Climate Change Adaptation of the Built Environment – An Examination

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Abstract: In a Danish context, climate changes are primarily manifested in an interaction between modified wind and precipitation patterns, increasing temperature and a rising sea level. The individual factors often act together and are reinforced in interaction with already known natural and cultural phenomena. This is why the term 'environmental changes' might be more accurate than climate change. ‘Environmental changes’ suggests that climate changes ought to be understood as extensive environmental changes, with an impact on the built environment. Following this, it is no longer sufficient only to assess for example a building, and anthropogenic impacts on the environment, also the impact of the environment on installations, and on the human activities must be included in the analysis and assessments. Based on observations and investigations into climate change adaptation in DK and abroad the research project, Waterscape (Vandskab), focus on some of the challenges that the architectural disciplines are facing in relation to climate changes adaptation.

Keywords: Climate Change, Adaptation Methodology, Architecture.

Climate Change Processes Lead to Environmental Changes

According to UN climate panel, IPCC (2013) there is up to a 90-99% probability of greenhouse gases emitted as a by-product of human activities are causing the ongoing climate changes. The ongoing climatic changes can thus be described as the largest and most comprehensive 'design project' humanity has embarked on.

The impact of the climate change processes include the fact that the temperature is rising, the ice is melting, permafrost thaws, and the oceans become acidified. The weather becomes wilder, agriculture and forestry are affected and the ground water rises. Other effects are multiple and prolonged heat waves, wet areas will get wetter and dry areas drier. With the expected continued emissions of greenhouse gases, it is estimated that the temperature rise will be at least 0.3 degrees Celsius in the 21st century. Less optimistic estimates predict temperature increases up to 4.8 degrees Celsius. It is further estimated that the oceans will rise between 26 and 82 centimetres up to 2100 (IPPC 2013). In a Danish context, climate changes are primarily manifested in an interaction between modified wind and precipitation patterns, increasing temperature and a rising sea level (DMI 2014). The climate change process is irreversible and requires that we adapt to these new conditions, and that we try to stabilize the processes.

The individual factors in the climate change process often act together, and are reinforced in interaction with already known natural and cultural phenomena and factors. Paskal (2009) thus suggests that climate changes leads to 'environmental changes'. Paskal (2009) illustrates this by referring to damages seen on buildings, roads and energy delivery systems in permafrost areas, which now due to more frequent and longer periods of warmer weather, no longer are permanently frozen, and thus no longer provide a stable base for example buildings. Further, Paskal (2009) points out, that in addition to various damages to buildings and facilities, this also means that a standard impact assessment methodology, Assessments of Environmental Impact (EIA) is no longer sufficient - the effects of the environmental impact on a given system now also have to be evaluated.

Climatic change thus also leads to change of an analytical tool and method used by architects, and others, in planning and design processes. This points out that climate change processes can not be considered and handled in isolation and only as a climatic problem. Also, climate changes cannot be seen as a purely technical problem that can be handled with extra foundations or other technical solutions. Climate changes also affect our understanding and notion of not only the climate but of nature *per se*, and of man's interaction with nature and natural phenomena, and thus climate change also have an impact on the built environment.

- In a Danish context climate changes are primarily manifested by: rising temperatures, a rising sea level, changed precipitation and wind patterns – in short: Wilder, Warmer and Wetter. These 'markers' interact.
- The term ‘environmental changes’ describes that climate change processes can not be isolated as a climatic phenomenon, but results in extensive environmental changes, including changes in the built environment, and thus changes how the built environment is planned, designed, used and experienced.
- In addition to the more technical and economic questions raised by climate change processes, also spatial, planning, and design – in short architectural – questions are addressed.

My interest in these questions is reflected in the research project, Waterscape (Krarup 2011), supported with funding from the Danish Ministry of Culture and conducted as part of my research at the Department of Planning, School of Architecture Copenhagen. The project takes its point of departure in examples of climate change adaptation measures in Hafencity, Hamburg, Germany, and the interaction of these initiatives within the urban zone with adaptation measures taken in the rural zone, e.g. the Elb river valley. The study focuses on the interrelationship between climate change adaptation measures across zoning and administrative divisions in order to investigate and discuss whether some of these German examples and experiences may be relevant in Danish climate change adaptation planning, and thus add other complementary climate adaptation measures to those already known.

In the following, some of the discussions and results in the project will be presented here, starting with a brief description of some of the climate change adaptations that have been developed and embodied in the development of Hafencity in Hamburg, and along the Elbe in Germany. This is followed by a presentation of the study on two Danish examples Kerteminde and Reersoe. It is discussed whether there are lessons to learn from the examples in Germany, and whether they are applicable in a Danish context.

