Deltas in Times of Climate Change
Rotterdam 2010
Connecting world science and deltas

Abstracts
Scientific Programme
Deltas in Depth

International conference
Rotterdam, the Netherlands
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Deltas in Depth

Deltas are physically complex systems. In them, many interactions take place between sea and land through surface- and groundwater. Climate change adds to this complexity. Many phenomena related to climate-induced complexity are not yet known or understood. Sociologically and culturally deltas differ from inland regions due to the regional position between the hinterland and the oceans and the activities related to that specific position. Climate change affects the lives of people in deltas and requires responses from societies. Every day economic investments are made. What would it take to make such investments more robust to climate change?

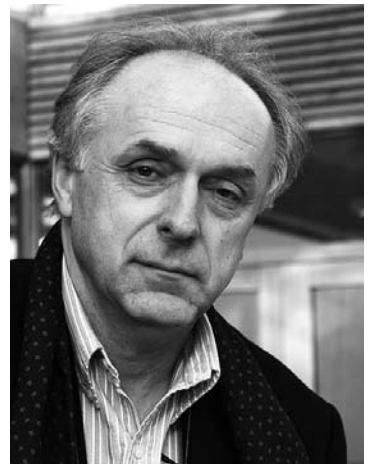
Science can help people analyze and understand climate change and the broad range of its physical impacts; it can explore the vulnerability of metropolitan areas and how people's lives could be affected and how they may respond; science can contribute to innovations in technology, governance and economic systems so that they can better handle climate change.

Everywhere in the world scientists are at work in different fields of research relating to climate change. Some of the research is specific to deltas. One of the goals of the conference is to exchange results of this research, to make them available to those who need them in order to learn and to make a scientific leap forward. At the conference, we are organizing 28 scientific sessions covering nine themes. The sessions will be of interest to scientists, policy makers and practitioners.

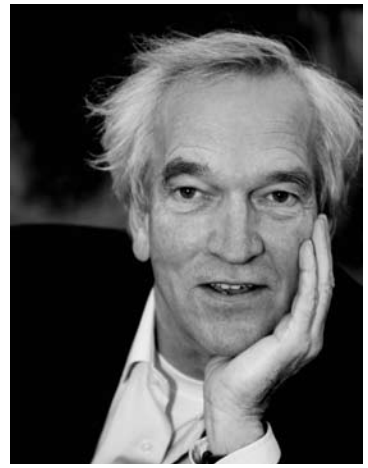
In December 2009 we sent out a call for papers. This resulted in the submission of 370 abstracts. The conference's 30 convenors assessed the abstracts and proposed a programme, which the conference's Scientific Committee subsequently approved. In total 310 abstracts were selected for oral and poster presentations.

In this booklet you will find the abstracts, exactly as submitted by the presenters, of the oral and poster presentations per theme.

Pavel Kabat, Chairman Scientific Committee
Pier Vellinga, Chairman Steering Committee



Pavel Kabat



Pier Vellinga

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Deltas in Depth Theme 1:

Regional climate, sea level rise, storm surges, river run-off and coastal flooding

DD1.1-02 A REGIONAL APPROACH FOR FUTURE SEA LEVEL CHANGE USING IPCC SRES SCENARIOS

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Contrarily to what is often believed, sea-level change is not spatially uniform. Regional variations in sea-level change are significant and therefore very important, especially for low-lying deltas. In the IPCC AR4 report, projections are presented for global average sea-level change for the 21st century using the SRES marker scenarios. We use the same model- and scenario-data, but in such a way that we create regionally varying sea-level projections. To model the contributions of small glaciers and ice caps to sea level change, we force a glacier model with IPCC scenarios, and use these results to drive a self-gravitating sea-level model. In addition we include regional patterns of thermal expansion from the IPCC models. Adding the regional contributions of all land ice components (small glaciers, ice sheets and dynamical ice discharge) and the thermal expansion of the ocean yields regional patterns for 21st century sea-level change for the different models and scenarios. The regional patterns reveal that some regions experience sea-level change above the global average (islands in the Pacific Ocean), while others show below-average sea-level change (Dutch coast). Results will be presented of the deviations from the mean sea-level rise and uncertainties in the regional patterns. Finally the implications are shown for key delta areas around the world.

DD1.1-03 SEA-LEVEL RISE AND SUBSIDENCE: A DUAL THREAT FOR THE MISSISSIPPI DELTA

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Sea-level rise and subsidence combine to pose an ongoing and increasing threat for the US Gulf Coast in general, and coastal Louisiana (including the Mississippi Delta) in particular. This presentation reviews the progress that has been made over the past decade in understanding these phenomena, both in terms of processes and rates. Comparison of detailed reconstructions of Holocene relative sea-level (RSL) rise from southwest and southeast Louisiana (the Chenier Plain and the Mississippi Delta, respectively) shows differential crustal motions of Pleistocene and deeper strata of ~0.15 mm/yr. This difference can be explained by the effect of sediment accumulation in the delta and the resulting depression of the underlying lithosphere. Reconstruction of RSL rise during the past millennium yields a pre-industrial rate for the central US Gulf Coast of ~0.4 mm/yr, primarily due to glacial isostatic adjustment (forebulge collapse) associated with the melting of the Laurentide Ice Sheet that affects the entire region. RSL rise as measured from tide-gauge records for the past century shows rates of 2 mm/yr or more, indicating a dramatic increase, echoing what is observed worldwide. Tide gauges in the Mississippi Delta show rates of RSL rise on the order of 10 mm/yr and sometimes higher. Given the relatively slow subsidence rates of the deeper subsurface, this indicates that subsidence occurs primarily in the shallower and more recent deposits. Studies of the deformation of deltaic strata have confirmed that subsidence rates due to sediment compaction (primarily due to loading resulting

