LOGO/PICTURE

Subgroup: Urban Cluster

Case-study: Copenhagen

(DBT & AAU, Denmark)

Date

Case study developed by:

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Danish Board of Technology (DBT); Aarhus University (AAU)

Project:

FP7/ Project BASE [2012-2016]

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Purpose of this document:

"The Case Studies Living Document (CSLD) will be the document that each case study leader will use to share the information that (i) characterize and give context to its case study, (ii) the goals within BASE, (iii) the methods used and mainly (iv) a synthesis of the results that that case study is providing to BASE project. This will allow the CS leader to understand how its own case is going (having a good overview), but also (v) will allow the sub-group to which the case study belong to know what is happening and what can be done (mainly on synergies and so on) as well as to (vi) WP4 & 5 coordinators to use that information to report (including each WP task leaders). These living document will also (vii) allow WP6 & 7 partner to know the information."

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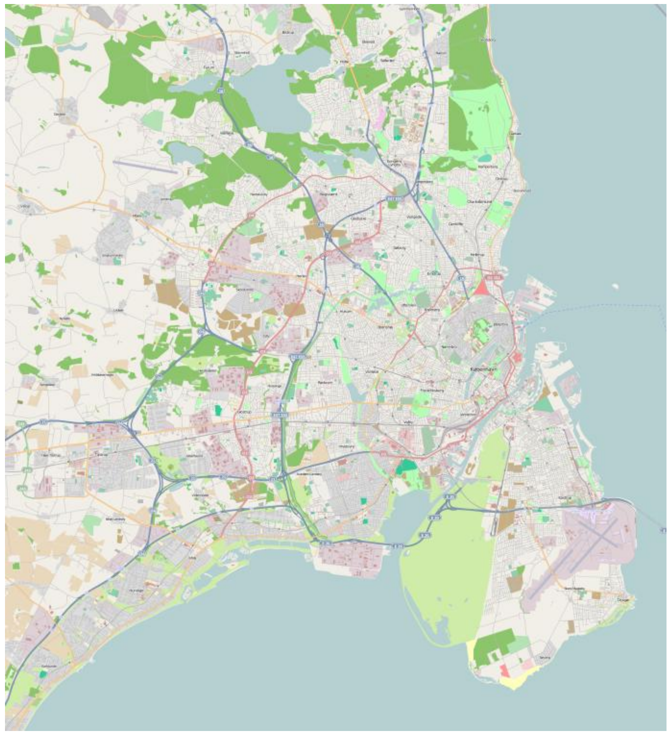
1. General Case Study Description

a) Location

(Please insert the coordinates of the geographical centre of your case study and additionally the area of the entire are under investigation. For a city, for example, use the city centre and the area of the municipality. Illustrate in the map the area in study)

GPS: N 55°40’34”N, 12°34’06”E / / 55.67611°N, 12.56833°E W(?) _____________

IMAGE / MAP / AREA



b) Case Study Summary

(Máx 500 words)

The Copenhagen case study focusses on the capacity to manage adaptation, with a specific focus on participation and strategic inclusion of climate adaptation, in a medium sized, coastal Northern European city. Compared to many other European cities, Copenhagen is a flat city with a well preserved old city centre located by the Øresund Coast. The core city has 1.2 mill inhabitants while Greater Copenhagen hosts 1.7 mill inhabitants. The Municipality of Copenhagen covers the inner city with 0.5 mill people and is growing by an average of 1000 new residents per month. Increasingly, the well-educated and the young families stay rather than moving to the towns and suburbs in the vicinity, providing the city with rising incomes and attracting knowledge-intensive businesses. This challenges the city as well as provides new options; in particular a strong economy and new neighbourhoods are developing where two of the largest areas, Ørestad to the south by the bridge to Sweden and Nordhavn to the north in the former industrial port area, have been appointed sustainable urban neighbourhoods.

Since the Climate Plan in 2008, the city has included adaptation in its urban vision, municipal plan and strategy, initially as a sub-theme in the mitigation strategy to make the city CO2 neutral by 2025. In 2012, the city launched with its Cloudburst strategy a climate adaptation plan. The major focus is on water issues, due to two major floodings in 2010 and 2011 and due to the proximity of the Baltic Sea. Moreover, the adaptation strategy has initiated a number of sectorial adaptation plans, including The Cloudburst Plan, the Waste Water Plan and the Storm Surge Plan. The strategy and subsequent plans intensify focus on green/blue spaces for water retention and heat reduction, i.e. services of ecosystems are increasingly considered in the strategy; on inclusion of private actors in developing, implementing and maintaining adaptation actions, i.e. participation, stakeholder involvement and collaboration are integrated elements of the strategy; and on innovative social, policy and technical solutions, i.e. clean tech business innovation and experiential/incremental planning.

c) Context

(Máx 500 words) *If relevant to the understanding of the Case Study , please provide any contextual information of the region, history, etc of the case study*

Copenhagen is the capital of Denmark and has since 2007 followed an urban strategy to become a sustainable, green metropolitan city. At national level, the government in 2008 issued the first National Adaptation Strategy, followed by the Cloudburst Action Plan in 2012 which mandated all Danish municipalities to develop a Local Adaptation Plan and which amended the Planning Act such that local government can issue Climate Plans to promote local adaption. In addition, Copenhagen is part of different networks that target adaptation in cities and/or in coastal regions. The city has a recent history – since the 1990s – for promoting sustainable urban

initiatives which against the backdrop of A21 to varying degrees have included and at times pushed the inclusion of citizens in sustainable initiatives at community or housing association level (byfornyelse, områdefornyelse). Over the past few years, local water retention measures such as green roofs have entered local agendas within this area.

In addition, as the main city in Denmark, it takes on the role of agenda setter and occasionally moves faster in some green transition areas than is possible in the national policy context. For example, as one of only three places in Denmark, Copenhagen has since the 1990s continued to increase the share of cycle mobility of urban transport, and has appointed a major neighbourhood under construction to be sustainable, including CO2 neutral.

d) Brief General Information on Climate CHANGE and related issues

(Máx 2000 words) *Please state which is the European climate zone of the case study and insert any information regarding the current available information regarding the case-study, namely expected impacts, scenarios.*

Copenhagen is predicted to experience more precipitation and more heavy rains. Risk scenarios increase the frequency of flooding events.

The sea level is rising and the risk of storm surges coming.

In the medium perspective, urban heat islands are also expected, however to a limited extend.

e) Existing Information on Case Study's adaptation history

(Máx 2000 words) *Please insert a Short resume of the Case study existing information related to Climate Change Adaptation (major goals, plans, measures and timelines already defined or implemented), important Milestones in its "Adaptation Journey" as well as relevant state-of the art regarding the implementation of Adaptation Strategies and Specific Measure*

In December 2009, Copenhagen hosted the 15th Conference of the Parties under the UNFCCC (Cop15). In this context it seemed only natural that Copenhagen formulated its own strategy on climate mitigation. And so it was decided by the Financial Management Department in the municipality of Copenhagen to develop a climate plan. The Copenhagen 2025 Climate Plan was finally approved by the town council (borgerrepræsentationen) in August 2012.In the making of the plan; a screening of future consequences of climate changes was done. As the screening showed that heavy rain and rising sea levels will affect the city in the near future, it became clear that mitigation is not enough to protect the city from the effects of changes in the climate, and that something needed to be done in order to handle these threats. With two large cloudbursts in august 2010 and July 2011 causing

massive flooding of the city, the latter causing damages for about 6 billion DKK in insurance payments[1], the momentum for a Cloudburst Mangagment Plan was established.

Copenhagen's "Skybrudsplan" (Cloudburst Management Plan) was finally approved by "Borgerrepræsentationen" the 13th of December, 2012[2] after it had been submitted for public hearing from 21/9 2012-19/10 2012[3] (blivhoert.dk).

In the plan, the Copenhagen area has been divided into 26 different water catchment areas (CPH Cloudburst Management Plan pp. 15). 8 of the catchment areas fall under the Municipality of Copenhagen. The mapping has been done on the basis of an analysis of the way the water flows. A water catchment area is defined as an area where the water will flow the same way under a cloudburst (CPH Cloudburst Management Plan pp. 14).

From this mapping, a prioritization has been made based on an economic risk assessment, an assessment of the implementation severity, and on the potential for synergy with other plans (CPH Cloudburst Management Plan pp. 15, COWIs Skybrudsplan pp. 52). The outcome is a prioritization of 4 areas in which the development – and implementation process will begin. The 4 areas are: Indre by, Østerbro. Sluseholmen, Vesterbro/Ladegårdsåen (Ibid.).