Learning From

The research project, *Waterscape*, took its point of departure with the great floods in Hamburg and along the Elbe in the spring of 2002 and 2006. During the flooding in 2006, I travelled along the Elbe from Hamburg to the Elbe source in the mountains between the Czech Republic and Poland, and experienced the extent of the flooding in-situ.

Hafencity in Hamburg is one of the most interesting examples of large-scale climate change adaptation coordinated with and incorporated in the urban development plans and strategies for Hamburg. Hafencity is situated in low-lying former harbour areas along the Elbe and the area is prone to flooding. This is why a number of mitigation and climate adaptation initiatives are taken. What is characteristic of these adaptation measures is that the flood problems in Hafencity are sought handled in a coordinated spatial, functional, and technical manner in the organization and design of this new urban district. The climate change adaptation plans and initiatives taken in Hafencity have attracted much attention in planning and architectural circles, whereas the climate adaptation measures taken in the open countryside along the Elbe are less known, despite the fact that they have an impact on Hafencity and interact with the initiatives taken and planned in Hafencity.

The climatic change processes experienced in the northern parts of Germany are in several respects comparable to those we experience in DK, e.g. a changed precipitation pattern characterized by heavy, torrential rains, changes in the wind patterns, storms and frequent strong winds from the west and northwest, and a warmer climate (NMI 2013). The normal fluctuations of the Elbe seems increasingly to be amplified by climate change, and thus increasing the risk of flooding of the low-lying areas of Hamburg.

270 km2, approximately one-third of Hamburg's total area, is located on low-lying areas around the Elbe and its tributaries Bille and Alster. Almost 180,000 people live and about 140,000 workplaces are situated in these areas. The harbour area contains storage areas for approx. 2500 companies using the 340 fixed routes connecting Hamburg with 1100 ports worldwide. At the harbour areas goods for a value of approximately 10 billion Euros (GHS 2000) are stored.

Hafencity

The plans for Hafencity outline a process of transformation running until 2020-2025. Existing industrial and harbour activities are being phased out and the area converted into a new urban district with new residential, and office buildings. Also new tourist and recreation facilities are planned together with educational and cultural institutions.

Hafencity extends over 150 hectares, making it one of the largest centrally located urban transformation areas in Europe, and will fully developed extend the area of Hamburg by approximately 40%. It is expected to built more than 6,000 new homes, and create 45,000 new jobs in the area.

Climate changes are playing a direct and decisively role in the spatial organization of the area, and in the design of the individual out-door space and buildings, and their adaptation to climate change.

New residential buildings are thus raised from the ground level. Openings in buildings are fitted with doors and shutters that can be closed at high water levels. Major roads and buildings are placed on Varfts (artificial mounds) that raises the terrain from 4.5 meters above normal water level to 7.2 m. The varfts are placed on the existing quay area, keeping a border zone of up to 20 meters free for public spaces.

This means that many of the public spaces in Hafencity are planned and designed in such a manner that they can and will be fully or partially flooded periodically. Other urban spaces such as Sandtorhafen is floating on a pontoon and thus following the water movements. Escape routes in the form of alleys and stairways are placed between the public areas in the border zone and the core, and dry, areas on the varfts.

The Elbe River Landscape

Hamburg and Hafencity is just one point, one city located in a river landscape that stretches some 1100 km. Approximately 740 km of the river flows through Germany, the remaining 370 km runs through the Czech Republic. The catchment area of the Elbe is 148 268 km2. In comparison, Denmark's total area of just over 43,000 km2, and the most water-rich river system in DK, Skjern Å, has a catchment area of 2,100 km2.

For centuries the Elb river valley has been developed into a highly specialized and increasingly mono-functional cultural landscape. The different regulatory actions can be recognized physically in the form of cultivated wet meadow areas, dikes, dams, canals, and cities and buildings located both along and in the riverbed. According to Internationale Kommission zum Schutz der Elbe (2014) the extension of the river valley has been reduced from 620 000 ha to 84 000 ha since the 12th century, which means that the buffer areas - meadows, wetlands, forest plantings, etc. - which potentially could absorb large amounts of excess water from the river system, and surface water from the adjacent land, are reduced by approximately 86%.

For long stretches the Elb river valley is thus transformed into a channel framed by dikes, and optimized to transport excess water. As a result the speed and the amounts of moving water is increased, which also increases the flood risks in Hamburg and in Hafencity. The water has little place to pause, and everybody wants to avoid and get rid of the excess water.

