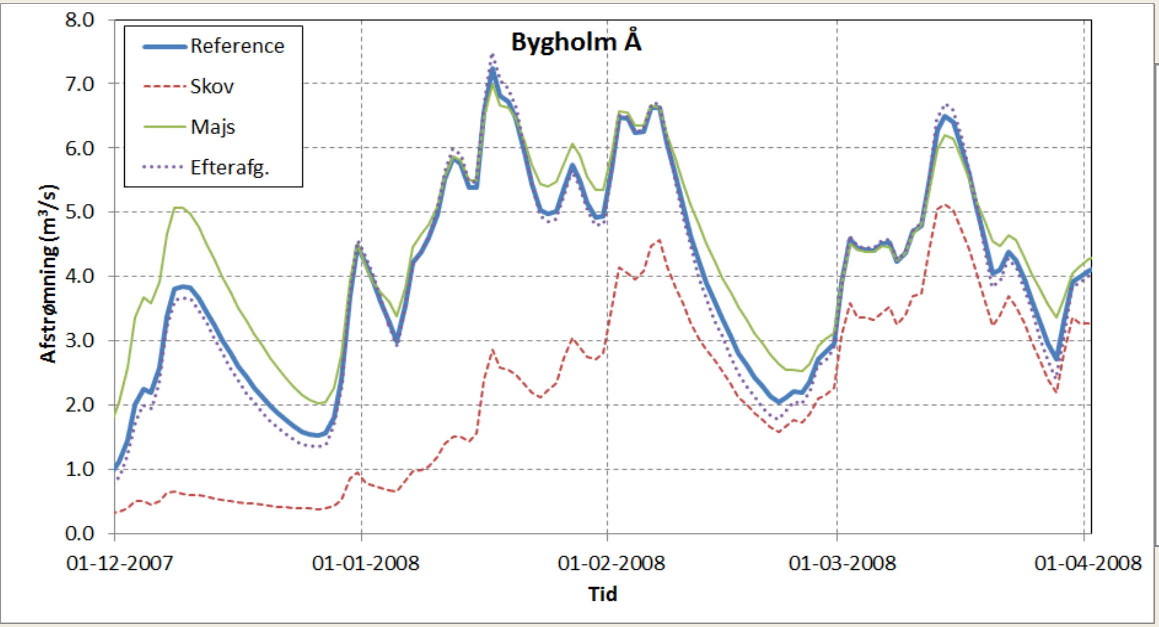
Example:
N Wetlands











Scenarios:

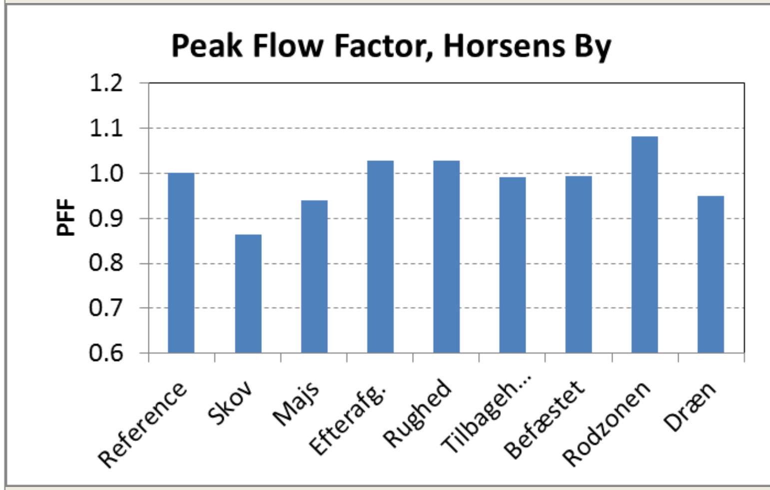
- **Reference /Actual land use**

Change of reference to all:

- **Forest /Conifers (Skov)**
- **Maiz (Majs)**
- **Catch crops (Efterafgrøder)**

Change of parameters to

- **Reduced surface M (Rughed)**
- **Wetlands (Tilbageholdelse)**
- **No paved areas (Befæstet)**
- **Root zone capacity (Rodzonen)**
- **Controlled drainage (Dræn)**