Prioritization amongst the water catchment areas is needed because; the Copenhagen Cloudburst Plan operates within a 20 year timeline (CPH Cloudburst Management Plan pp. 23). The 20 years are divided into 3 investment periods (2013-2016, 2016-2025 and 2026-2033). Because of the time-division in the investments, it has been important for the Municipality of Copenhagen to find a way to prioritize the effort as it is not possible to carry out the whole plan at a time (CPH Cloudburst Management Plan pp. 23 and pp. 14).

Rambøll (extern private consultant bureau) has been chosen as the advisor, carrying out suggestions for solutions on the basis of the "service target level/accepted risk" set by the Municipality of Copenhagen in the Cloudburst Management Plan. Once the suggestions are finished, by the 1st of April 2013, they will be sent out for an intern hearing in the Municipality of Copenhagen. Here after the citizens will be involved in the process of choosing which solutions should be implemented. This will take place in a workshop where Rambøll will present 2-5 possible solutions and the citizens will be able to discuss and to give advice on which solution should be implemented in their opinion.

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[1] (The Danish Government 2012: How to manage cloudbursts and rainwater. Action plan for a climate-proof Denmark pp. 5).

[2] http://subsite.kk.dk/PolitikOgIndflydelse/Moedemateriale/Referater/~/media/95E9BCEADC3B42D8AF4975C0CFE47F23.ashx

The Copenhagen stormsurge management planning has only begun, with possibilities for DBT to influence on the planning process.

Stormsurge was mentioned as an issue for the city in the Copenhagen 2025 Climate Plan with more specific calculations to be presented in the Climate Adaptation Plan.

On the background of impact assessments and cost benefit calculations from the private consultant company, COWI, on stormsurge adaptation measures, the Municipality of Copenhagen has started looking into different possibilities for securing the coasts of Copenhagen[4]. The goal is to find solutions that on the same time combines securing the coasts from storm surge and contributes to the future development of the city by adding more recreational elements for the citizens to enjoy. There has not been made any final political decisions yet, but several adaptation solutions have been considered[5].

However, there are many unresolved problem areas and questions in regards to storm surge adaptation planning, which needs to be resolved before the planning can continue. Thus, DBT has started a 'stakeholder involving process' to facilitate the discussion about unclear questions such as: financial and legal questions, and allocation of responsibilities in adapting CPH to storm surges now and in the future. Two workshops have been carried out, and two will follow in autumn/spring 2014 as described in Chapter 2.

f) Connection with other research projects:

(Please list and shortly describe previous or ongoing research projects directly related with the Case Study) Please write the name and summary of the project, relevant partner institutions, year of beginning and end of project)

At Aarhus University, we have in recent years worked with climate issues relevant for the Copenhagen case study in the following projects POCACITO (transition to post-carbon cities, ongoing), LINABY (specifically green spaces, finalised in 2012), ECOFORS (green spaces of suburbs for climate adaptation and biodiversity, finalised 2013), KFT INSTITUTIONAL BARRIERS FOR LOCAL ADAPTATION IN DENMARK (case studies and survey of municipal climate adaptation strategies, finalised 2013), KFT GREEN ROOFS (green roofs in Copenhagen's planning, including its adaptation policy, finalised 2013), PASHINA (scenarios for low-carbon futures, case area of Greater Copenhagen, finalised 2012).

g) Case ID, Typologies and Dimensions

Having in mind the following BASE Objectives; Categories of Case Studies, please fill in the following table.

BASE OBJECTIVES
1. Compile and analyze data and information on adaptation measures, their effectiveness. (…)

[4] http://www.klimatilpasning.dk/aktuelt/nyheder/april-2014/koebenhavn-stormflodssikres.aspx

[5] http://www.klimatilpasning.dk/aktuelt/nyheder/april-2014/koebenhavn-stormflodssikres.aspx

2. Improve current, develop new and integrate methods and tools to assess climate impacts, vulnerability, risks and adaptation policies (…).
3. Identify conflicts and synergies of adaptation policies at different levels of policy making with other policies (including climate mitigation) within and between sectors. (…)
4. Assess the effectiveness and full costs and benefits of adaptation strategies to be undertaken at local, regional, and national scales using innovative approaches (mainly by integrating bottom-up knowledge/assessment and top-down dynamics/processes) with particular attention on sectors of high social and economic importance.
5. Bridge the gap between specific assessments of adaptation measures and top-down implementation of comprehensive and integrated strategies.
6. Use and develop novel participatory and deliberative tools to enhance the effective use of local contextualized knowledge in adaptation strategies to assess perceptions of adaptation pathways and their co-design by citizens and stakeholders.
7. Disseminate findings by sharing the results of the project with policy-makers, practitioners and other stakeholders. (…)

CASE STUDIES CATEGORIES	
A.	Public administration (municipality, regional, national, european)
B.	Research and education Centres (universities, research centres, projects and groups, schools)
C.	Public companies
D.	Companies (farms, SMEs, big businesses)
E.	Social enterprises (cooperatives, non profit companies, woofing farms, etc)
F.	Consortiums (partnerships, campaigns),
G.	NGOs (environmental NGO, local development NGO, charities, etc)
H.	Transition Initiative
I.	Ecovillage
J.	Informal groups, Movements

Case ID			Typologies and characterization				
Country & Name of CS	BASE Objectives to be answered by the CS	Category of case study	Territorial zones	Scale	Process Direction	Temporal Definition	Timescale[6]
	[x] Objective 1 [x] Objective 2 [x] Objective 3 [ ] Objective 4 [ ] Objective 5 [ ] Objective 6 [x] Objective 7	Example: [A] Companies (Farms)	[ ] Rural [x] Urban [ ] Coastal [ ] River Basin	[x] Local [x] Regional [ ] National [ ] Transnational [ ] European /Global	[x] Bottom-Up [ ] Top-Down	[x] Retrospective [x] Prospective	2013 - 2014

h) Impacts, Sectors and Implementation

Please tick the relevant boxes for impacts and implementation and insert the number 1 for primary sector and the number 2 for secondary sector.

[6] Please insert year of start and year of end of case study.

Impacts		Sectors		Implementation	
Primary CC Impacts (Climate-Adapt)	Primary CC Impacts (BASE)	Primary and Secondary Sector (Climate Adapt)	Primary and secondary Sector (BASE)	Implemented[7]	Phase of Implementatio
[ ] Extreme Temperatures [ ] Water Scarcity [x] Flooding [x] Sea level Rise [ ] Droughts [x] Storms [ ] Ice and Snow	[ ] Extreme temperatures [ ] Water scarcity [x] Flooding [x] Coastal Erosion [ ] Droughts [ ] Soil Erosion [ ] Vector Borne Diseases [x] Damages from extreme weather related events (storms, ice and snow)	[ ] Agriculture and forest [ ] Biodiversity [x] Coastal Areas [x] Disaster risk reduction [x] Financial [ ] Health [x] Infrastructure [ ] Marine and Fisheries [2] Water Management [1] Urban	[ ] Agriculture [x] Biodiversity & Ecosystems [ ] Coastal and Marine systems [ ] Energy [ ] Health and Social Policies [x] Transport [x] Production Systems and Physical Infrastructures [ ] Water resources [ ] Tourism	[ ] Yes [x] Ongoing [ ] No	[x] Assessment [x] Planning [x] Implementation [ ] Monitoring [ ] Evaluation

i) Importance and Relevance of Adaptation

Please tick the relevant box for the case study.

[X] Case developed and implemented as a climate change adaptation measure

[ ] Case developed and implemented and partially funded as a climate change adaptation measure

[ ] Case mainly developed and implemented because of other policy objectives, but with significant consideration on climate change adaptation aspects

2. Case study research Methodology

a) Research Goals

(Máx 500 words) *Please insert which are the General Goals for the case study as well as how will the case study contribute for BASE projects and BASE key research questions.*

The overall research objective of the Copenhagen case study follows from the overall BASE objectives and is to identify *How Copenhagen responds to which impacts of climate change and why Copenhagen seems to have success with adaptation*?

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[7] When the case study consists of a public administration with a top down approach, implementation can be an approved legislation or regulation. When the case study is about practical adaptation measures like a sand dune, for example, implementation should be considered finished when the dune is built in situ.