from clastic sediment accumulation) can be as high as 5 mm/yr over millennial timescales, and likely higher over decades to centuries. Projections for the future within the context of climate change suggest that sea-level rise may progressively overtake subsidence as the main threat to coastal Louisiana.
The implications of these findings can be summarized as follows. Comparison of rates of sea-level rise over various timescales highlights the impact of global warming on the US Gulf Coast by means of a rapid acceleration, with rates of sea-level rise about five times higher during the 20th century compared to the previous (pre-industrial) millennium. This is augmented in coastal Louisiana by high subsidence rates, thus providing one of the conditions that have contributed to the exceptionally rapid loss of coastal wetlands. An analysis of subsidence mechanisms and rates brings both good and bad news. Since most subsidence occurs in relatively shallow deposits (uppermost ~40 m), infrastructure anchored in the Pleistocene substrate is generally relatively stable. On the other hand, the high sensitivity of shallow deltaic deposits to compaction demands caution in the selection of target areas for river diversion projects for coastal restoration. These things said, the primary threat for coastal Louisiana is the continued acceleration of sea-level rise due to climate change.

DD1.1-04 FUTURE COASTAL FLOODING RISK IN THE SEVERN ESTUARY DUE TO SEA LEVEL RISE

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The Bristol Channel and Severn Estuary constitute a large, semi-enclosed body of water in the southwest part of the UK. Over the last few hundred years, human settlement has flourished in the coastal lowlands of the Severn Estuary. Many of these lowlands and their settlements have been subject to sea flooding and have relied on the protection of artificial sea defences. In England and Wales alone it is estimated that 5 million people and 2 million properties are currently at risk of flooding, and many of these are located in coastal floodplains. With the occurrence of global warming accompanied by the sea level rise, the probability of coastal flooding risk in the Severn Estuary will be increased accordingly. However, it is difficult to predict accurately the magnitude of sea level rise in this area. According to the predictions by Hansen (2007), a sea level rise of several meters will be a near certainty if greenhouse gas emissions keep increasing unchecked. Using results from the Hadley Centre's HadCM3, Hulme et al. (2002) predicted that by the 2080s, relative sea level may reach over 70 cm above the current level in Wales and southwest England for the case of high CO_2 emissions scenario, while the Inter-governmental Panel on Climate Change Third Assessment Report estimates that sea level rise over the 21st century will be between 9 and 88 cm (Church et al. 2001). Therefore, it is necessary to estimate the future coastal flooding risk in the Severn Estuary using different extents of sea level rise.
In the current study, an existing two-dimensional hydrodynamic model based, on an unstructured triangular mesh and a finite volume algorithm is outlined, and the model can simulate the operational process and impacts of the proposed Severn Barrage. Two scenarios at the open seaward boundary have been adopted, including the water level hydrograph observed in March 2003 as the current baseline (scenario I), and the level hydrograph in scenario I plus a sea level rise of 1.0 m for an extreme assumption in the future (scenario II). The above-mentioned model was then applied to predict the distributions of maximum water levels using these scenarios, under the conditions without and with the Severn Barrage. Finally, the potential inundation extent of sea level rise were obtained for three reaches, including the outer, middle and inner estuary and both without and with the barrage. As compared with the current maximum water levels, simulated results between without and with the barrage due to sea level rise indicate that: (i) without the barrage, the maximum water levels along the estuary were predicted to increase by 1.0-1.2 m; and (ii) with the barrage, the maximum water levels upstream of the barrage were predicted to decrease by 1.0-1.3 m in the outer estuary, 1.1-1.2 m in the middle estuary, and 0.5-0.9 m in the inner estuary. Therefore, it can be concluded that the construction of the Severn Barrage could reduce the future coastal flooding risk due to sea level rise.

Deltas in Depth Theme 1: Regional climate, sea level rise, storm surges, river run-off and coastal flooding
Session DD 1.1: Sea level rise, surge and coastal processes (part 1) **ORALS**

DD1.1-05 ASSESSING CURRENT AND FUTURE STORM SURGE RISK AROUND TASMANIA, AUSTRALIA

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Storm surge hazard along the Tasmanian coastline has recently been investigated as part of the 'Climate Futures for Tasmania' (CFT) project. The CFT project was initiated to provide Tasmania with detailed information on a range of climate variables under future climate conditions. Using the Conformal Cubic Atmospheric Model (CCAM, McGregor and Dix, 2008), six of the Coupled Model Intercomparison Project (Meehl et al., 2007) simulations under two IPCC emission scenarios (A2 and B1) were dynamically downscaled to approximately 60 and 15 km resolution over Tasmania yielding sub-daily information for a large number of model variables over the late 20th and 21st Century. One project undertaken as part of the CFT project was an investigation of storm tide hazard. An analysis of extreme sea levels in tide gauge records around Tasmania revealed that for much of this coastline the extremes were highly correlated both with each other and with tide gauges on the southeastern mainland Australian coast suggesting that the method of McInnes et al., (2009) could be extended to Tasmania. A population of historical storm surge events was identified from tide gauge records over the late 20th century and simulated using a hydrodynamic model. Extreme value statistical analysis was applied to the model output to evaluate storm surge event probabilities and return periods for late 20th century conditions. Joint probability analysis was then used to combine the storm surge data with tide heights to obtain return periods for total sea levels. It was found that the highest storm surges occurred along the southeast coast of the state and the lowest occurred on the northern coast. However, the highest stormtides occurred on the northern coast owing to the large contribution of the astronomical tides.
The impact of climate change on the wind speeds in the CFT climate model simulations indicates a robust response of wind speed increase particularly on the east coast of Tasmania implying possible changes to storm surge heights in this area in the future. This paper will report on the characteristics of storm surges and tides around Tasmania and present results on the impact of climate change on storm surges by means of hydrodynamic model simulations that have been nested in the output of selected CFT model simulations.