In this way the Elb river valley as a whole has an impact on the amount and nature of climate change adaptation taken in Hamburg and Hafencity, no matter administrative and zoning divisions. Following this, the city of Hamburg is increasingly to be seen and understood in its landscape context - in its environmental context, its Habitat (Painado Ponton 2006) – as part of a larger entity.

This suggests a more integrative and coordinated - systemic - thinking and understanding of how we see and understand cities and settlements in their landscape context, and the interdependence between, for example Hamburg and the Elbe river valley. This points towards a stronger focus on the relationship and coordination between urban planning, and landscape planning and use across competencies, legal and administrative divisions, and thus on a more holistic planning process and methodology.

Based on my observations along the Elbe the following categories of protection and adaptation measurements have crystallized:

1. Protection and adaptation at building level
    a. Mounting watertight bulkheads, doors and gates on buildings
    b. No habitation in ground floors / raised ground floors
    c. Choice of materials and design that can withstand periodic flooding
2. Protection and adaptation measures at urban space level
    a. Urban spaces as retarding basins during peak periods
    b. Spatially design that supports urban space as retarding basins
    c. Choice of materials and design that can withstand periodic flooding
    d. Floating urban spaces (pontoon on the water surface)
    e. River and water walls
    f. Urban spaces on ‘stilts’ (elevated sidewalks, squares)
    g. Urban spaces located on dikes and varfts
    h. Optimization of sewerage in terrain
3. Protection and adaptation measures on structural and spatial level (urban level)
    a. Dikes
    b. Varfts
    c. Sectioning urban areas into districts with dikes and sluices
    d. Green retarding spaces ('suction sponge' areas) in exposed areas
4. Protection and adaptation measures at landscape level
    a. Construction and/or withdrawal of dikes
    b. Construction of varfts
    c. Construction / restoration of wet meadows as retarding basins
    d. Construction / restoration of planted areas, for example forest, that can absorb large amounts of water (retarding areas)

5. Protection and adaptation measures at administrative level
    1. Creation of administrative and operational modes of communication, detection and monitoring systems that transcend administrative boundaries and is adequate for tackling the problem from a holistic understanding
    2. Establishment of climate adaptive measures that supports detection and monitoring systems

Ad. 4.a

Following the 2002 flood it was decided to expand the space of the Elb river bed on some stretches in Germany by withdrawal of the dikes, and thus creating a larger volume in the riverbed, and, at the same time, re-establish some of the lost wet meadow areas.

Ad. 5.a&b

A voluntary monitoring, reporting and water retarding system have been established between the German cities situated along the Elbe and its tributaries. Each town is obliged to observe, and inform each other, and to regulate the water inflow by closing or opening the inflow from the tributaries. The principle is that everyone takes their share of the excess water, and that no one 'export' more excess water than necessary to the neighbour city further down the river. A city situated by an inlet to the Elbe, will thus during peak periods have to close the water inflow to the Elbe and thereby flood its own area. This was the case in Havelberg in 2006, where it was necessary to close the inflow from the Havel to the Elbe and delay the masses of water moving down the system. This meant that larger parts of the low-lying neighbourhoods in Havelberg were flooded during my visit.

A lesson that can be drawn from the observations of climate change adaptation along the Elbe is that each initiative interacts and is part of a complex network between both natural and cultural processes and activities, between visible and invisible conditions and phenomena, between scales, and between administrative and legislative divisions. An example, the protection measures at the administrative level (cat.5) does not make sense if they are not followed up in synergy with other initiatives at other levels.

What also stands out clearly is, that the individual climate adaptation initiative in itself may be both functional and effective, but relating it to other initiatives across scales and domains qualifies each element and initiative. In order to do so it presupposes,

- The establishment of an understanding of the problem across fields of knowledge, across scales, and interests, and economic and administrative boundaries
- The development of adequate tools and methodologies, for example analysis methods for identifying relationships, impacts and interactions between, for example, natural (climatic / geological), and cultural, economic, social and spatial phenomena and relationships, and needs.

Learning For

Kerteminde and Reersoe are chosen as representative of some of the common questions concerning climate change adaptation many small Danish coastal towns and settlements are faced with due to their low location in an already low-lying Danish landscape. The two Danish examples have been studied through field studies, literature studies and through material from websites and various published municipal planning and strategy documents. The studies have focused on the extent to which official strategies and plans are influenced and motivated by climate change adaptations, and what specific adaptation measurement that might be described or taken. The studies also include spatial analyzes of the two examples.