Based on this objective, we developed three research questions that structure the analysis:

1. How and what are the main policy drivers and triggers of adaptation and of adaptation strategy
- Which aspects are decisive for Copenhagen's capacity to manage the impacts of climate change and how do these influence strategic adaptive actions?
- What are the main drivers of implementation

2. Which adaptation options are considered/assessed?
- How and what adaptive actions are implemented?

3. What are the costs/benefits of adaptation?
- Which costs and benefits are included in the adaptation strategy and which methods for assessing costs and benefits are applied?

b) Stakeholders involved

(Máx 2000 words) *Please insert any information about the stakeholders involved in the adaptation process with which you will relate to, namely their nature, involvement in the process, etc. If possible highlight the decision-making process as well as the leadership process for Climate Adaptation Strategies. Do Mention if there exists any kind of public engagement and participation within the Adaptation process.*

The stakeholders involved are primarily local policy makers, politicians and local business, developers, citizens and citizens associations. In the participatory part of the case study, DBT is working closely with the Copenhagen municipality on the process of stakeholder involvement regarding storm-surge planning. Over the course of several thematic workshops and stakeholder involvement processes, a wide array of actors and stakeholders will be involved, including local and national politicians, ministries, authorities in charge of natural and coastal protection, municipalities, the Danish Meteorological Agency, and private engineering companies.

c) Methodology

(Máx 2000 words) *Please insert what will be your research approach regarding this case study, how did you define it (did it include participatory sessions or not) and how you will implement it during the BASE Project period.*

The analytical approach of the case study is designed to respond to the research questions and objectives. The analytical approach takes the concept of adaptive capacity as point of departure. Based on the argument that participation and integration of climate adaptation policy issues in a range of local policy areas are critical and decisive dimensions of adaptive capacity, the study has two main focus areas; participation and urban adaptation strategy.

The analysis of Copenhagen adaptation strategy is conducted within a policy analytical perspective, applying an analytical framework based on the concepts of adaptive capacity and climate policy integration. Data production for the analysis is based on qualitative methods, including *policy document analysis*, *ethnographic observations* and *qualitative semi-structured interviews*. Moreover,

BASE partners will take lead in designing a stakeholder involvement process, in order to facilitate the legislative planning process dealing with adaptation to storm-surge. This stakeholder process will be documented through the methods described above.

- Note: Partners/Case Studies using PRIMATE tool will be using CBA (to prioritize) and/or MCA (with stochastic PROMETHE II) and the Monte Carlo Uncertainty Analysis, so please check these boxes.

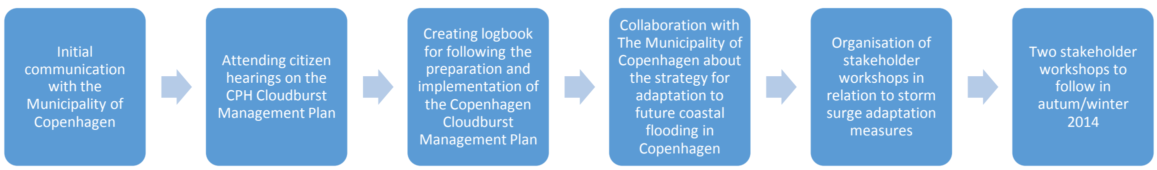
METHODS to be used in Case Studies[8]	YES // NO
A) Methods for prioritizing adaptation options	
Cost-Benefit Analysis (CBA) (An analysis of CBAs conducted by CPH Municipality and private consultants)	Yes
Cost-Effectiveness Analysis (CEA)	No
Multi-criteria Analysis (MCA)	Yes
Analytic Hierarchy Process (AHP)	No
B) Quantification of impacts and relationships between factors affecting adaptation	
Causal Diagrams	No
Influence Diagrams	No
Process-based Modelling	No
Welfare variation analysis under restrictions	No
C) Uncertainty and sensitivity analysis	
Probabilistic multi model Ensemble	No
Monte Carlo simulations (PRIMATE uses this method)	No
Real option analysis	No
Climate risk management process	No
D) Participatory Methods	
Scenario Workshop	Yes
Participatory Cost Benefit Analysis (PCBA)	No
Participatory add-ons to CBA	No
Participatory add-ons to Multi Criteria Decision Analysis	No
Participatory add-ons to Adaptation Pathways	Yes
Other (add extra lines if necessary): Facilitating stakeholder involvement in legislative planning process	Yes

[8] For descriptions and references of the Methods please refer to Milestone 8. For data requests from specific Work Packages please refer to Deliverable 4.1

d) Case study Timeline

(Please insert and image/graph of the Timeline of your Research Approach, highlighting important milestones and deliverables.)

Hvilke milestones og deliverables skal ind i diagrammet – hvis der skal nogen ind?



M1-M6 (Fra Interim Rapporten):

Meetings and other communication with Copenhagen Municipality and Local Committees in order to discuss the possible use of participatory methods in a case study about the Copenhagen Cloudburst Strategy. Discussions focused on the form and content of a series of citizen hearings in 8 different catchment areas. The involvement of citizens in such hearings is often a sensitive issue, and the initiatives considered by the municipality involve a lot of infrastructural changes in the city.

M7-M12 (Fra Interim Rapporten):

Collaboration with The Municipality of Copenhagen – attending 3 citizen hearings on the implementation of the Copenhagen Cloudburst Management Plan.

Collection of data and information on the process of preparing The Copenhagen Cloudburst Management Plan and creating a logbook following the preparation and implementation of the plan.

Collaboration with The Municipality of Copenhagen about the strategy for adaptation to future coastal flooding in Copenhagen.

M13-M18 (Fra Interim Rapporten):

Collaboration with The Municipality of Copenhagen – attended two citizen hearings on the implementation of the Copenhagen Cloudburst Management Plan, as well as carried through interviews with attendees.

DBT has organized stakeholder workshops on climate data and financing in relation to storm-surge, involving municipality officials and a variety of stakeholders (national coastal authority, national meteorological agency and private sectors representatives). The purpose of the first, was to present

the current plans to counter future storm-surge impacts in Greater Copenhagen, future climate data developments (IPCC AR5) and the need to revise planning in the light of these developments. The second workshop investigated the financial models available for financing storm surge adaptation today, but it also investigated how such models could be developed in the future, to better support the work of the municipalities with the adaptation to storm surges.

Two more workshops will be held in autumn/winter 2014

- Adaptation solutions for the area of Copenhagen

- Demands for legal changes for the coast – and storm-surge adaptation area

e) Collaboration with other Partners and Case studies

Collaboration with BASE case studies (see list in EMDESK):

Case: Cascais ; Person: André Vizinho, Filipe Alves, Gil Penha-Lopes

Case: Vagueira ; Person: André Vizinho, Filipe Alves, Gil Penha-Lopes

Case: ____________________________; Person: _____________________

Case: ____________________________; Person: _____________________

Case: ____________________________; Person: _____________________

Case: ____________________________; Person: _____________________

Collaboration within BASE partners/researchers (EX: for a specific competence):

Name: Filipe Alves ___________________; Partner: FCCUL (Economic assessments)

Name: André Vizinho, Filipe Alves, Gil Penha-Lopes ; Partner: FFCUL (Participatory methods)

Name: Joost stronkhorst________________; Partner: Deltares

Name: _______________________________; Partner: _____________________

Name: _______________________________; Partner: _____________________

Name: _______________________________; Partner: _____________________

Name: _______________________________; Partner: _____________________

f) Research Outputs

a. Scientific Publications

- Interim reports + final case study report for D5.5 (Month 30)

- Scientific papers: 2

Provisional Title: Policy Integration and Climate Adaptation Policy in Copenhagen Urban Strategy; Month/Year: 10/2014 (submission)

Provisional Title: The Cultural Embeddedness of Participation: The multiple forms and conditions of participation in Denmark

Month/Year: 10/2014 (submission)

(add more papers in case you need)

b. Other Publications

- Books/Books Chapters: # 1

Provisional Title: ____; Month/Year: ___/_______

c. Other

- Scientific conferences: # ___

Provisional Title: Jensen, A., Nielsen, H. Ø., and Peersen, A.B. (2013) *Forms of knowledge in climate policy and climate policy integration – a Foucauldian framing perspective*, paper presented at WG6 Adapting to Climate Change in City Areas: Urban Climate Governance in Multi-level Contexts, Nordic Environmental Social Science Conference, 11-13 June 2013 Copenhagen___

Conference: NESS

Month/Year: 06/2013

Provisional Title: Anne Jensen, Anne, Lorencová, Eliška, Li, Xin, Zandvoort, Mark, Bedsted, Bjørn, Breil, Margaretha, Alves, Filipe, Gerbhardt, Oliver, Branth Pedersen Anders, Nielsen Helle Ørsted, 2013. Urban adaptation: Challenges, strategies and capacities, paper presented at Science for the Environment, Aarhus, 4-6 October 2012.

Conference: Science for the Environment, Aarhus

Month/Year: 10/2013

- Invited seminars, presentations at local events, etc…

3. Participation in Climate Change Adaptation

j) Process overview

(Please describe the use of Participatory Methodologies within your case study, namely its integration in the overall Research Methodology explained earlier in the CSLD, the rational behind it and key expected outcomes – Máx 1000 words)

Distinguish between the case itself and the research we conduct.

To assess the participation of climate change adaptation in the Copenhagen case, the methodological approach was divided into two themes: cloudburst and storm-surge.