- McGregor, J. L., and Dix, M. R., 2008: An updated description of the conformal-cubic atmospheric model. High Resolution Simulation of the Atmosphere and Ocean, Hamilton, K. and Ohfuchi, W., Eds., Springer, 51-76
- McInnes, K.L., Macadam, I., Hubbert, G.D. and O'Grady, J.G. 2009: A Modelling Approach for Estimating the Frequency of Sea Level Extremes and the Impact of Climate Change in Southeast Australia. Natural Hazards 51 115-137. DOI 10.1007/s11069-009-9383-2.
- Meehl, G.A., Covey, C.,Delworth, T., Latif, M. McAvaney, B., Mitchell, J.F.B. Stouffer, R.J. and Taylor, K.E., 2007: The WCRP CMIP3 Multimodel Dataset: A New Era in Climate Change Research Bull. Amer. Meteor. Soc., 88, 1383-1394.

DD1.1-06 OCEAN HEAT CONTENT RISE PAUSES: HOW UNUSUAL IS IT AND WHERE DOES THE HEAT GO?

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Timeseries of upper ocean heat content (recently revised after several instrumental biases were discovered) display not only a substantial mean rise over the second half of the twentieth century, but also a pause in this rise over the past few years when upper ocean heat content (OHC) remained nearly constant [e.g., Levitus et al 2009].
This observation has raised two important questions: (1) can such a fluctuation in OHC be attributed to natural variability, as has been suggested, and (2) if the excess heat in the climate system due to greenhouse forcing did not get absorbed (partly) by the upper ocean in those recent years, then where did it go? Considering the large difference in heat capacity between the ocean and the atmosphere it a redistribution of the heat between these two components of the climate system seems unlikely. Alternatively, it has been suggested that the observed slow-down of the upper ocean warming may be explained by an additional increase in the deep OHC and/or an additional loss of heat at the top of the atmosphere.
In this study, we analyze the variability of upper OHC and its causes from a 17-member ensemble of climate model simulations. According to the model, a period of five or more years during which upper OHC remains nearly constant is not unusual. For these cases without upper ocean warming, we construct a consistent heat budget of the various components of the climate system. We also address how subsampling in space and time affect the characteristics of OHC variability in the model ensemble as this is certainly an issue for the observational record.

DD1.1-07 HISTORY AND PERSPECTIVES OF STORM SURGE MANAGEMENT IN HAMBURG

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The history of storm surges in Hamburg since about 1750 is reviewed, and perspectives for future measures discussed.
Drivers as well as perspectives for the future are identified. For the time prior to 1850, coastal defence failure was a regular phenomenon; from about 1850-1960 coastal defence was hardly challenged, and after 1962 storm surge heights rose to levels never recorded before. The most likely causes for this change are modifications of the Elbe estuary, related to coastal defence and improving the shipping channel. Anthropogenic climate change may lead in the future to even higher storm surges (mainly because of increased sea level in the German Bight). While for the foreseeable future, conventional measures will be sufficient for ensuring coastal defence, an mitigation option of local mitigation of high water levels seems to be available. This may be achieved though the ‘tidal Elbe project’, which was designed to reduce upstream river sediment transport.

DD1.1-08 COASTAL INUNDATION LEVELS AND STORM SURGES AT THE COLOMBIAN CARIBBEAN COAST

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The reconstruction of coastal inundation level series is a complex problem which includes deterministic and stochastic variables. Coastal inundation level can be seen as the sum of mean sea level, astronomic tides, meteorological tides and wave run up. At Colombian Caribbean coast there are not previous studies about coastal inundation levels and storm surges in spite of their importance for coastal management, protection design and decision taking. In this study we reconstructed 28 year series of coastal inundation from the reconstruction and sum of each one of the series that compose it. Tide gauge records all over the Caribbean, their harmonic decomposition and a long wave model, the H2D forced with Reanalysis NCEP/NCAR wind fields, were used to reconstruct astronomical and meteorological series at six localities along Colombian shore. Waves at deep waters were obtained from the SWAN model and Run Up using an empirical equation that considers wave height only. Results indicate that there is a spatial variability along the shore, with higher inundation levels and more extreme events to the north eastern coast. The resulting series note hurricanes that have impacted the Colombian coast and the most important storm surges reported by the press. Storm surges occur mainly during the dry season, linked to strong winds. They only occur during the hurricane season (wet season) in specific cases. Advantages and limitations of the methodology are discussed.

PDD1.1-02 EXTREME STORMS AND COASTAL EVOLUTION UNDER ACCELERATED SEA-LEVEL RISE (ESCALATE)

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The aim of the ESCALATE project is to quantify future coastal change at mid-latitudes under global warming, with an emphasis on dune erosion. Climate change may influence surge levels and storm-wave characteristics and is expected to lead to accelerated sea-level rise (SLR). Our working hypothesis is that the future behaviour of mid-latitudinal coasts is determined primarily by changes in the storm climate, with associated changes in surge levels and wave characteristics and that, in contrast to common believe, SLR is a secondary climate driver only. Our study area is the North Sea area.
The wind patterns over the North Sea can change as a result of global climate change, in terms of a change in wind strength or wind direction. Both can influence the surge level and wave characteristics along North Sea coasts. It will be of particular interest to see whether thresholds in storm strength or frequency exist that result in sudden, irreversible changes in dune patterns, such as breaches. It is also interesting to see whether such thresholds, if they exist, are altered by SLR.
We will base our work on existing projections of the wind speed and direction. Here we will use the ESSENCE ensemble, a climate simulation with the ECHAM5 model with a relatively high spatial and temporal resolution and a

large number of ensemble members. Because of the latter, it is possible to investigate the change in events with high return periods, such as 10 - 100 year return water levels and wave heights. The ESSENCE ensemble covers 150 years (1950-2100). We will additionally consider the wind results of the upcoming EC-earth simulations for the next IPCC assessment report to examine model and scenario variability.
The wind predictions of the ESSENCE ensemble and the EC-earth high resolution simulations will be used to compute surge levels and wave characteristics using state-of-the-art surge and wave models operational at the KNMI. The results from the surge and wave models will then be the input for a recently developed physically based coastal storm-impact model.
At the conference we will present the ESCALATE project as well as the results of the wind analysis and the first results of the wave analysis. Preliminary analysis of the ESSENCE wind fields indicates a shift toward more south-westerly winds over the North Sea area, see abstract by Sterl. The effect of this change for wave characteristics will be discussed at the conference.