The spatial analysis of the two examples are placed between an overall landscape character analysis (Stahlschmidt 2001), which almost does not deal with the city's location in the landscape, and, a spatial urban analysis by the SAVE method, which mainly deals with buildings, and the cultural and building structures, and only to some degree with relationship between the landscape and the city/settlement/buildings. In the following a short summery of the analysis of Kerteminde and Reersoe will be given.

Kerteminde

The municipality of Kerteminde is inhabited by approx. 24,000 people. The main city, Kerteminde, is located at the mouth of Kerteminde Fjord. The historical part, e.g. the city built before 1900 is located on a beach sediment surface at the mouth of Kerteminde Fjord. The two manor houses, Lundsgård south of Kerteminde, and Hverringe north of Kerteminde have formed barriers to the urban development along the coast, and thereby contributed to control the urban growth and push it towards the west and northwest.

Northwest of Kerteminde the landscape is a dammed and drained fjord landscape ranging from Odense to Kerteminde Bay. In this area Kerteminde Municipality has started restoring a wet meadow area, Sybergland. Between this area and Kerteminde central part is an arc-shaped little hill island, on

which the modernistic part of Kerteminde is situated. Previously this area appeared as an islet with water and wetlands to almost all sides.

The industrial area is located on the flat, reclaimed land to the north and northwest of the historic center. The area turns its back to the landscape and is starting to 'float' out into the drained fjord landscape.

The streets in the historic part of Kerteminde are oriented in two directions. Langgade, Strandgade, and Strandvejen runs north south. Præstegade, Vestergade and Fiskergade runs east west, all originating from Langgade, the central spine of the city. Langgades southern end culminates in the meeting with the harbour and the bridge across the mouth of Kerteminde Fjord. To the north, the building structure in Langgade change from apartment buildings to small fishing houses situated shoulder to shoulder, and forming a fine street space that ends with a remarkable look out into the bay and Nordstranden.

Praestegade, Vestergade and Fiskergade constitute an old fishing neighbourhood. Here the houses are situated side by side and are predominantly single storey houses. Almost all the old houses have low bases at the same height. This seems to have ensured that previous floods have not reached the ground floor level. The same is true for some of the newer fishing houses around Drossingen and Havnegade on the opposite side of the harbour, where the base heights also seems fixed in a specific height as protection against flooding.

Another spatial characteristic that can be observed in the old part of Kerteminde is the long narrow gardens situated on the backs of the houses. It represent a significant spatial structure consisting of elongated pieces of land with rear buildings for fishing gear and narrow gardens. The houses in the southern part of Fiskergade have gardens ending on the water's edge. Vestergade and Praestegade have no direct access to the water, but also consist of elongated plots ending in narrow back alleys.

Urban Development Projects in Kerteminde

The most significant ongoing urban planning projects seek to repair the town's connection to the landscape context (Kerteminde Kommune 2009, 2011, 2012, 2013, 2014). The three major areas of focus in the transition between the city and the water is,

A. The outer harbour
B. Renaissance Harbour
C. The dammed meadows - Recreational lake and wetlands, Sybergland, and a private golf course

Ad A:

Based on a debate and an architectural competition, the municipality has prepared a general plan for the outer harbour area, e.g. the area east of the historic centre between Strandvejen and the marina, as well as the outer quay of the inner harbour where the Fjord and Belt Centre is situated. The plan consists of a simple zoning, each area with its own content, for example, housing or leisure, or mixed commercial activities.

The use of climate change adaptation as a planning parameter is fairly sparse: only a single sketch describes a vision about sustainability, local infiltration and green ribbons connecting the city with the waterfront.

Ad B:

The project is a result of an architectural competition and aimed to restore and reinterpret the meeting between the city and harbour. Since there is no access to the competition program, it is not possible to ascertain whether climate change adaptation were an important point in it.

Ad C:

The urban growth of Kerteminde now covers the hill island to the northwest, where the city meets the drained meadows at the foot of the slope. So far the extension of the hill island have set a limit to the city's growth. In the meadow area there are two significant landscape projects underway.

1. A restoration and recreation project, Sybergland, where the idea is to exploit the terrain-related benefits to reinterpret the fjord landscape as it was before reclamation in 1814.
2. The second project is a golf course initiated by a private consortium.

Plan Strategy 2011 for Kerteminde Municipality

The development strategy is focused on settlement, culture, education, business and commerce in Kerteminde city. In the villages, the strategy is to develop qualities based on existing resources in terms of landscape, nature, tradition, and local building tradition. Concerning the planning of the rural zone, no overarching or guiding thoughts for the rural zone, nor is a potential relationship between the landscape planning and the urban planning are outlined.