The finalization of the Cloudburst Management Plan in December 2012, gave DBT the opportunity to study the participatory processes involved in the cloudburst plan. DBT has participated in citizen meetings, interviewed…, in order to analyse citizen participation in the implementation of the climate adaption planning.

For a study of the , DBT partook in citizen meetings in the different water catchment areas.

The first citizen meeting was in the ¨Vesterbro/Ladesgårdså¨ water catchment, as it is highest prioritized in the Municipality of Copenhagen.

On the 18th of June 2013 DBT attended a citizen-meeting in Østerbro.

The adaptation planning of storm-surge protection in Copenhagen has only just begun, which gives DBT the possibility to influence the planning process. DBT has started a `stakeholder involving process´ to facilitate the discussion about financial and legal questions, concrete adaptation solutions and the allocation of responsibility in adapting Copenhagen to storm surges in the future. Four stakeholder workshops have been organized by DBT; one focusing on storm surge planning,

On February 4th 2014 DBT arranged the first thematic workshop with focus on storm surge protection in the Copenhagen metropolitan area. The workshop brought together 19 stakeholders including politicians from Copenhagen and surrounding municipalities, consulting firm COWI, Real Dania (a private philanthropic organization) The Danish Meteorological Institute, The Danish Nature Agency, The Danish Coastal Authority, Local Government Denmark (interest group and member authority of Danish municipalities) and The Capital Region of Denmark. The main aim of the workshop was to characterize the current knowledge of future sea level rise and storm surge, as well as to discuss further development of the future planning of flood protection in the metropolitan area.

The second event was a half-day strategic forum on financing adaptation to storm-surge which took place on the 25th of April 2014. The main aim of the day was to initiate dialog between central actors on the basis of financing adaption to storm-surge and coastal protection, highlight experiences and complications and discuss solution for financing storm-surges. The strategic forum was divided into

two parts: Part 1- presentations with brief Q&A and Part 2- Discussion and group work. Presentations were held by the National Coastal Authority, Local Government Denmark (the interest group and member authority of Danish municipalities), Deltares and Horten Lawyers. Apart from the presenters the participants included: The Danish Insurance Association, CPH City & Port Development, Ministry of Business and Growth, Real Dania, NGOs, interest organizations and local and national heads of technical and Environmental Departments.

DBT is organizing the third workshop on the 8th of October 2014 in order to identify possible concrete adaptation solutions in relation to storm-surge in Copenhagen and receive input for the planning process. The goal for the day is receive input from important stakeholders in order to access dyke solutions to protect Copenhagen from storm surges based on the solution proposals from 2010 (Teknik og Miljø). The solutions will be rated by innovative, recreational, business oriented aspects which can be integrated in the different dyke solutions. The workshop will also focus on concretization of adaptation solutions to storm-surge and sea-level rise in Copenhagen until the permanent solutions have been established. The two participatory methods which will be used for at the workshop are: Multi criteria analysis (MCA), to receive input from stakeholders to protect Copenhagen from future storm-surges, and Adaptation Pathways, to point out the protection measures which can be used to protect Copenhagen from storm-surges until the permanent solution has been established. The participants invited to partake in the scenario workshop included politicians from Copenhagen and neighbouring municipalities, nature and environmental organizations, harbour authorities, the tourist and business committee, architectural firms, consultancy firms, outdoor organizations, interest organizations…

k) Participation in the Process Phases

(Please uncover the role of all participants in the process of implementing adaptation measures. The adaptation implementation has been divided into four phases for purposes of ease: 1) Initiative/decision to act, 2) Development of potential adaptation options, 3) Decision-making, and 4) Implementation. The process phases are to be filled out with information corresponding to each participant. I.e. if experts were not consulted in the 'decision-making' phase, then describe why they were not included. It is also important that a wide array of participants is described, including those that were excluded from parts of the process.)

Make a bullet point for each of the five participant categories below (and distinguish between for example different stakeholder or expert groups) and be as descriptive as possible how, <u>why/why not were they involved</u>.

Who participated in each phase, what role did they play? Role: In the capacity they were invited/engaged

Process phases:

1. *Initiative/decision to act*

Stakeholders

Citizens

Experts

Politicians

Officials/legislators

2. Development of potential adaptation options

Stakeholders HOFOR (forsyningen),

Citizens Spørgeskemaer ud til borgerne for at kortlægge hvor vandet ramte under skybrudene

Experts COWI, RAMBØLL?

Politicians

Officials/legislators

3. Decision-making (decision on adaptation plan)

Stakeholders

Citizens

Experts

Politicians

Officials/legislators

4. Implementation

Stakeholders

Citizens

Experts

Politicians

Officials/legislators

I) Participation Experience

(Please report with regards to your case study and the implementation of Participatory Methodologies using a traditional SWOT analysis – Strengths; Weaknesses; Opportunities and Threats)

Strenghts	Weaknesses
Opportunities	**Threats**

m) Learning through Participation

In order to capture how participation could improve the climate change adaptation process, please report with regards to your case study:

a) Your view whether and how participation influenced the strategies and measures decided in your case?

b) How you think the participatory process in your case could be/have been improved?

c) Any novel (use of) participatory methods observed in the case studies

4. Climate Change Adaptation Measures and Strategies

n) a) Adaptation Measures under analysis in your case study

(Please identify your Adaptation Measures considered in this case-study and provide a short description of each)

Adaptation Measure(s):

1) ____
2) ____
3) ____
4) ____

Short description for each Adaptation Measure (Máx 50 words):

o)

p) b) Adaptation Measures selection and data availability prior to BASE

(Please describe how and why where these specific measures selected for further research and analysis under BASE and what is the baseline data already available for each specific adaptation measure. Máx 500 words)

q) c) Full description of Adaptation Measures

(Please provide a full description on each of the Adaptation Measures regarding this 21 leading questions under. If more than one Adaptation Measure please copy paste the structure provided.)

Process

I. Would, or at which part would, institutions and private stakeholders implement the measure autonomously to adapt to climate change (Adaptive capacity)?

(fill with your answer)

II. Does the measure initiate further activities for adaptation to climate change? (Y/N)
    a. If Yes, please name which

III. Does adaptation aim for flexibility and reflexivity (i.e. the ability to change as CC and other factors develop)? (Y/N)

IV. Is the measure effective under different climate scenarios and different socio-economic scenarios? (Y/N)

V. Is the adaptation measure iterative? (Y/N)

VI. Does the measure contribute to overall sustainable development, alleviate already existing problems and bring benefits for other social, environmental or economic objectives than adaptation (no regret measures)? (Y/N)

    a. Please describe briefly how

(fill with your answer)

VII. Can adjustments be made later if conditions change again or if changes are different from those expected today? (Y/N)

<u>Outcome</u>

Relevance and effectiveness of adaptation measures

VIII. How important is the climate change threat addressed by the measure? What economic values, ecosystem functions and socio-cultural values are at stake, and to

what extent are they affected by climate change impacts? Is there an indication of overriding public interest, e.g. critical infrastructures, public health ?

(fill with your answer)

IX. What portion of the targeted potential damages can be avoided by implementing the measure? (0-100%)

Efficiency

X. How high are the benefits of the measure relative to the costs? Are the costs justified by the benefits (Please refer to results of economic evaluation in chapter 5)

(fill with your answer)

XI. What are the costs of the administrative implementation of the measure? Are there potential funding under the umbrella of other European policies(eg. CAP/Cohesion

(fill with your answer)

policy ?

XII. Does the measure give an incentive for innovation to different actors (e.g. SMEs) / can it deliver a competitive advantage for the local economy? (Y/N)

XIII. Does the measure have effects on employment? (Y/N)

XIV. How long is the time-lag between implementation of the adaptation measure and the effect of the measure? ______

XV. What is the timeframe during which the measure will have an effect?

____

XVI. Does the measure create synergies with mitigation (i.e. reduce GHG emissions or enhance GHG sequestration)? (Y/N)

XVII. Does the measure alleviate or exacerbate other environmental pressures? (Explain briefly)

(fill with your answer)

Equity

XVIII. What are the impacts on different social or economic groups, are there expected

(fill with your answer)

impacts on particularly vulnerable groups? (distributional impact)

XIX. Does the measure enhance well-being and quality of life (e.g. in the urban environment)? (Y/N)

5. Impacts, Costs and Benefits of Adaptation measures

(This section of the CSLD follows the Economic Assessment Steps put forward by UFZ and thoroughly described in D4.1, chapter 4. Please check D4.1 for any doubts or questions. In case of duplication of information with previous sections of the CSLD feel free to copy paste.) For more detailed guidance (incl. two examples) please see the above mentioned chapter 4 of D4.1. Please do not hesitate to contact volker.meyer@ufz.de, oliver.gebhardt@ufz or Filipe Alves if you have questions about how to fill out this section.

