

Coastal Flood Hazard and Risk Management in Denmark within the context of the EU's Floods Directive

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- Denmark and the Danish context
- Identified flood prone areas (PFRA)

2. Flood Hazard and Risk Mapping (FHRM)

- The HARIMA-approach
- Hazard analysis
- Vulnerability analysis
- Results

3. Flood Risk Management Plans (FRMP)

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- Risk perception
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- 5. Considerations for the 2nd implementation cycle



Denmark and the coastal zone





⊕ Coast accumulation









The Danish context

No catastrophic flood event since 1872. Why worry then?

Because

- No one in Denmark has more than 50km to the coast
- Development is especially taking place in the coastal zone
- A large flood event could take place tomorrow and it will get worse in the future
- The highest point in Denmark is a bridge





Identified flood prone areas (PFRA)



22 municipalities (of 98 municipalities in total):

- 7 on Jutland
- 3 on Fyn
- 12 on Sealand

Risk areas	Municipality	Source
Randers Fjord	Randers Kommune	Sea water &
	Norddjurs Kommune	fluvial
Juelsminde	Hedensted Kommune	Sea water
Vejle	Vejle Kommune	Sea water &
		fluvial
Fredericia	Fredericia Kommune	Sea water
Aabenraa	Aabenraa Kommune	Sea water &
		fluvial
Odense Fjord	Odense Kommune	Sea water &
	Nordfyn Kommune	fluvial
	Kerteminde Kommune	
Korsør	Slagelse Kommune	Sea water
Nakskov	Lolland Kommune	Sea water
Køge Bugt	Dragør Kommune	Sea water &
	Tårnby Kommune	fluvial
	Hvidovre Kommune	
	Brøndby Kommune	
	Vallensbæk Kommune	
	Ishøj Kommune	
	Greve Kommune	
	Solrød Kommune	
	Køge Kommune	
	Københavns Kommune	
Holstebro	Holstebro Kommune	Fluvial



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The SPR-model



Risk = Hazard x Vulnerability Capacity



The HARIMA Approach





Hazard analysis (Hydraulic boundary conditions)





Scenarios

Scenarios	Open coast [Hw]
Low probability (extreme event scenarios)	Extreme events used in accordance with Article 4(2)(b,c)
Medium probability	1/100
High probability	1/20
Climate scenario 2050, medium probability	1/100 + 30 cm SLR ± local land movement
Climate scenario 2050, high probability	1/20 + 30 cm SLR ± local land movement
Climate scenario 2100, high probability	1/100 + 80 cm SLR ± local land movement

Land movement



Overtopping approach



Hazard analysis (Numerical modelling)



21.februar 2002 20.december 2001 2.januar 2002 2.januar 2002 21-02-2002 00:00 21-02-2002 12:00 22-02-2002 00:00

MIKE 21 FM: Model setup



Roughness map





Flood Hazard (Result of numerical modelling)





Vulnerability Analysis



Skadesprocent

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Depth-damage functions

- Buildings
- Inventory
- Agricultural acreage
- Livestock
- Infrastructure
- Cultural losses

Shown on the maps

- Number of inhabitants
- Hazard companies
- Installations
- Protected nature

Flood vulnerability assessment

Map KORT 10 for valuation and vulnerability assessment





Cell-Based-Risk Assessment



Ref. Burzel & Oumeraci, 2012

Grid sizes:

- 25 x 25 m
- 50 x 50 m
- 100 x 100 m
- 200 x 200 m
- 500 x 500 m

All maps are available at WebGIS.



(**i**)

Flood vulnerability assessment

Operationalisation of GIS analyses by the use of Model Builder tools



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Hazard and flood damage maps

(flood extend, flood risk)

Three map groups

Map group	Мар
A	A1: Flooding+ Inhabitants
	A2: Flow velocity
Β	B1: Buildings
	B2: Movable property
	B3: Infrastructure
	B4: Agricultural acreage
	B5: Livestock
	B6: Protected nature + Hazard heritage
	B7: Cultural losses
c	C1: Total damage
	C2: Flood risk



Vejle 100 MT 2012 EU Oversvømmelsesdirektivet, Fase II





Visualisation and sharing of data by Google Earth





FHRM public available



http://miljoegis.mim.dk/spatialmap?&profile=oversvoem2



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The municipal involvement (Flood risk circle)



- Flood risk management plans (FRMP) are developed by the 22 municipalities involved in the 10 flood prone areas.
- Focus on prevention, protection and preparedness, including flood forecasts and emergency management.
- Focus on actions for the prevention of new risks and reduction of existing risk <u>before flood</u> <u>events</u>, the reduction of adverse consequences <u>during a flood event</u> and the reduction of adverse consequences <u>after a flood event</u>.
- Public hearing of six months.
- Final FRMPs were adopted and published 4 weeks after adaptation.
- Minister of Environment published FRMP for each river basin district by December 22, 2015.