PDD1.1-01 AN ENSEMBLE STUDY OF EXTREME NORTH SEA STORM SURGES IN A CHANGING CLIMATE

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The height of storm surges is extremely important for a low-lying country like the Netherlands. By law, part of the coastal defence system has to withstand a water level that on average occurs only once every 10,000 years. The question then arises whether and how climate change affects the heights of extreme storm surges. Published research points to only small changes. However, due to the limited amount of data available results are usually limited to relatively frequent extremes like the annual 99%-ile. We here report on results from a 17-member ensemble of North Sea water levels spaning the period 1950--2100. It was created by forcing a surge model of the North Sea with meteorological output from a state-of-the-art global climate model which has been driven by greenhouse gas emissions following the SRES A1b scenario. The large ensemble size enables us to calculate 10,000 year return water levels with a low statistical uncertainty. In the one model used in this study, we find no statistically significant change in the 10,000 year return values of surge heights along the Dutch during the 21st century. Also a higher sea level resulting from global warming does not impact the height of the storm surges. As a side effect of our simulations we also obtain results on the interplay between surge and tide.

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Session DD 1.1: Sea level rise, surge and coastal processes (part 1) **POSTERS**

PDD1.1-03 THE GANGES-BRAHMAPUTRA DELTA IN A CHANGING CLIMATE

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The Ganges-Brahmaputra river delta is considered to be at substantial risk due to climate change related sea-level rise. We present a historical geophysical reconstruction of the Bengal delta since the end of the last ice age. The future dynamics of the delta are discussed based on varying fluvial sediment loads and subsidence rates. Different sea-level rise scenarios are incorporated in order to project future inundation scenarios.

PDD1.1-04 IMPACTS OF RISING MEAN SEA LEVEL ON GERMAN ESTUARIES

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Due to changing climatic conditions several parameters influencing hydrodynamics and transport characteristics at the German North Sea Coast are expected to change. Among these parameters mean sea level rise is supposed to have the strongest impacts at the coast and in the estuaries. Embedded in the two joint venture programmes called KLIWAS and KLIMZUG NORD these impacts are investigated at the German Federal Waterways Engineering and Research Institute.
In the presented study, a numerical model of the North Sea is run to evaluate the effects of rising mean sea level in the North Sea. Furthermore the North Sea model is used to generate boundary conditions for the numerical models of the Elbe, Weser and Ems Estuary which are run subsequently. Two situations are modelled and analysed: a situation representing actual conditions and a situation with an assumed mean sea level rise of +80 cm at the borders of the North Sea.
With rising mean sea level the results of the North Sea model display a shifting of the amphidromic points as well as an increase in tidal range at the coast and in the mouth of the estuaries. This illustrates the necessity to generate the boundary conditions for the estuarine models with the help of the North Sea model.
Although magnitudes are different, the results of the Elbe, Weser and Ems model show similar tendencies in all the three estuaries. Mean high water remains virtually unchanged whereas mean low water decreases in the upstream direction. This leads to an increase in tidal range and current velocities. Due to the less pronounced effect of bottom friction flood current velocities are enhanced to a greater extent than the ebb current velocities. This effect causes suspended sediments as well as water of higher salinity to be transported further upstream.
The results demonstrate that the estuaries are sensitive to changing mean sea level. In a next step measures to adapt to these possible changes have to be developed to ensure the sustainable use of the estuaries as waterways for shipping, for irrigation and tourism which, however, must go hand in hand with the estuaries' natural demands. These results are aimed at stakeholders involved in questions dealing with the current and future development of the German estuaries. They will give fundamental advice for the waterway and shipping administration acting in coastal region e.g. for future sediment management strategies. This work provides the physical elements for vulnerability studies and for the development of creative adaption strategies.

PDD1.1-05 SENSITIVITY STUDY OF THE STORM SURGE OF NOVEMBER 1ST 2006 IN THE EMS ESTUARY

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As climate will change in the next century and beyond, the German Ministry of Transport (BMVBS) is interested in the effect of climate change on waterways. In order to find a strategy for adaption to climate change it is important to understand todays situation and analyse the future situation under the influence of climate change. This concept will be presented by looking into a storm surge in the Ems estuary which hosts the waterway from the North Sea to Emden and Papenburg. This investigations are embedded in the scientific joint venture programme KLIWAS.
On November 1st, 2006 a severe north - westerly storm caused extreme high water levels in the German Bight and in the mouth of the Ems. In parts of the Ems estuary during this 5th Allerheiligenflut the highest water levels since 1906 were observed. As a consequence, the storm surge barrier Ems near Gandersum was closed for the first time during a high storm surge.
A hydrodynamical numerical model of the Ems estuary (UnTRIM, V. Casulli and P. Zanolli (1998)) is used to simulate the 5th Allerheiligenflut. A good correlation between measured and modelled water levels can be found. The influences of the closed Ems barrier on the water levels along the estuary have been analysed. The results of this analysis can be used to understand the effects during a storm surge.
The development and intensity of a storm surge in the Ems estuary is determined by the water level at the boundary to the North Sea, the river run off into the estuary and the wind field over the estuary. Based on a sensitivity study the influence of
- sea level changes in the North Sea,
- increase / decrease of river run off into the estuary,
- increase / decrease of the local wind over the estuary and
- operation of the storm surge barrier

on the highest water level along the Ems estuary during storm surge was analysed. The parameters mentioned are varied according to the knowledge about expected changes in a future climate.
The aim of this investigation is to get a better understanding of the probable changes of water levels during storm surges along the Ems estuary depending on parameters that might change in a future climate. The results will help to identify vulnerabilities of e.g. the shore protection of the Ems estuary and give us a chance to work on adaption and mitigation of problems caused by a possible climate change.