Introduction

In the spring of 2010, the City of Copenhagen decided to investigate opportunities and consequences of climate adaptation against flooding, as a part of their background material to form the basis of the future work for a comprehensive climate strategy and a detailed climate adaptation plan. The report was written by the consultancy firm, COWI, who divided the consequences of flooding into flooding

from storm-surge and flooding from extreme rainfall events where the sewer system capacity is exceeded.

Risk maps were developed for the municipality in which the entire municipality was divided into 100x100 meter cells. The risk was calculated in DKK, based on a weighing of the probability of flooding and the damage costs associated with the flooded areas. In addition, the optimum time for protecting Copenhagen from storm-surge with a dike was calculated based on an economical risk assessment and a cost-benefit analysis over a 100 year period.

Flooding from sea-water

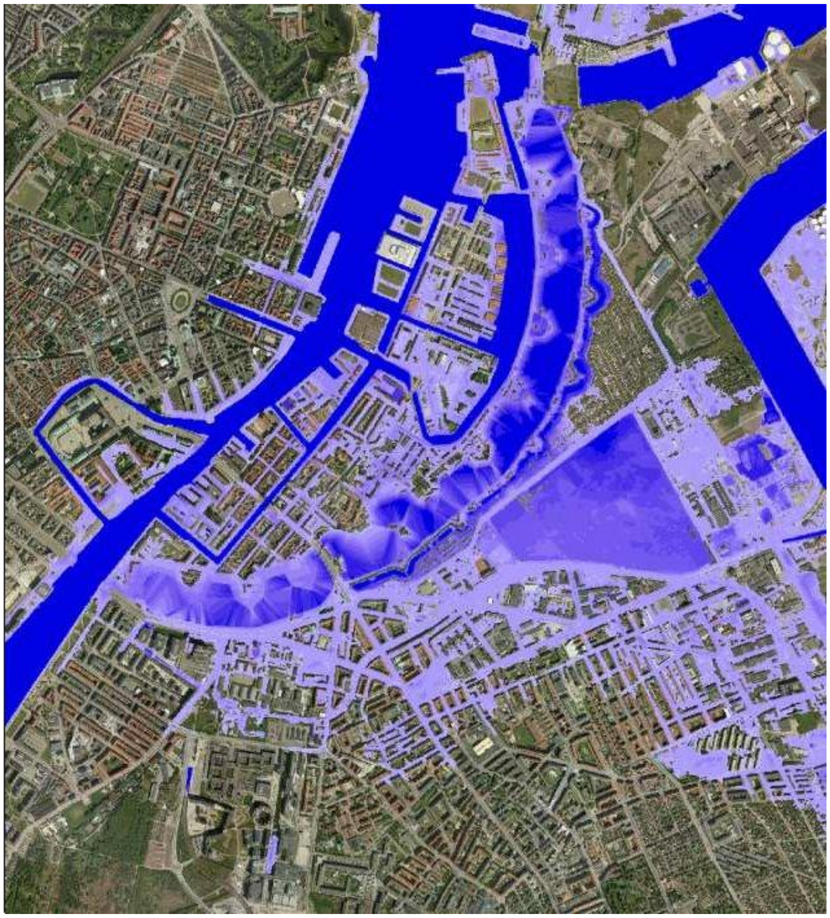
The extent and consequence of various high tide levels for the current situation and for the next 100 years with the expected climate and sea-level conditions has been investigated.

Sea-levels around Copenhagen are expected to rise 1 meter from 1990 to 2100. High tides will be a little more extreme in the rare events, for example, a 100-year high tide will be 10 cm higher than today, in addition to the general sea-level rise.

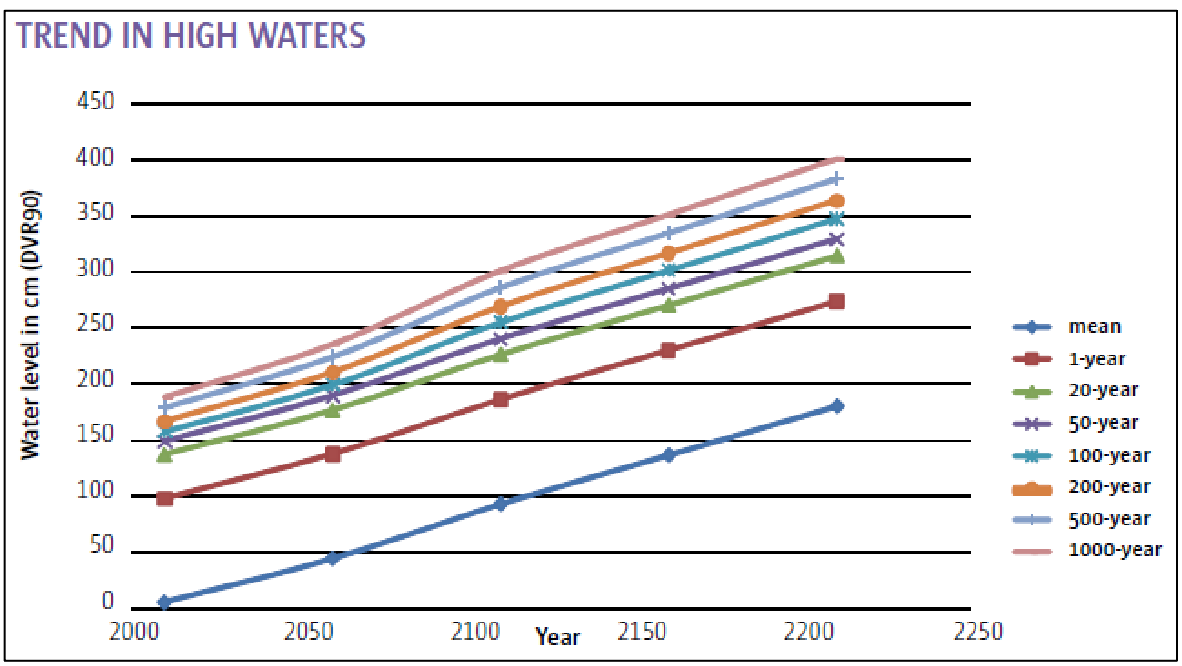
Storm-surges can lead to high waters and flooding in Copenhagen. In the table below it can be seen that high water levels are expected to reach a higher level above the sea-surface more often, this can potentially cause more serious flooding in the future. The surface of the sea is defined in this context as the basis of the national height system DVR90 (Danish Vertical Reference 1990) which is used as standard reference for heights above mean sea level in Denmark DVR90. The studies are performed using a method of calculation that takes account of how the high water builds up and falls again and the way in which the water will flow over land.

Water level in DVR90	Year 2010	Year 2060	Year 2110
20 year flood (DVR90)	139 cm	180 cm	233 cm
50 year flood (DVR90)	151 cm	194 cm	247 cm
100-year flood (DVR90)	160 cm	205 cm	263 cm

High tide is measured by the national height system DVR90 (compared to the baseline 1990).



Maximum propagation of a high tide of 226 cm (DVR90), corresponding to an expected 11-year high tide as it will look in 2110



The table above shows the expected development in high waters and water levels as a result of

storm surges. The figure shows that high waters levels which occur rarely today will occur far more frequently in the future. For example a 160 cm high water level only occurs every 100 years today, while a high water level of 180 cm will occur every 20 years in 2060.

Flooding from rainwater

The magnitude and impact of different predicted extreme rainfall events is investigated from today and until 2110. Extreme rain is defined as rain that exceeds the capacity of the sewer systems' dimensions. The table below shows the maximum extent of flooded area from projected extreme rainfall events. The results show a large increase in the flooded area between a 20-year event in 2010 compared with a 100-year event in 2010 and 20-year event in 2110.

Frequency	Year	Flooded area (Total ha.)	Copenhagen (ha.)	Christianshavn (ha.)	Amager (ha.)
20 year	2010	230	162	2	67
100 year	2010	595	492	2	101
20 year	2110	595	492	2	101
100 year	2110	742	554	2	184

Maximum extent of flooded area from extreme rainfall events. The flooded area includes all surfaces where the water is higher than 3 mm.

The map shows for each rain event, the maximum propagation of the flood during the course of events and the maximum water depths occurring in the flooded areas. Note that the model results showed that a large portion of the rainwater will be collected in the hollows by Lyngbyvej and Lersø Avenue. This was also the case when a real cloudburst event occurred in August 2010, which corresponded to a 100 rain event.