Climate Change Adaptation in Kerteminde

Over the past few years, Kerteminde has repeatedly been flooded. The recent flood was the beginning of December 2013. The historic city centre is generally situated 1.5 to 2.0 metres above sea level. In 2006, the water level rose to 1.60 metres above normal water level and large parts of the harbour and buildings with full basement, and ground floors in those houses situated directly on the ground were

flooded. The floods in December 2013 were less dramatic.

Climate change adaptation measurements are sought embedded in the long-term planning of the natural and urban green areas in Kerteminde by (Kerteminde Kommune 2011) by,

- Uphold and protection of the existing green areas in cities.
- Assessing the potential for planting trees along several roads and trails.
- Thinking green areas and green urban spaces into the planning of residential areas as well as by urban renewal.
- Minimizing the extent of paved surfaces.
- Flood protection

With focus on the increasing sea level, and more frequent extreme precipitation, the following measurements are proposed to be incorporated in future municipal and local planning,

- Climate Change adaptation should be incorporated into future plans for the design of buildings and infrastructure. These are requirements to building base height, selection of materials, and design of basements, etc.
- Future reservation of land for dikes or other flood control.
- Use of the recommended minimum ground floor heights from the Danish Coastal Directorate when planning new residential areas.
- Support local (individual) initiatives concerning flood protection

Besides the above mentioned initiatives in the Plan Strategy 2011, there were mid-2013 not developed further climate adaptation strategies or plans for Kerteminde. A service has been set up at the website of the municipality, where the citizens can see the expected flood scenarios and the consequences of different water heights on the individual land.

It should be noted that a change in the national legislation in 2013 now has opened for new types of corporation between the municipalities and the water facility companies. This means that new and more inspiring plans for climate change adaptation are now being developed, and that the water companies now are allowed to invest in such projects.

It should also be noted that several of these plans are mainly focusing on storm water treatment, and not on the rising sea level, nor on the interaction or coordination between the two.

Reersoe

Reersoe is a small peninsula at Goerlev, West Zealand, covering just under 6km2, and with a 9 km long coastline, and 516 inhabitants (Den Store Danske 2014), consisting partly of permanent residents, and partly of summerhouse residents. The peninsula is located in Store Belt and separates Jammerland Bay in the north from Musholm Bay in the south. Since the municipal structural reform in 2007, Reersoe has been part of Kalundborg Municipality.

Reersoe consists of several moraine islets, which in time have become land-based and interconnected by an elevated seabed, and by drainage of the marsh areas. The former islets stand out as small hilltops on the flat terrain. The east coast is characterized by a shallow wetland. To the north the coast is characterized by a long sandy beach with a dike located between the beach and the summer house area behind. The west coast is a low cliff coast affected by material transport and erosion processes.

In the former seabed areas, Store Saltsoe, Lille Saltsoe and Tagsoe, the majority of the summerhouses are located. Reersoe old Village is located on one of Reersoe's highest points.

The harbour area is positioned low in the terrain and at high risk of flooding. Many of the old fishermen's houses have high bases with correspondingly high ground floors, which have provided some protection against flooding. Typically, the newer houses are situated directly on the terrain.

The summerhouse area at Reersoe northern coast was developed in the 1950s and onwards. Almost all houses are from the 1960s and '70s, and located directly on the terrain and none have a high base. The area is about the same terrain level as the beach. As protection against flooding from the sea there is a dike between the area and the beach. The area is further divided by a series of open drainage channels wedged in between the plots.

Climate Adaptation Reersoe

Kalundborg Municipality participated in 2009 to 2012 in the EU project BaltCICA; a collaboration between 24 partners in eight Baltic Sea countries. The purpose of the project was to assess the impact of the climate change processes locally and test concrete solutions. The coastal areas at Tissoe and Reersoe were selected as test areas, as these hold both permanent habitation, agriculture, cultural environments and large areas of summer houses. The areas also have large natural areas with lakes, streams and marshland. Moreover Reersoe is one of the areas in Kallundborg Municipality most frequently hit by periodic flooding.

In the fall of 2009, the Technology Council and the Municipality of Kalundborg invited to a scenario workshop on climate change adaptation. The following scenarios and possible solutions were discussed:

- A basic scenario or "laissez-faire" scenario - nothing is done specifically to mitigate the effects
- A protection scenario - aimed at the utmost to try to protect all interests
- An adaptation scenario

Possible solutions included:

- The construction of sea dikes
- Establishment of large dikes on the coast and in the countryside.
- Phasing out and replacement of vulnerable settlements and constructions situated in former wet areas during this century
- Transforming exposed areas into natural areas

These formed the basis of a citizens' summit in Kalundborg March 2011, where the participants voted on the options:

- 16% were for a large sea dike
- 20% were for a large dike solution on land
- 43% were for phasing out exposed settlements
- 21% were for ongoing transformation of exposed areas into natural areas

11.2% of the total of 350 participating citizens were either from Reersoe or Slagelse.