PDD1.1-06 NATURAL CALAMITIES OR A FAIL OF SOCIETY: STORM SURGES THROUGH TIME AND SPACE

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The existence of short term sea level fluctuations caused by climate change has been a subject for discussion for several decades. In particular, the discussion whether the late medieval transgression period in the Low Countries did occur, was very agitated. First of all, the question arose whether we can talk about trans- and regressions during the last two millennia and more specifically in the late middle ages. In literature, there can be found that for almost a whole century, scientists believed that several short term sea level fluctuations had occurred, caused by climate changes. Sedimental sequences of silt and peat and the increased storm surge frequency 'proved' this supposition. However in the seventies of the last century, several scientists doubted the direct relationship between an increasing storm surge frequency and a transgression period. The point is that 'transgression' is defined as 'a period characterized by widely occurring sea-invasions and the coverage of continental sediment layers by marine sediments over vast areas' (Edelman in Gottschalk, 1980). The first constraint is fulfilled for the late middle ages in the Low Countries, but the second constraint is more doubtful because it is proven that a complete inundation of the coast in the Netherlands and Flanders was very rare.
So a new direction of thoughts arose; historical storm surges should be seen as individual events which are not caused by climate change, but occur by accident. Gottschalk (1997) even put it this way: "We have tried to find parallels between the movements of the glaciers and the storm surges, river floods and severe winters, but there is very little that can be directly correlated."
The increased storm surge frequency in the late middle ages is therefore caused by something else. There can be suggested that the storm surge events have been reported more frequently and thoroughly due to the invention of typography. However, the explaining power of this must be nuanced because of the significant drop of storm surges in the seventeenth century.
So the question still remains: what caused the increase in storm surges in the late middle ages in the Low Countries? After research, it can be concluded that human activities, such as land exploitation (peat) and embankments by water boards are the main reasons. Peat exploitation and drainage caused massive lowering of the surface behind the dikes. The non-democratic system of water boards, where the landowners did not give any notice to the grieves of the local peasant community and neglected the maintenance of the coastal protection structures, was also a main factor in the increase of storm surges. Even wars and specific local circumstances had their influence.
The theorem of a higher number of storm surges caused by human activities has several other examples which differ in time and space. By studying literature, the comparison can be made and proven right with the major floods in the sixteenth century of the Po (Italy) and the storm surge, caused by hurricane Katrina in 2005 (New Orleans).

PDD1.1-07 A NEW INFERENCE OF GLOBAL SEA LEVE RISE FROM TIDE GAUGE OBSERVATIONS

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Tide gauges provide a decade to secular record of the elevation of the free surface of the oceans, approximately corresponding to the geoid, relative to the solid surface of the Earth. Sea level variations, defined by the offset between these surfaces, are evolving according to a wide spectrum of spatio-temporal scales. Among the long-term mechanisms of sea level change, the Glacial Isostatic Adjustment (GIA) driven by the melting of the late-Pleistocene ice sheets is a dominating component on global scale. GIA effects need to be removed from the tide gauges trends in order to estimate the secular sea level variation driven by climate change. In this work we perform an analysis, in the spectral domain, of the secular sea level change measured by the tide gauges belonging to the Permanent Service for the Mean Sea Level (PSMSL). By performing a real spherical harmonic expansion of the rates derived by the longest time-series we compare degree-by-degree the observed fields with the GIA predictions based on a suite of available

late Pleistocene ice models and Earth rheological models. After removing the GIA signal from the observed rates we perform a second expansion and compare the results with the modelled gravitationally self-consistent sea level change expected from the current melting of land-based ice masses. Because of the gravitational interaction between ice masses, oceans and the deformable Earth, the current melting of glaciers results in a complex spatial pattern of sea level change. A correlation analysis between the two fields is performed with the purpose of detecting the sea level fingerprints cause by the modern melting.

PDD1.1-08 LOCAL GEOMORPHOLOGY AS A DETERMINING CONTROL OF COASTAL CLIMATE-CHANGE IMPACTS

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Regardless of uniformity of climate-change effects at a regional scale, local controls may amplify uncertainties in the magnitude of expected coastal impacts such as shoreline retreat and increased storm erosion. The potential for variability in regional impacts due to the influence of local geomorphology on responses to climate-change effects was explored in numerical experiments involving manipulation of the volume and distribution of sediment accommodation and supply. These experiments compared forecast shoreline retreat between two ostensibly similar ocean facing coastal barrier beaches, fronting separate estuarine lagoons (Lake Macquarie and Tuggerah Lake) that are located in close proximity (13 km alongshore) on the southeast Australian coast. Both sites may be likened in terms of morphology and energy regime to a distal wave-dominated delta setting. Shoreline retreat at each site was modelled using an alongshore-averaged morphokinematic profile model - the Shoreface Translation Model (Cowell et al., 1995; Cowell et al., 2006). Uncertainties in the magnitude of climate-change effects were addressed within the model using the inbuilt stochastic input-sampling functionality, in which environmental forcing variables and parameters specifying profile geometry are selected at random from user-defined distributions. Repeated trials (n = 2000) of the model thereby yielded probability distributions of shoreline retreat that are presented here in terms of risk. Despite the close proximity of the two sites, similar geomorphology and exposure to the predominant energy climate, and uniform climate-change forcing, model forecasts indicate that by 2100 in the absence of mitigation measures, forecast recession of one beach is a factor 1.5 times greater than for the other, at the 50% risk of exceedance level, although the difference reduces to factor 1.3 at the 0.01% risk level (cf Lake Macquarie and Tuggerah Lake beaches respectively in Table 1) To isolate the relative contribution of various geomorphologic features to the disparity in shoreline retreat between sites, the experiments were repeated with parts of the surveyed geomorphology of the Tuggerah Lake barrier substituted with corresponding features from the Lake Macquarie barrier. More specifically, differences in dune volume, flood-tide delta demand, submerged reef structures, shoreface lithology and shoreface bathymetry were considered in individual experiments. The findings indicate that shoreline retreat is most sensitive to effects on sand accommodation due to variations in shoreface bathymetry between sites. Bathymetric differences accounted for approximately two-thirds of differences in forecast shoreline retreat between sites, an effect almost three times greater than that attributed to differences in dune volume (values in parentheses in Table 1). In this example the impacts of regionally-uniform climate-change effects are moderated at Tuggerah Lake by both a reduced accommodation under rising sea level conditions over the local bathymetry (a comparatively narrow and rock truncated inner-shelf) and the greater sand-volume reservoir conferred by a larger dune system. These findings demonstrate that site-specific geomorphology must be taken into account when planning for climate change impacts in the coastal zone regardless of regional-scale deviations in climate-change forcing.