Bygholm å

Effect of adaptation options

peak flow factor = $Q_{max\ T=10\ years\ scenario} / Q_{max\ T=10\ years\ ref}$

Adaptation option	Hansted å 270045 Hilly clayey soil	Bygholm å Horsens Flat sandy soil
Forest	**0,79**	**0,86**
Maiz	**0,96**	**0,93**
Drainage	**0,96**	1,00
Wetlands	0,99	0,99
No paved A	1,00	0,98

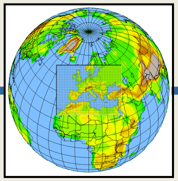
Note that scenarios for forest and maiz is for changing all current land uses (crops) into forest or maiz. Controlled drainage only impacting clayey soils, and wetlands is only a limited part of the catchment. Paved areas have limited extension in rural areas (relatively little effect)

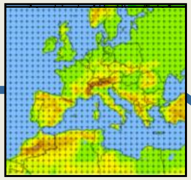
What is needed for coping with climate change effects?

Climate change impacts on hydrologi and extreme river runoff ($Q_{T=10\ year}$, $Q_{T=100\ year}$ etc.)

Present climate

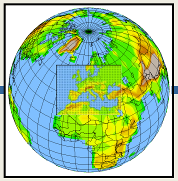
1961-1990

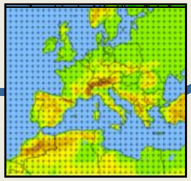




Future climate

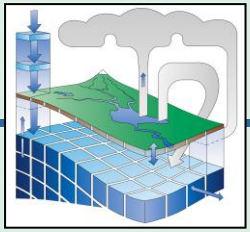
2021-2050



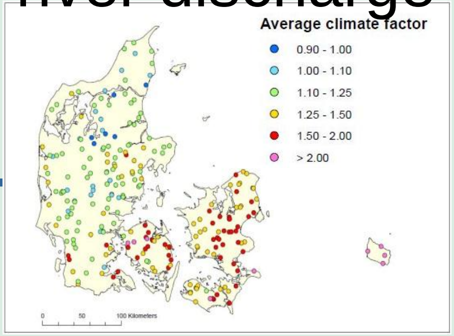


Max river discharge

Downscaling and bias correction



DK model (MIKE SHE)



DHI-EVA software

	Global	Regional	Hydrological	Modeller
	100-250 km	10-25 km	50-500 m	Skala

Extreme value methodology:
POT/GP2 distribution function most optimal for max Q simulated with DK model with L-moment

WATER RESOURCES RESEARCH, VOL. 33, NO. 4, PAGES 771–781, APRIL 1997

Generalized least squares and empirical Bayes estimation in regional partial duration series index-flood modeling

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Uncertainty of climate factor

Climate factor estimate:

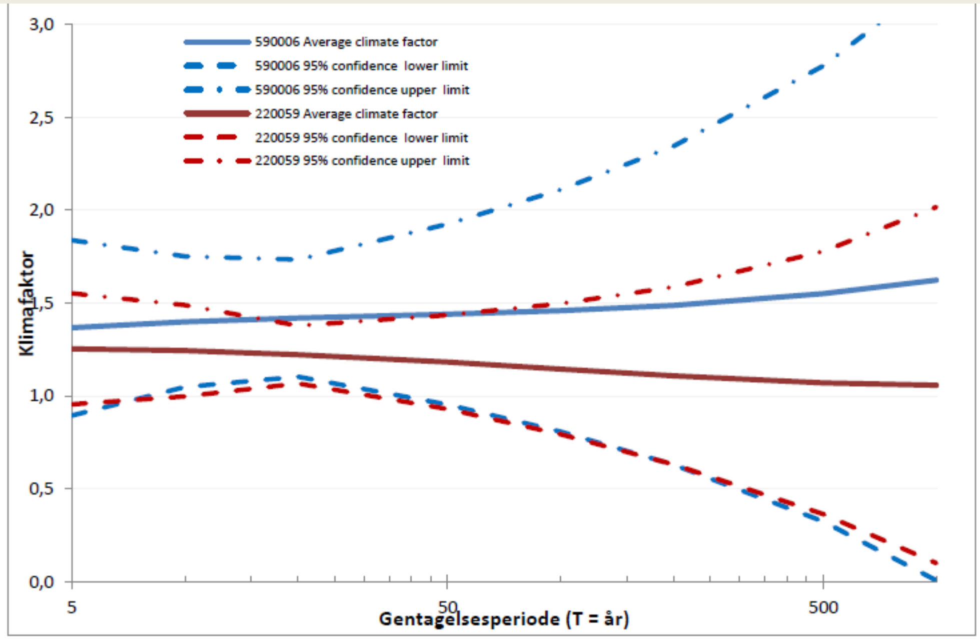
$$CF = \frac{x_{T,F}}{x_{T,C}}$$

where $x_{T,F}$ and $x_{T,C}$ are estimated T-year events for future and control, respectively.

Variance of climate factor estimate:

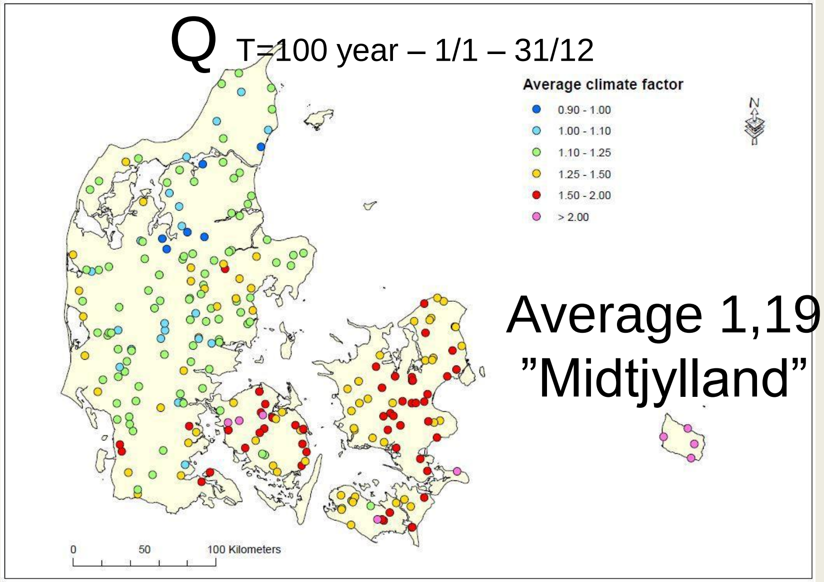
$$Var\{CF\} = CF^2 \left(\frac{Var\{x_{T,C}\}}{{x_{T,C}}^2} + \frac{Var\{x_{T,F}\}}{{x_{T,F}}^2} \right)$$

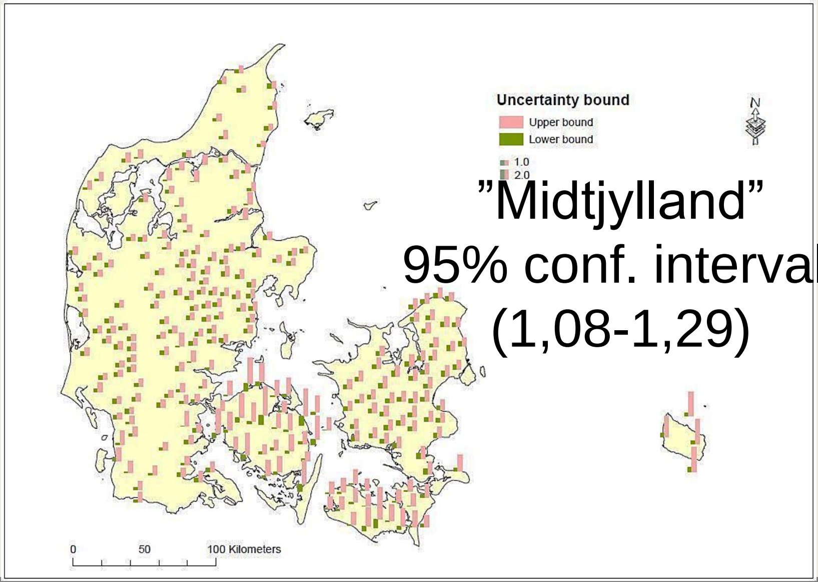
where $Var\{x_{T,F}\}$ and $Var\{x_{T,C}\}$ are variances of the T-year events for future and control, respectively