Detailed map showing the extent of flooding from a 100-year extreme rainfall event in 2110

1. Risk assessment

Storm-surge

Damage costs as a consequence of predicted storm-surge events are calculated in the areas affected by flooding from seawater and the maximum depth in the affected areas. In addition to the direct damage costs the indirect costs associated with lost work hours/production etc. are included. The table below shows the socio-economic damage-costs associated with single storm-surge events without mitigation. The damage costs are used to assess the socio-economic consequences of not building a dike.

High tide DVR90	Frequency	Year	Total costs million DKK
139 cm	16 year	2010	0
158 cm	85 year	2010	465
200 cm	73 year	2060	1,576

226 cm	11 year	2110	4,647
225 cm	70 year	2110	9,287
285 cm	300 year	2110	13,583

The damage is primarily associated with the flooding of ground buildings and buildings with basements. The scope of the flooding of ground floors, basements and shops is calculated based on data from the Building and Dwelling Register. With sea-level rises the traffic is also affected, the estimated delay due to a storm-surge event is 242,000 hours.

The damages are priced with a set of socio-economic unit price from earlier studies. The unit and m^2 price can be seen in the table below calculated in factor prices. These prices have been regulated by 10%.

Damages		Price (DKK/ m^2)	Price (DKK/Unit)
Traffic Disturbances all highways	Unit	0	363
Road fracture	Unit	0	1,100,000
Ground Floor	m^2	5,973	0
basement	m^2	352	0
Substations	Unit	0	1,100,000
Power shortage - private (> 5 h)	Unit	0	1,850
Power shortage – businesses (> 5 h)	Unit	0	5,551
Power shortage - public	Unit	0	0
Shops – production loss	Unit	0	0
Shops – Compensation of stock - basement	m^2	2,328	0

Shops - Compensation of stock - Ground floor	m^2	2,328	0
Shops, compenstation costs – Ground floor	m^2	3,121	0
Damage on sewers	Unit	0	1,100,000
Stations, seawater	Unit	0	228,788,185

Unit prices of damage by sea-water rise. Source: *Source: Report to Miljøstyrelsen "Klimatilpasning af afløbssystemer og metodeafprøvning. Økonomisk analyse, 2007¨*

Cloudbursts

The investigation of extreme cloudburst has covered the entire city of Copenhagen and adjacent areas which have an importance for the flooding in the municipality from upstream areas. It is chosen to assess 4 alternative approaches a part from the reference, where no adaptation action is taken. During extreme rainfall events basements are primarily affected.

The table below shows the socio-economic costs with single events from cloudbursts without mitigation, calculated in factor prices.

Intensity (cm)	Frequency	Year	Total costs (Mio. DKK)
47.1	20 year	2010	2,039
62.4	100 year	2010	4,548
52.5	20 year	2060	
71.7	100 year	2060	
62.6	20 year	2110	4,548
87.3	100 year	2110	5,625

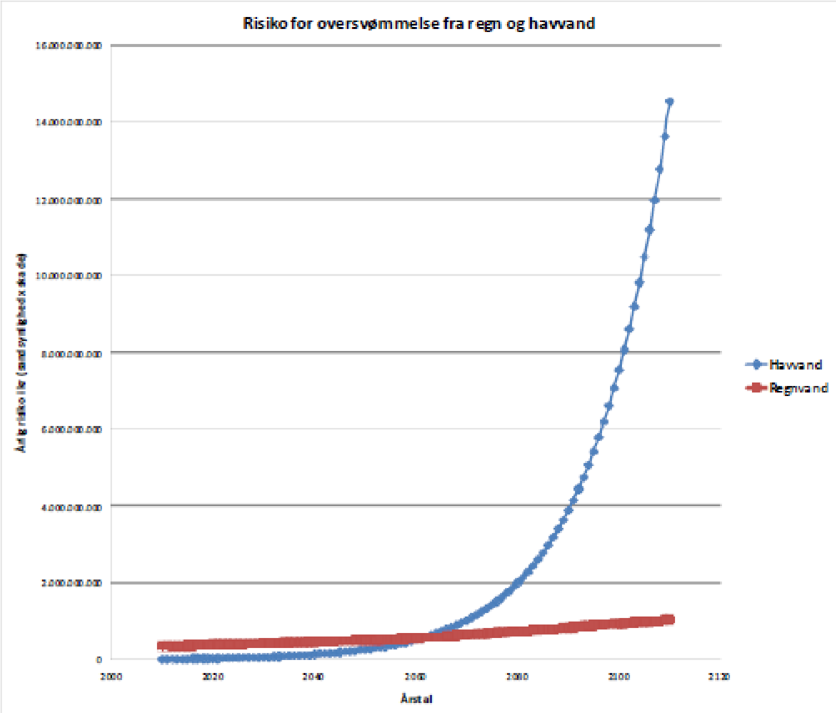
The table below shows the damage costs for rainwater in factor prices if no action is taken. The results show that the total damage costs of a 100 year event in 2110 is 5,625 million DKK.

Measured in mio. DKK	Sewage today	20/2020	100/2010 20/2110	100/2110
Traffic Disturbances all highways	0	9	35	53

Road fracture	0	11	22	33
Ground Floor	397	368	1,274	1,700
basement	0	641	1,045	1,181
Substations	0	28	66	77
Power shortage - private (> 5 h)	0	0	2	3
Power shortage – businesses (> 5 h)	0	2	9	11
Power shortage - public	0	0	0	0
Shops – production loss	245	0	0	0
Shops – Compensation of stock-Gasement	0	748	1,493	1,734
Shops - Compensation of stock - Ground floor	0	205	528	741
Shops, compenstation costs – Ground floor	0	15	28	39
Damage on sewers	0	6	17	22
Stations, seawater	0	0	0	0
Stations, rainwatet 47, 1	0	7	0	0
Stations, rainwatet 61,2	0	0	29	0
Stations, rainwatet 87,4	0	0	0	31
Total	0	2,039	4,578	5,625

To support the prioritization of climate adaptation measures economic risk assessments for seawater and rainwater have been calculated. The risk is calculated as the total probability for flooding multiplied by the damage costs connected with the expected damages the flooding will cause. In other words Risk = probability * consequence. The risk of flooding from the sea and rain over a 100-year period is visualized on maps over the municipality by dividing the municipality into 100 x 100 meter cells. This is done under the assumption that nothing will be done to mitigate the expected trend in sea-level rise and storm-surge. The economic risk is calculated for each of the 100*100 cells for each year and for the total 100-year period 2010-2100. The areas with the greatest probability and greatest costs have the greatest risk (red colour), while areas with great probability but where the damage costs are minimal (parks etc.) a low risk is specified (yellow or no colour).

The figure below shows the development of the yearly economic risk from seawater (blue) and rainwater (red) with no mitigation. The yearly risk in DKK is the probability multiplied by damage costs.



3. Cost Benefit Analysis

The aim of the socio-economic screening analysis is to quantify the benefits and costs of climate change by storm-surge and cloudburst events in Copenhagen. The results from the CBA express the sum of the negative and positive consequences of the proposed adaptation measures. It is important to note that regarding the costs on the environment, there are elements which are not included in the analysis.

- Cloudburst
- Storm-surge

3.1 Potential measures

3.1.1 Storm-surge

A comprehensive analysis of the socio-economic costs if nothing is done to protect Copenhagen from the rising sea-levels the next 100 years are compared with the implementation and operation costs of the adaptation measures, which can mitigate some of the flooding which otherwise will occur. The table below shows net current gain of the damage costs and possible adaptation calculated in million DKK. The net-gain is calculated to 15,911 million DKK.

Gain by adaptation measure	19,908
Costs	3,997

Net gain	**15,911**

Adaptation measures

The adaptation solutions considered are designed to withstand a high tide of 255 cm (measured through the DVR90 model). 2.55 m corresponds to a 70-year high tide in 2110, and it is highly unlikely that a storm-surge of that magnitude could occur today. The ports can withstand a future SLR of 1-1.4 m above the present level, however, there are certain low-lying areas that are likely to be flooded at this development. This applies, for example, to large parts of Christianshavn. On the basis of the risk assessment, the municipality of Copenhagen has pointed out that it would be most appropriate to close the port in the north and in the south by establishing dikes and sluices, along with levees, elevated wharfs and other targeted measures for low lying areas (Amager east, etc.).

In the table below the market prices are shown for the proposed dike solutions and sluices in the north, south and Amager are shown. The market prices include the investment costs, life expectancy, operation and maintenance costs and reinvestments costs in mio. DKK. The market prices mean the costs are not corrected for tax distortion loss and net tax factor.