Proposal for Climate Adaptation Plan for the Municipality of Kalundborg

Based on the mapping of risks of flooding and on citizens' summit Kalundborg Municipality prepared a climate change adaptation plan in 2013. The plan has a threefold purpose:

- The individual landowners have the opportunity to assess flood risks and act accordingly.
- The mapping allows to take into account climate change adaptation in future planning and in specific projects.
- By identifying action areas the most vulnerable areas and/or the most endangered values may be targeted.

It is generally up to the individual landowner to secure his house and property.

The plan also has a contingency significance - a flood will reduce the accessibility to the peninsula, and flooding of certain types of risk enterprises may cause major pollution problems. Ensuring greater public buildings also have a contingency significance as evacuation sites, like the municipality has an interest in ensuring their own investments (Kalundborg Kommune 2013).

Both residential, commercial, and summerhouse areas have together with the natural and agricultural areas been identified as risk areas. At a water level of +1.5 m, significant parts of the summerhouses and residential areas will be flooded. The road connection to Reersoe will be cut off and it may be critical for the emergency service to access Reersoe. Furthermore the harbour and adjacent areas will be flooded, and finally, a reflux along the drainage canal will, at a sea level of +1.4 m, flood large parts of the agricultural land to the west, i.e. Store Saltsoe og Lille Saltsoe.

The municipality prioritises the initiatives in the following order:

- Ensuring the access road - either by raising it or by marking it in such a way so that its location is visible at a flood, and the emergency service will be able to access Reersoe.
- Supporting the local Dike Group in preparing a proposal for a dike solution and assist in the dialogue with Coastal Authority.

The Dike Group consists partly of summerhouse owners and partly of residents on Reersoe. In 2009 the group developed a proposal for new and elevated dikes along the coast of Reersoe to protect the peninsula against flooding.

Discussion

In Denmark, there are no harbour cities or rivers similar to Hamburg, HafenCity and the Elbe. Nevertheless the climatic change processes experienced in the northern parts of Germany are in several respects comparable to those in DK, e.g. a changed precipitation pattern characterized by heavy, torrential rains, changes in the wind patterns, storms and frequent strong winds from the west and northwest, and a warmer climate. Comparable is also the location of settlements in the intersection between a low-lying terrain, a fluctuating water system (the sea/a river or a lake), and ‘normal’ surface and storm water treatment.

In Hamburg and Hafencity and along the Elbe the climate change adaptations are more advanced than in Denmark. Therefore, it seems interesting to consider if some of the adaptation measures and lessons learned here are applicable in a Danish context. Further, the fact that climate changes impact exceed established divisions in zoning, competencies and administration, suggests a revision of traditional ways of thinking, and methods in planning processes.

With the Local Government Reform (structural reform) in 2007 the counties (Amterne) in Denmark were abolished and their duties and knowledge on nature, environment and planning in landscape zone were transferred to the municipalities. This could be seen as an opportunity to develop and carry out a more interacting and coordinated – systemic - planning than previously possible, e.g. a planning where the landscape zone, the summerhouse zone and the urban zone, could be mutually related and coordinated to each other and to the natural basis, the geological structure, and the cultural landscape. The growing recognition that climate change processes are not just a temporary or isolated climatic problem, and that climate change affect all administrative planning zones at all levels might promote such a

thinking and planning, and thus encourage a planning methodology and practice in which climate change adaptation strategies and initiatives for the benefit and development of both the landscape zone and the urban and settlement zones could be developed.

Although the competence and responsibility for the landscape planning was transferred from the counties to the municipalities by the local government reform in 2007, the county employees and their resources, e.g. their knowledge and man-hours, were not necessarily transferred to the municipalities. In several cases this has undoubtedly meant that the responsibilities and tasks relating to landscape planning were transferred to the municipalities jurisdiction, but the transfer wasn't followed either by people, their knowledge, or by time and money to carry out the assignments. Additional, the regulatory systems are still following the old administrative divisions, with imbedded potential barriers for a higher degree of integrated planning across zoning and administrative divisions.

Further, the economy in climate change adaptation is unclear – who is going to pay? Is it the individual landowner, the municipality, or the state? A discussion and definition of when climate change adaptation of the built environment is an individual responsibility, and when climate change adaptation is for the common good – on a societal level - is needed.