	Gentagelsesperiode T = antal år							
	5	10	20	50	100	200	500	1000
Tryggevælde å Station 590006								
Øvre 95 % konfidensgrænse	*1,84*	*1,75*	*1,74*	*1,93*	*2,11*	*2,35*	*2,78*	*3,24*
Middel klimafaktor	1,37	1,40	1,42	1,44	1,46	1,49	1,55	1,62
Nedre 95 % konfidensgrænse	*0,90*	*1,05*	*1,10*	*0,95*	*0,81*	*0,63*	*0,32*	*0,01*
Skjern å Station 220059								
Øvre 95 % konfidensgrænse	*1,55*	*1,49*	*1,38*	*1,44*	*1,50*	*1,59*	*1,78*	*2,20*
Middel klimafaktor	1,25	1,24	1,22	1,18	1,15	1,11	1,07	1,06
Nedre 95 % konfidensgrænse	*0,96*	*1,00*	*1,07*	*0,93*	*0,79*	*0,63*	*0,36*	*0,10*

Rare winter events - Climate factor
2021-2050 versus 1961-1990





		DK1	DK2	DK3	DK4	DK5	DK6	DK7
5a	Regional average CF	1,39	1,58	1,32	1,17	1,22	1,13	1,85
	Lower confidence limit	1,24	1,02	1,12	1,03	1,11	0,91	1,67
	Upper confidence limit	1,55	2,14	1,51	1,30	1,33	1,34	2,02
10a	Regional average CF	1,42	1,55	1,34	1,17	1,21	1,12	2,04
	Lower confidence limit	1,27	1,00	1,13	1,04	1,11	0,90	1,52
	Upper confidence limit	1,57	2,10	1,55	1,30	1,32	1,34	2,57
20a	Regional average CF	1,45	1,53	1,38	1,18	1,20	1,12	2,27
	Lower confidence limit	1,32	0,99	1,15	1,04	1,10	0,88	1,97
	Upper confidence limit	1,58	2,08	1,62	1,32	1,30	1,35	2,57
50a	Regional average CF	1,50	1,53	1,44	1,21	1,19	1,11	2,63
	Lower confidence limit	1,36	0,98	1,17	1,04	1,09	0,86	2,23
	Upper confidence limit	1,63	2,07	1,72	1,37	1,29	1,35	3,03
100a	Regional average CF	1,55	1,54	1,60	1,24	1,19	1,10	2,98
	Lower confidence limit	1,39	0,99	1,28	1,05	1,08	0,84	2,23
	Upper confidence limit	1,71	2,09	1,91	1,43	1,29	1,37	3,03
200a	Regional average CF	1,62	1,58	1,77	1,28	1,19	1,11	3,42
	Lower confidence limit	1,44	1,02	1,41	1,07	1,07	0,82	2,84
	Upper confidence limit	1,81	2,14	2,13	1,50	1,31	1,40	4,01

Extreme value methodology:
POT/GP2 distribution function most optimal for max Q simulated with DK model with L-moment

Comparison of effects of rural measuers compared to climate change impacts

Peak flow factor Qmax T=10 years Adaptation measure	Hansted å 270045 Hilly clayey soil	Bygholm å Horsens Flat sandy soil	Midtjylland
Forest	**0,79**	**0,86**	
Maiz	**0,96**	**0,93**	
Drainage	**0,96**	**1,00**	
Climate factor Qmax T=10 years	**1,13** (0,82 – 1,45)	**1,12** (0,86 – 1,37)	**1,21** (1,11 – 1,32)
Climate factor Qmax T=100 years	**1,23** (0,80 – 1,66)	**1,17** (0,87 – 1,46)	**1,19** (1,08 – 1,29)

Conclusions

Most efficient measures (farmers)

- Land-use change
  - Forest (conifers, energy crops?)
  - Maiz
  - Controlled drainage
  - Wetlands (if large area/or many small)

  - Important also to evaluate synergy effects on biodiversity, CO_2, nutrients etc.

Business models (Private sector/farmers <> Municipality):

- Tendering auctions/rounds or
- Compensational payment (institutional challenges/EU)