For illustrations see website: www.climatedeltaconference.org/results

Deltas in Depth Theme 1: Regional climate, sea level rise, storm surges, river run-off and coastal flooding
Session DD 1.1: Sea level rise, surge and coastal processes (part 1) **POSTERS**

PDD1.1-10 THE EFFECT OF THE 18.6 YEAR NODAL CYCLE ON REGIONAL SEA LEVEL RISE ESTIMATES

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For protection of the Dutch coast the expected relative sea level rise is an important factor. There have been several reports projecting an accelerated sea level rise based on data from tidal stations.
In this study we try to determine if sea level acceleration is still present after including the effect of the nodal cycle at the Dutch coast. We also examine the global variation of the effect of the the lunar nodal cycle on relative sea level rise.
Data from the 6 main tidal stations in the Netherlands show that the relative sea level in the Netherlands has been rising at a rate of 0.19 cm/year since 1890. In the period 1996-2005 the rise accelerated to 0.28 cm/year. In this presentation we show that this period coincides with the phase of the 18.6 year nodal cycle. This cycle not only affects the tidal amplitude but also the regional estimates of relative mean sea level. After taking into account the nodal cycle no significant increase of sea level rise above the 0.19cm/year is found.
To see if this effect is also present in other tidal stations around the world, we analyzed the time series of the Permanent Service for Mean Sea Level. From the 1100 stations 511 stations with information on at least 57 years were selected. These stations were used to examine the global variation in phase and amplitude of the nodal cycle. Of these 511 stations 187 showed a significant effect of the nodal cycle (phase and or amplitude). These 187 stations are mainly located in the northern hemisphere and show a phase distribution where the eastern part of the Atlantic and Pacific Ocean are in anti phase with the western part.
We conclude that, for the Dutch coast, there is no significant acceleration of relative sea level rise apart from the nodal cycle.
We also conclude that, when making regional sea level rise projections, the nodal cycle is an essential factor to take into account.

PDD1.1-12 RELATIVE SEA LEVEL VARIABILITY WITHIN MISSISSIPPI RIVER DELTA

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The U.S. National Oceanic and Atmospheric Administration (NOAA) and its predecessor organization have been measuring water levels and tides since the mid-19th century. Originally in support of charting and marine boundary delineation, long-term data sets, like those recorded since 1947 at Grand Isle, Louisiana, now quantify SL variability that directly affects an extremely vulnerable region of the Mississippi River Delta. Observations from the NOAA Station Grand Isle 1) capture event-driven storm tides such as Hurricane Katrina in 2005 and determine the reoccurrence frequencies. 2) The observations define a 0.3-m mean seasonal cycle highest coincident to hurricane season that results from fluctuations in the regional atmospheric pressure and wind fields, coastal currents, and water densities. 3) The observations isolate the frequency and magnitude of SL variations and anomalies driven by irregular ocean-

atmosphere interactions forcing SL above/below seasonal predictions. 4) The observations track a 9.24 ± 0.59 mm/yr long-term relative SL trend, which includes local vertical land motion from subsidence and sediment compaction over the Mississippi river delta.
The backbone of each NOAA station is a network of benchmarks that monitor the vertical stability of the observation platform and provide user access to the vertical tidal datums. The centimeter-level accuracy of the SL measurements transferred onto the benchmarks via geodetic surveys facilitates a highly detailed local vertical reference frame.
A localized informational picture of future inundation related to SL variability can be construed within the national geospatial reference system with the addition of hierarchal levels of increasingly accurate topographic data such as that (~29 cm, 95% confidence level) obtained when using Light Detection and Ranging (LIDAR). In the face of climate change, deciphering and presenting data concerning local SL variability is imperative for adaptation strategies such as coastal restoration initiatives, emergency preparedness, habitat management and planning of coastal infrastructure.