	Investment costs (mio. DKK)	Life expectancy (year)	Operation and maintenance costs (mio. DKK)	Reinvestment costs (mio. DKK)
North				
Inlet closes w/flaps	1,300	50	10	600
Dam	300	100	2	20
Navigation canal, beach etc.	100	100	2	10
South				
Sluices (2 pcs. Of 100 mio. DKK)	200	50	3	150
Dam	50	100	1	30
Miscellaneous (temp. dam etc.)	50	0	0	0
Along Amager				
Dikes/dams/spun etc.	300	80	6	0
Total	**2,300**	**0**	**24**	**810**

Table: Construction and operation costs for possible actions against sea-level rise, market prices in mio. DKK (Source: COWI)

By converting the investment process to present value and corresponding risk (costs) for each year for the completion of the dike a graph illustrates the gain in present value depending on the year of the start of the investment/completion of the dike. The x-axis refers to the start of the investment, assuming a construction time of 5 years. From a purely economic assessment 2035 appears to be the optimal year to start the investment, whereas the dike will be finished in 2040. If the dike is constructed relatively fast there will be a net gain of approximately 6 billion DKK in present value looking over a 100-year time period.

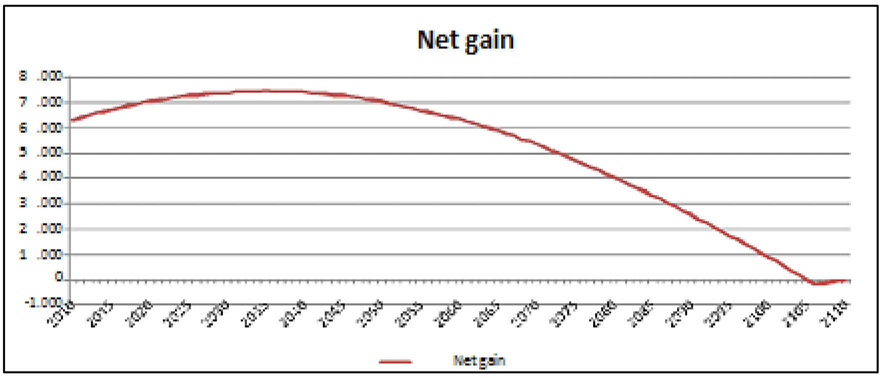


Table: Total present value over a 100-period of net-gain for the dike solution in million DKK. Depending on when the construction of the dike starts. The economically optimal year to start the investment is around year 2035.

Cloudbursts

A comprehensive assessment of the societal costs connected protection against cloudburst is made.

The analysis shows the 5 scenarios. The basis situation is assumed no investment in upgrading the sewers, surface actions is made.

1. Maintain sewage service level
2. Maintain sewage service level plus backflow valve in all basements
3. Maintain sewage service level plus backflow valve in all basements plus surface adaptation
4. Only backflow valve in all basements plus surface adaptation
5. Only backflow valve plus surface adaptation after the sewage system is upgraded

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Damage costs in basic situation	15,552	15,552	15,552	15,552	5,458
Damage costs w/adaptation measures	5,458	2,471	1,785	4,316	1,785
Gain	10,094	13,081	13,767	11,236	3,673

Measures	10,372	11,108	13,374	3,001	3,001
Net gain	-278	1,973	394	8,235	672

In scenario 1 the results show that the net benefit by maintaining the current service levels is -278 million DKK. There is a large gain in scenario 2 compared to scenario 1, where backflow valves are installed. In scenario 3 an additional measure is taken by surface adaptation. By comparing scenario 2 and 3, there is a large benefit in installing backflow vales.

If the sewer system is not extended and the adaptation measures only include the installation of backwater valves, protection of basements and other surface measures, a net presents gain of 6 billion DKK is achieved. However, it is not realistic to not improve the existing sewer system, which is the case in scenario 4.

In scenario 5 it is assumed that the reference service level is maintained which means the implementation costs do not include an extension of the sewer system. A net present profit of 0.7 billion DKK is calculated if adaptation measures are made.

Evaluation method

The socio-economic analysis presented here aims to quantify the costs and benefits of climate impacts of sea level rise and extreme rain in Copenhagen. The following section will outline the major methodological choices, which this analysis is based on.

Evaluation of the adaptation interventions overall profitability, depends on the value of the socio-economic surplus, relative to a reference point without the measure. A positive overall value indicates that it would be beneficial to society. A negative value indicates the contrary.

However, in the results it is important to notice that certain elements are omitted from the analysis. In particular, three reservations are notable:

- Non-monetised effects
- Uncertainty
- Distributional consequences

The table below summarizes the key assumptions used in the CBA.

Parameters	**Value/conditions**
Basic method	Price base method based on social principles
Timeframe	2110
Discount rate	3%
Net Tax rate	17%

Tax Discount rate	20%
Geographical boundaries	Denmark
Price level	2010-prices

A discount rate is used to convert the values which decline over time with an annual value.

The discount rate is determined by the Ministry of Finance. The latest official rate is 6%. Socio-economic analyses on climate change often consider very long time horizons of 50 or 100 years. Using a high discount rate in these circumstances means that the present value of future investments becomes very small. Therefore, damage costs that occur in the latter part of the century, almost does not count in the equation. For this analysis it was consequently decided to use a discount rate of 3%.

In accordance with the Ministry of Finance's recommendations a tax distortion loss for all net costs is included in the analysis. Tax distortion loss is set at 20% in accordance with the recommendation of the Ministry. To express production goods marginal value, the productivity in a price range that reflects the market price and thus the willingness to pay for the resulting products

Market prices are used in the analysis and in order to reflect market prices and the willingness to pay for the resulting products, purchase prices are increased by an average net tax factor. This expresses the average tax burden found in consumer products. Newer public guidelines recommend the use of a 35% net tax factor, but there is considerable disagreement about this rate. The transportation area operates with a net tax factor rate of 17%, which is the 'old' rate from the Ministry of Finance's existing guidance. 17% is used in this report.

Sensitivity analysis

The results are subject to uncertainties, which is why a sensitivity analysis is made. Sensitivity analyses are calculated for sea-level rise and cloudbursts.

Sea-level rise

The results from the sensitivity analysis of the net-gain for sea-level rise in million DKK are show in the table below. It is assumed that the flood frequency is every two years. Overall the results show that the chosen parameters influence the magnitude of the net-gain.

Parameter	Million DKK
Reference	6,429
Unit price + 50%	11,642
Unit price – 50%	1,216
Initiative costs + 50%	4,430
Initiative costs - 50%	7,028

Discount rate 1%	37,035
Discount rate 6%	-1,061
Discount rate 6%, unit price -50%	-2,087

The sensitivity analysis is conducted with a discount rate of 1 % and 6% because the calculations are over a 100 year period, meaning they are very sensitivity to the chosen discount rate. The conclusion is that the results are very sensitive to the discount rate. If the discount rate is 1% instead of 3%, will give a socio-economic benefit of approximately 37 billion DKK which means there is an extremely high financial benefit of eliminating the damages of a 100 year event. This is primarily due to the fact that the damage costs will weigh more in the calculations which are spread out over 100 years. A discount rate set to 6% will results in a negative net-gain of approximately 1 billion DKK.

The conclusion is that climate adaptation in terms of storm-surge protection is affected by the discount rate factor. There will be a socio-economic benefit of a discount rate set to 1%, 3% and 6%.

If the unit prices increases the damage costs will increase and vice versa. The sensitivity analysis is therefore conducted with a 50% price increase and a 50% price decrease. The conclusion is that regardless of whether the unit prices rise or fall, there will be socio-economic benefits of climate adaptation in terms of storm-surge protection.

A sensitivity analysis is conducted on the costs of potential initiatives. The prices are varied with +/- 50%. There is only a slight variation in the net-gain because the costs of possible actions is only approximately 20% of the damage is costs. There will therefore always be a net-gain with climate adaptation.

If we assume a discount rate of 6% and a 50% price increase a negative socio-economic gain will occur because the damage costs will be 1,583 million DKK and the potential initiative costs is 3,122 million DKK meaning a socio-economic loss will occur.

Cloud-burst

The net gain for the sensitivity analysis from cloudburst in million DKK is shown in the table below. For an explanation of the scenarios described below, please see section 3.1.2 above.

Parameter	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Reference	-278	1,973	394	8,235	672
Unit price + 50%	4,769	8,513	7,277	13,853	2,508
Unit price – 50%	-5325	-4566	-6490	2,617	-1.165
Initiative costs + 50%	-5464	-3580	-6293	6,734	-829
Initiative costs - 50%	1,278	3,640	2,400	8,685	1,122

Discount rate 1%	8,039	14,025	12,441	21,876	4,401
Discount rate 6%	-2136	-1264	-2469	3,182	-333
Discount rate 6%, unit price -50%	-4487	-4293	-5643	602	-1156

The sensitivity analysis is conducted with a discount rate of 1 % and 6% because the calculations are over 100 year period, meaning they are very sensitivity to the chosen discount rate. If the 6% discount rate is chosen there will be a socio-economic loss in scenario 1, 2, 3 and 5, there will be profit for scenario 4. If a 1% discount rate is chosen, there is a socio-economic benefit in all scenarios.