Risk perception (Flood risk management plans (article 7) – guidance)

Guidelines distributed to all involved municipalities for preparation of flood risk management plans. Focus on goals and measures with respect to

Prevention

Prevention of future activities that can induce potential future flood damage



Reserving areas for water retention



Planning of foundation height in flood prone areas

Protection

Dike protection

Flood protection wall

Structural measures in order to reduce the risk of flooding











Compilation of risk management plans



Risikostyringsplan for kystzonen i forhold til stormflod fra Køge Bugt 2016-2021



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KØGE KOMMUNE	2015



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Experiences from the 1st EU Floods Directive Planning Cycle

Screening and Appointment of Flood Risk Areas

- The appointment of the 10 flood risk areas across 22 municipalities in Denmark is based on criteria, that reflected the political climate at that time. (1 river, 7 coastal, 2 combined)
- The criteria appointing the flood risk areas have been criticised by a number of municipalities, since they excluded municipalities from being appointed, despite the fact that they also have experiences with flooding from the sea or streams.
- In the mean time, national approaches, such as the preparation of climate adaptation plans with a special focus on cloud bursts of all 98 municipalities, have been performed.



Experiences from the 1st EU Floods Directive Planning Cycle

Flood Hazard and Risk Mapping

- The HARIMA-method allowed to prepare flood hazard maps and flood risk maps in a common way for all 10 flood prone areas having a significant diversity in spatial extent, flood exposure, vulnerability across the flood risk areas.
- The selected HARIMA-method comprises the assessment of the flood risk in a structured and comprehensible way that allows to be communicated to others (e.g. end-users).

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Pf

Database - hazard and vulnerability 1 sources - hydrological and hydrodynamic 2 2.1 2.2 **River discharge** Storm surge Flood Defence Reliability analysis 3 Numerical Inundation modelling Δ 5 Vulnerability and damage analysis 5.1 5.2 Tangible damages/losses Intangible damages/losses

6 Overall flood risk assessment



Experiences from the 1st EU Floods Directive Planning Cycle

Flood Risk Management Plans

- All municipalities have prepared Flood Risk Management Plans, however the plans differ significant in extent and level of detail.
- The municipal focus is on prevention and preparedness. Protection measures are little considered in the Flood Risk Management Plans.
- The municipalities have given a positive response on the preparation of the Flood Risk Management Plans since they can move the local politicians to take more responsibility for climate adaptation and risk management, because the plans are binding.

FRMPs overall conclusions of future needs:

- Defining acceptable risk
- Improve coordination between stakeholders
- > Changes in legislation
- Increase in awareness
- Improved risk management and preparednes planning
- Emergency management needs increased capacity



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Considerations for the 2nd EU Floods Directive cycle

Screening and Appointment of Flood Risk Areas

- A change in the methodology of appointing flood risk areas in order to anchor the concept of risk analysis and risk management more broadly and sustainable in Denmark. Further new flood risk areas may be appointed in the 2nd cycle of the EU Floods Directive.
- The fluvial flood hazard must be integrated on a more detailed level in the appointment of flood risk areas
- Multi-hazard events must be considered in risk areas, where appropriate. Lager integration of climate change projections.
- The assumption of flood defences are reliable at any time, must be modified.

Flood Hazard and Risk Mapping

- Update of Kystdirektoratets extreme value statistics
- Numerical modelling vice versa GIS-tools, since modelling is very time-consuming
- Evaluation of depth-damage functions for the assessment of tangible and intangible losses, including further damage categories to be considered

Flood Risk Management Plans

- Dispose a process to follow up the implementation of the municipal Flood Risk Management Plans
- Guidelines for the transfer of risk analysis results to risk communication and decision making



Screening methodology based on three classes



Screening Concept - The dynamics of the risks





Change in the methodology of appointing flood risk areas

Conceptual considerations for appointing potential flood risk areas (intermediate determination)





So, overall ...

... we conclude that,

- although vulnerability towards flooding in Denmark is usually considered low compared to other EU member states, …
- ... the implementation of the Directive has led to substantial national advancements in our ways of perceiving, mapping and dealing with risks from flooding.

Thank you for your attention!

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