PDD1.1-14 THE INFLUENCE OF VERTICAL MOVEMENTS OF THE EARTH SURFACE ON LONGTERM WATERLEVEL VARIATIONS

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The variation of the mean sea level (MSL) is considered by many scientific institutions to be an indicator of global climate change. Particularly, rising water levels are interpreted as a consequence of global warming. The acceptance of long-term water-level time series as indicators of climate change presupposes that the elevations of the water-level gauges remain constant, or otherwise are known, throughout the observation period. Tectonic processes and anthropogenic activities (e.g. mining) may cause vertical movements of the earth surface, and the water-level gauges that are fixed thereto follow these movements. Frequently, true variations of the water level and vertical movements (reaching several mm per year) superimpose. Unnoticed or ignored vertical self-movements of the gauges may be mistaken for variations of the water level, while real fluctuations of the water level due to hydrologic or climate-related causes remain unidentified.
For several years now, the use of the Global Navigation Satellite System (GNSS) in combination with permanently installed GNSS-sensors has made it possible to monitor elevation changes at the gauging stations. The heights of the gauge datum are now determined directly, so that the water levels are free from the influence of recent vertical movements of the earth surface. In May 2008, the BfG began to equip important tide gauges in the German Bight in the North Sea and in the River Ems with permanent GNSS-sensors. The GNSS-sensors are directly installed at the gauges. At present 18 (BfG-)GNSS-tide gauge stations are running. The acquired data together with observations of comparable German and European GNSS gauging stations on the coasts of the North Sea and the Baltic Sea are administered and processed by the BfG in cooperation with the German Geodetic Research Institute (DGFI). The results are related to a global reference frame (IGS 05) to make world-wide comparison of water levels possible.
This paper presents the analysis of the influence of vertical movements on water levels and the possibility to distinguish between the signals of recent vertical movements and long-term water-variations with examples of important German tide gauge stations. Furthermore, the results of the analysis of the permanent GNSS time series are shown and interpreted.

PDD1.1-15 SEA LEVEL CHANGE IN THE RIVER DELTA AREAS OF THE GULF OF THAILAND

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Sea level rise and other factors such as land subsidence, clearance of mangrove forest and land use changes in coastal areas, have been designated as possible causes for the accumulated erosion of the coastal area of Greater Bangkok. The determination of local sea level change in the Gulf of Thailand is hampered by the vertical motion and deformation of the land caused by pre-, co- and post-seismic activity. Because tide gauges are tied to the land, vertical land motion corrupt traditional tide gauge observations. This makes it difficult to discern the actual rate/magnitude of absolute sea level change. In frame of the Thailand-EC Co-Operation Facility GEO2TECDI project and legacy of the EC-AUNP SEAMERGES project, we investigate the vertical land motion in Thailand and sea level change in the Gulf of Thailand. An important focus in this study is on Bangkok which faces a number of problems; 1) it is situated in a river delta and the height is close to sea level, 2) the land is subsiding due to ground water extraction, 3) though Thailand itself is not really seismic active it is close enough to Indonesia to experience the co-seismic and post-seismic tectonic (vertical land) motion, and 4) due to increasing global climate change the absolute sea level is rising. This poses a serious threat to all dimensions of Thai society and economy. Before hazard and damage mitigation methods can be devised all these effects have to be charted, separated, qualified and quantified. For this we employed three independent space geodetic techniques, viz. Global Navigation Satellite System (GNSS), Interferometric Synthetic Aperture Radar (InSAR) and Satellite Altimetry (SALT) and combine the results with in situ observations from tide gauge and levelling. Adding GPS based vertical land motion to the tide gauge sea level registration reveals the absolute sea level change at a number of tide gauge stations surrounding the Gulf of Thailand, which is conclusively confirmed by satellite altimetry. In the Gulf of Thailand we find an average absolute rise of approximately 3.5 mm/yr ± 0.7, but near the estuaries of the Chao Praya River (Bangkok), the Kah Bpow River (Koh Kong) and the Mekong delta (Ho Chi Min City), this mounts to 4 to 5 mm/yr, a definitely faster pace than the acknowledged global average value of 2 to 3. The situation worsens when taking into account the tectonic subsidence that resulted from the 2004 9.2 Mw Sumatra/Andaman earthquake; From 2005 onwards we find negative uplift in the order of 10 mm/yr resulting in relative sea level rise of 10+ mm/yr over the last 5 years. This subsidence will relax after decades but poses a more serious threat to Bangkok and other larger urban areas near the coast than anticipated. For each delta, there is a need to re-evaluate the currently accepted scenario of coastal-sea interaction and also a reconsideration of flood protection measures.

PDD1.1-16 CHANGES IN LAND AND SEA LEVELS ALONG THE THAMES ESTUARY AND RIVER THAMES, UK

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Information on changes in land and sea level is vital to long term flood risk management (both operationally and strategically).
The 'Absolute fixing of tide gauge benchmarks and land levels: Measuring changes in land and sea levels around the coast of Great Britain and along the Thames Estuary and River Thames' project was carried out as part of the joint UK Department of Environment, Food and Rural Affairs / UK Environment Agency flood and coastal erosion risk management R&D programme and the UK Environment Agency Thames Estuary 2100 studies.
The project involved the combination of Persistent Scatterer Interferometry (PSI), GPS, absolute gravimetry, tide gauges and geoscience datasets in order to assess the combined impact of sea level rise and ground stability on flood risk.
The project concluded that the combined effect of changes in land and sea levels is a 1.8 to 3.3mm/yr rise in sea level with respect to the land along the River Thames and Thames Estuary over the past few decades.
This poster focuses upon the PSI analysis, and the subsequent integration and cross-comparison work, in particularly the geological interpretations of the measured ground deformation.

PDD1.1-17 THE SEA LEVEL FINGERPRINT OF 21ST CENTURY ICE MASS LOSS

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The sea level contribution from glacial sources has been accelerating during the 21st Century. This contribution is not distributed uniformly across the world's oceans due to both oceanographic and gravitational effects. We compute the sea level signature of 21st Century ice mass ï¬‚uxes due to changes in the gravity field and Earth's rotation. Mass loss from Greenland results in a relative sea level (RSL) reduction for much of North Western Europe and Eastern Canada. RSL rise from this source is concentrated around South America. Losses in West Antarctica marginally compensate for this and produce maxima along the coastlines of North America, Australia and Oceania. The combined far-field pattern of wastage from all ice melt sources, is dominated by losses from the ice sheets and results in maxima at latitudes between ±40° across the Pacific and Indian Oceans, affecting particularly vulnerable land masses in Oceania. The spatial pattern of RSL variations due to the observed ice mass loss is temporally invariant. Thus, sea level rise from the present-day distribution of ice loss will be amplified for this sensitive region.