There will be an economic benefit for all the scenarios if the unit price increases by 50%. If the unit price increases by 15% the damage costs will be a lot greater, this will result in a socio-economic benefit.

If the initiative costs decreases by 50% there will be a benefit connected with all scenarios. If the initiative costs increases by 50% scenario 4 will be the only scenario which is socio-economic profitable. A sensitivity analysis by combining a high discount rate and low unit prices results in all scenarios being unprofitable for society.

Data Collection

Storm-surge

The damages inflicted by seawater to buildings and infrastructure are extensive. Six levels of sea water rise (in centimetres) have been chosen for the analysis, 137, 158, 200 226 255 and 285. For each of these elevations the damages costs are calculated. The level of damages is primarily concerned with living rooms and basements in the Copenhagen, calculated by using the public “BBR” register. The BBR register contains a number of categories. In this model some main categories are chosen covering approx. 95% of the flooding.

It is evident from the table below, that the number of flooded living rooms and basements (m2) are dramatically increased with each elevation level.

Storm surge water heights above 1990 levels (cm)		**137**	**158**	**220**	**226**	**255**	**285**
Traffic Disturbances all main-roads	Citizens delay in hours	0	0	60,500	242,000	242,000	242,000
Road damages	Number	0	0	1	2	4	9
Ground Floor	Flooded m^2	0	25,999	110,147	337,770	748,076	1,179,501
Basements	Flooded m^2	0	10,033	127,991	390,435	724,938	1,025,561

Substations	Number of substations as damaged and repaired	0	10	20	60	114	185
Power failures private (> 5 h)	Number of houses / people without electricity for 5 days	0	30	371	1190	1977	3,589
Power failures businesses (> 5 h)	Number of businesses without electricity for 5 days	0	91	543	1504	2643	3,517
Power failures public (> 5 h)	Number of institutions without electricity for 5 days	0	0	0	0	0	0
Shops - production loss	Flooded m2	0	0	0	0	0	0
Shops – inventories, basement	Flooded m2	0	43,254	165,978	348,869	559,942	718,825
Shops - inventories, ground floor	Flooded m2	0	80,341	168,064	570,637	1,117,615	1,560,859
Shops – renovating ground floor	Flooded m2	0	2,279	13,274	28,600	56,777	94,484
Damages on sewers	Number	0	0	5	11	15	17
Stations, seawater	Number	0	0	0	0.4	1	1

Seawater surges also affect traffic. According to traffic counts undertaken by the Copenhagen Municipality's Centre for Traffic 290,400 cars crossed the lake section in 2007. It is assumed that there is one person per car and each car is delayed for 10 minutes per. day for 5 days. The total delay for all citizens will be 242.000 hours.

Unit prices

The damage is priced with a set of socio-economic unit prices (DKK/unit) from a previous study. These have been subject to price regulation by 10%.

Table 7.12 Unit prices - damage by seawater rise

Damages		Price (DKK/m^2)	Price (DKK/unit)
Traffic Disturbances all main roads	Unit	0	363
Road damages	Unit	0	1,100,000
Ground Floor	m^2	5,973	0
Basements	m^2	352	0
Substations	Unit	0	1,100,000
Power failures private (> 5 h)	Unit	0	1,850

Power failures businesses (> 5 h)	Unit	0	5,551
Power failures public (> 5 h)	Unit	0	0
Shops - production loss	Unit	0	0
Shops – inventory costs basement	m^2	2,328	0
Shops – inventory costs ground floor	m^2	2,328	0
Shops – renovating costs ground floor	m^2	3,121	0
Damages on sewers	Unit	0	1,100,000
Stations, seawater	Unit	0	228,788,185

Source: Report to the EPA "Climate Change Adaptation of drainage systems and method of testing. Economic analysis 2007"

The 1,168 rooms in the detached houses that are flooded at level 285 are priced by DKK 550,000 per unit. This gives a total cost of 642 million DKK for flooded living rooms. This price is now seen in relation to the number of square meters, and we thereby obtain an m2 cost of living rooms at 5,593 DKK/m2. The same calculations have been done for basements which results in a cost of 352 DKK/m2.

Cloudburst

Four alternatives in addition to the reference baseline were nothing is done, has been looked at, to evaluate the damage costs caused by cloudbursts. The four options are:

1. Maintain sewage service level
2. Maintain sewage service level plus backflow valve in all basements
3. Maintain sewage service level plus backflow valve in all basements plus surface adaptation
4. Lowering the level of services (no sewer expansion), only backflow valves in basements plus surface adaptation

Regarding the level of damage, it is seen that it is primarily basements that are affected by cloudbursts. On the basis of the model, it has been possible to give an estimate of the number of road disturbances, sewers, disruption of services and the number of stations affected by cloudbursts.

Number of damages by extreme rain

Frequency, years		**20/2010**	**100/2010** **20/2110**	**100/2110**
Traffic disturbances all main roads	Citizens delays in hours	24,200	96,800	145,200
Road damages	Unit	10	20	30
Ground Floor	Flooded m^2	61,615	213 305	284 676
Basements	Flooded m^2	1819.015	2965.571	3350.850
Substations	Number, damaged and	25	60	70

	repaired			
Power failures private (> 5 h)	Unit	261	1,172	1,644
Power failures businesses (> 5 h)	Unit	303	1,599	1,912
Power failures public (> 5 h)	Unit	0	0	0
Shops - production loss	Unit	0	0	0
Shops – inventory costs basement	Unit	321 403	641 303	745 035
Shops – inventory costs ground floor	Flooded m^2	88,289	226 691	318 557
Shops – renovating costs ground floor	Flooded m^2	4,667	9,123	12,346
Damages on sewers	Unit	5	15	20
Stations, rainwater (frequency/years) 20/2010	Unit	1	0	0
Stations 100/2010	Unit	0	1	0
Stations 100/2110	Unit	0	0	1

Source: Data for basements and living rooms are received from BBR.

The number of living rooms and basements that have been affected are calculated form BBR. The table below specifies the water depth from the building base where damage occurs.

Apartments with basement:	Damage when water depth is greater than (cm)
Water in the basement from surface water (not from sewer)	15

Water penetrates and destroys ground floor	50
Apartments without a basement:	
Water penetrates and destroys ground floor	30
Detached houses with basement:	
Water in the basement from surface water (not from sewer)	10
Water penetrates and destroys ground floor	30
Detached houses without a basement:	
Water penetrates and destroys ground flood	20

To assess the number of hours affected by traffic disturbance the same method as for storm surge was used. A 0.17 hours delay per car was assumed. It is considered that rain water will cause delays for one day. It is estimated that for a 20-year event in 2010 there will be 24.200 hours of delay and 145,200 cars affected, while for a 100 year-event in 2110 there will be 145.200 hours of delay and 871,200 cars affected.

6. Implementation Analysis

The aim of this section is to establish whether adaptation measures can be implemented in the real world context of case studies, and what the key obstacles and opportunities are in doing so.

Please answer the following six questions giving specific evidence and examples where possible. In principle all implementation activities should be analysed, i.e. activities supported by BASE partners as well as those by other actors. If it is possible to inform about the implementation of those adaptation measures assessed for task 5.2, it is very important to do so in order to comply with the DoW.

To ensure the answers provided are comprehensive and in line with WP2 and WP7, a checklist is provided below with the main factors that all case holders need to consider. Please read through this checklist and ensure you have discussed in your answers, all those factors that were in some way relevant to the implementation of your case study.

Questions

1. How have climate change adaptation measures and strategies been advanced in the case study? Describe the process! (Minimum 500 words)

2. What drives the implementation process and who enables implementation of adaptation measures and strategies/policies? Please explicitly refer to the factors mentioned in the checklist and be specific about any relevant policies! (500 – 1000 words)

3. What obstacles were encountered to implement adaptation measures and strategies/policies? Please explicitly refer to the factors mentioned in the checklist and be specific about any relevant policies! (500 – 1000 words)

4. If any obstacles were overcome, how was this achieved? (Minimum 500 words)

5. What are the future prospects of the climate change adaptation activities in the case study? (200 – 500 words)

6. What is the key message from this case study (and which could work in other cases as well)? Don't forget to consider any specific policy recommendations that arise in your case study! (200 – 500 words)

Checklist

When answering the above questions ensure you consider each factor listed in the checklist below that might have had a role to play in the implementation of your case study; please mark in the table what factors you have covered in your answers. The checklist might not be all-inclusive, so feel free to discuss other factors that might not be listed. Mark 0 – 5 (0 being not relevant and 5 being extremely relevant), or not applicable (N/A)

10. References

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