Also, it seems necessary to address the question on climate change adaptation measures for the common good undertaken on private ground.

Comparing the climate adaptation plans for Kerteminde and Reersoe with the climate change adaptation observed along the Elbe and in Hafencity, only few of the initiatives taken in Germany are undertaken or suggested in the plans for Kerteminde and Reersoe.

In the two Danish examples the use of high building bases in the old part of both Kerteminde and on Reersoe Harbour is observed, and in the case of Kerteminde also recommended for new buildings. Other recommendations on adaptation at building level are not observed. The installation of hatches and bulkheads (cat.1a) could be used on both existing and new buildings, whereas it does not make much sense to remove residential programmes from the ground floors (cat.1b / c), since the majority of the buildings in Kerteminde and Reersoe are one to two floors. In the construction of new buildings or new urban districts the initiative could be used, as suggested in Planstrategi 2011 for Kerteminde.

At the urban space level (cat.2) an initiative concerning optimization of sewage is observed, as well as the choice of materials (cat.2 c), which can withstand flooding as seen at the Renaissance Harbour project in Kerteminde, where granite is used for the new pavements. Water walls or spatial reconfiguration of urban space into retarding basins, as well as location of new urban space on dikes (cat.2.a/e/g) could be used.

On a structural urban level (cat.3) the construction of new dikes is promoted. In none of two Danish examples the construction of green retarding basins (cat.3 d) is discussed.

In the Plan Strategy 2011 for Kerteminde planting of trees in the urban spaces are suggested.

Kerteminde historic centre is today characterized by, 1. the absence of street trees, and, 2. of the narrow back yards, giving the area a clear and easy to read spatial character and identity, which can be undermined by planting trees in the street spaces. One might consider whether working with open water channels in the street profile, and the use of semi-permeable pavements, where it is not absolutely necessary to cover with paving stones or asphalt, could be an option instead. Many of the private gardens and driveways in Kerteminde are today unnecessarily covered with paving stones and similar water repellent materials.

The large area to the north-east in Kerteminde, is today used only for winter storage of boats, but it could possibly be redesigned in such a manner that it would not only serve as winter storage for boats, but also as a relieve area at high tide, and designed in such a manner that it could lead excess water to other relief areas - such as to the restoration area, Sybergland, north for the city. This suggests a more proactive mixing and coordinating of programs, and interest, in climate change adaptation on a general level, that seen in the two Danish examples.

Only the emergency plan for Reersoe and the Dike Group at Reersoe's wish for additional dikes involves the planning of the rural areas. Other direct initiatives to transcend and integrate administrative areas, levels and divisions (cat. 5) between urban and rural planning are not observed in the two Danish examples.

In Kerteminde, the two projects in the reclaimed meadow area northwest of the city, the golf course and the restoration of the fjord landscape, are even in conflict with each other. The golf course stretches from the village of Over Kærby on the islet west of Kerteminde, down the northwest side and ending on the flat reclaimed area (at level 0) behind the existing industrial area in Kerteminde. A golf course is a highly regulated piece of mono functional landscape design that makes great demands on drainage work - it requires static landscape conditions so to speak. The restoration project, Sybergland, is located in the same area, and bordering the golf course. The project is motivated by national targets for conversion of arable lowlands into water-rich dynamic natural areas controlled by natural processes.

There are thus two very different types of landscape projects with very different needs and demands close to each other in the area. The golf course requires a static landscape where natural processes have to be controlled as much as possible in order to meet the program requirements for a 'permanent' landscape.

The natural processes are to some extent met by the other project, Sybergland. But by locating the golf course in the area follows a reinforcement of the dikes and pumps located at respectively Kerteminde Bay and Odense (Orbicon 2012). Depending hereon the outcome of the restoration project, Sybergland, is likely to be a low freshwater lake depending on the climatic and hydrological fluctuations during the year under the influence of the continued regulation of the runoff by pumps and dikes. One can therefore fear that the Sybergland project will appear as a superficial landscape design, a green-washing project.

Instead, the golf course could have been located elsewhere, e.g. higher in the terrain, and the whole reclaimed low lying area given over to the restoration project, and to the natural water fluctuations by removing the dikes, and thereby ensured a potentially exciting urban landscape accessible to the public. The area could thus function both as a recreational area, and as a relief area at high tide for the benefit of the entire city.

Further, such an urban landscape could be seen as a contribution to a spatial clarification of the city's relationship to the open countryside and to the water.

At the citizens' summit in 2011 in Kalundborg Municipality 43% of the participants voted for a phasing out of vulnerable settlements. The attendants at the summit thus displayed a far more advanced understanding and acceptance of settlements as non-permanent than the authorities themselves. How many of the attendants that were summerhouse owners are not known. But the vote could be seen as in opposition to the Dike Group project that seeks to protect the exposed settlements, and maintain status quo, by constructing new dikes.

Phasing out, relocation or demolition of settlements is rarely seen in Denmark. But transformation of previously built-up areas into natural areas would in many cases undoubtedly contribute to adapt remaining settlements to climate changes. What speaks against is,

- Ownership of land and buildings is equal to the economic value
- We ascribe meaning and emotional value to a place and house
- Natural, systemic processes do not have a visible or defined place in our planning thinking and methodologies and they are rarely considered as an active participant in the planning process

On the other hand settlements may not be completely ruled out in the flood risk zones. One could for example imagine building typologies that relate actively to landscape and water fluctuation processes, e.g. building typologies that are adapted to dynamic water levels, examples already exist in the Netherlands.

A question not addressed by either Kerteminde or Kalundborg Municipality, is the question of a distinction between primary and secondary settlements, e.g. between permanent residential and recreational housing. Both municipalities state that it is the owners' responsibility to secure their property, and thus avoid the question. But it should be possible to address the question of relocation and phasing out secondary settlements situated in low-lying terrain, if these areas could act as a relief area for permanent settlement, for a city or urban district or constructions of importance for society – for the common good.

In hindsight and under the influence of the ongoing climate change processes, the summerhouse areas on both Reersoe and by Kerteminde should have been located elsewhere or built otherwise. But this happened at a time when climate change was not on the agenda, and where we as society had an almost unlimited confidence to technological solutions to control nature and natural processes - popularly known as the technological fix. Our confidence in the capability and the raison d'etre of the technological fix is now questioned by the climatic change.

Concluding Remarks

Climate changes leads to 'environmental changes', meaning that in addition to actual damage to buildings and infrastructure, also an architectural method such as Assessments of Environmental Impact (EIA) are affected. Besides assessing the impact of a building or some given system on the environment, also the environmental impact on a given system now has to be evaluated. Climate changes thus also affects architectural methodologies, thinking and practise.

Based on observations in Hafencity in Hamburg and along the Elbe five categories and levels of climate change adaptation in the built environment have crystallized,

1. Building level
2. Urban space level
3. Urban structural level
4. Landscape level
5. Administrative level.

One lesson that can be drawn from the observations of climate change adaptation along the Elbe is that each initiative on each level must be seen as part of a complex systemic network covering interactions between both natural and cultural processes and activities, between visible and invisible

conditions and phenomena, between scales and levels, and between administrative and legislative conditions. The individual climate adaptation initiative in itself may thus be both functional and effective, but coordinating it with other initiatives across scales, and domains qualifies each element and initiative.

Based on observations from the Elbe river and Hafencity in Hamburg it is thus suggested that climate change adaptation of the built environment should be viewed in context, e.g. in relation to and in interaction with other adaptation initiatives and natural processes in the environment, across the scales, functions, interests and across administrative and legal divisions and conditions.

Following this, the need for a new understanding of the problems, which relate to the impacts of climate change processes is pointed out. It is thus proposed to understand climate change adaptation of the built environment in a larger and in a relational perspective beyond the individual initiative, the individual building, the individual urban space, and beyond the division between urban and landscape zones. This proposition is exemplified and supported by the design of the individual spaces in Hafencity in their urban and natural context, and in interaction with the whole Elbe river landscape and the adaptation initiatives taken here – Hafencity in its Habitat.

Such an understanding challenges conventional architectural and planning understanding and categorization, architectural methodology and proposal making - it points towards a reconsideration of the understanding of the relationship between the built environment and the context, e.g. the landscape and the natural processes, and human and cultural activities. And it thus points towards the development of an integrated and coordinated planning thinking, process and methodology.

Two Danish examples, Kerteminde and Reersoe, are studied and the actual and planned climate changes adaptation is discussed according to the five categories crystallized from the observations in Germany. Both in the case of Kerteminde and in Reersoe both actual and planned climate changes adaptations are rather sparse. The initiatives taken or planned are all seen individually. It can thus be concluded that, in respect to climate change adaptation of built environments exposed to both a rising sea level and flooding by storm water there is:

1. A large potential for developing a more integrated and coordinated – systemic – architectural and planning understanding of the built environment in its habitat, and of climate – nature and natural processes per se as part of, and ‘actors’, in the built environment and its planning, design and governance
2. A need to develop architectural and planning thinking and methodologies adequate and supportive for such a thinking, planning and design, and governance of the built environment

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