Deltas in Depth Theme 1: Regional climate, sea level rise, storm surges, river run-off and coastal flooding
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PDD1.1-18 TRANSLATING LAND BASED WIND OBSERVATIONS TO LARGE WATER AREAS

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The design of coastal defense systems is often based on storm surge and wave strength with long return periods (for example 10,000 years). Storm surge and wave strength are determined by the occurring wind fields. Therefore knowledge of the occurrence of high wind speeds over sea and large water areas is required.
The use of atmospheric models or reanalysis data for extreme wind analysis is often hindered by the limited availability of measurements at large water areas. The measurement networks over sea are often sparse, and remote sensing techniques are missing long, consistent time series. Verification of model results often reveals discrepancies between modelled wind fields and observations.
Wind speed measurements above land consist of longer time series in a more densely spaced network. However, when translating long observational series from land stations to representative series for wind over sea, the variability in surface roughness should be taken into account.
To extrapolate wind speed measurements over land to open water areas, a conceptual physical boundary layer model can be used. By applying gustiness analysis at measurements, the local surface roughness at the station locations can be derived. By using surface drag derived from land use information and a digital elevation model, the wind speed can be vertically extrapolated to the top of the atmospheric boundary layer. After extrapolating this wind field to large water areas, the near surface wind speed over water can be calculated by using the typical surface roughness for water.
As an example, the model will be applied to wind speed measurements from the Netherlands. For the Netherlands, knowledge about the occurrence of storm surges is an important factor when protecting the areas below sea level. The model is used to derive wind speeds with long return periods at sea and near the coast, based on the measurement network over land.
It was found that differences in roughness between land and sea cannot fully explain variances in measured wind speed. We show that differences in atmospheric stability over land and over sea might be an important factor, even at high wind speeds. In the end, this appears to be an important source of uncertainty when designing coastal defense systems. It is also shown that gustiness analysis on the Dutch data revealed that over land, the surface roughness has gradually increased over the last decades, resulting in lower average and peak wind speeds in land based observations.

PDD1.1-19 WIND CLIMATE AND DYNAMICS OF CAY BEACH IN SERIBU ISLANDS, JAKARTA BAY, INDONESIA

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Seribu Islands off Jakarta, south-west of Java Sea are complexes of patch reefs constructed by coral platforms. Coral islands (cays) exist on top of several of them. They are accumulation of sediments originated from eroded corals having several decimetres in heights and few of hectares in areas. Due to plausible global warming, erosion is expected to exacerbate and threatening cay beach zones, as sea level rise facilitates wave to expand to higher

elevation landward. Cay beaches are covered by sands and their extents are dynamic. This is due to alternating monsoonal wind-induced waves that produce subsequent shifts of sands on coral cay by surf action along the primary axes of bi-directional monsoonal winds, oriented north-west (NW) and south-west (SW). These cause variability of shoreline positions on cays. Recent setting on wind climate and the scale of erosion in Seribu Islands are least known. This paper is aiming at understanding the pattern of long-term wind magnitudes and directions that explains the shifting of cays' shorelines.
The research is based on study of historical wind record, interpretation of multi-temporal remote sensing images and field survey. The study is focused on uninhabited Semak Daun cay. Six-hourly basis of assimilation wind data of the period 1948 to 2009 from NOAA National Centres of Environmental Prediction is analysed. The analyses include characterization of mean monthly, mean annual, mean decadal and mean bi-decadal of wind vectors. Statistical analyses of linear trends and spectral analyses of time-series of wind vectors are also carried out. Remote sensing images are used to detect shift of extent of cay beach sands. SPOT5 image from 2003, aerial photo mosaic from 2005 and IKONOS image from 2008 are available. Field surveys collect spatial distribution of sediment grain sizes according to grab samplings and evidence of erosion or accretion according to visual inspections.
During the last 62 years, regional monthly winds vectors show evidence of consistent directional pattern. Deviation of monthly mean wind direction throughout the investigation period ranges between 12 and 18 degrees (Table 1). Spectral transformation of time series wind data shows strong three-monthly cycle correlated with monsoonal variations and the transitions. Field surveys in July and November 2008 confirmed evidence of shift of cay beach sands. Pebbles observed in July 2008 in the south-west corner of the cay were covered entirely by sand in November 2008. Linear trends of regression line of mean monthly wind magnitudes are given in Table 2. Evidence of reduction of magnitude of NW monsoon wind by roughly 1m/s is obtained. Increase of magnitude of SW monsoon wind by approximately 0.5m/s is observed. This is thought to result in changes of equilibrium pattern of seasonal wind-induced wave, as with respect to NW wind, SW wind is getting relatively stronger. Results from interpretation of remote sensing imagery confirm extension of beach sand spit westward and development of elevated deposit of sandy shoals around 100m west of the cay. These are believed to correspond with the strengthening of SW wind.

For illustrations see website: www.climatedeltaconference.org/results

PDD1.1-20 SEA-LEVEL RISE - A HAZARD IN A WARMER CLIMATE

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We have looked at the model runs from the Intergovernmental Panel on Climate Change (IPCC) multi-model ensemble (MME) that project an end-of-century global average temperature rise above 4ºC, compared to pre-industrial temperatures, when forced by emissions scenarios A1B and A2 of the IPCC Special Report on Emissions Scenarios (SRES). For this subset of simulations we analyse the corresponding projections for thermal expansion of the oceans and consider changes in mass balance of glaciers and ice sheets. Our analysis includes information on the spatial pattern of sea level rise, and vertical land movement. Understanding the impacts of warmer projections is important because it gives us an opportunity to better understand the different possible degrees of adaptation. Our results are mapped on an interactive web-based GIS tool that enables decision and policy makers easier access to global coastal regions that are likely to be at an increased risk from flooding and erosion due to sea-level rises in a warmer planet. The work further enables users to assess sea-level rise as a hazard in a warmer world, between now and the end of the century, at continental, country, regional and local levels. We will demonstrate case studies of areas identified by our work where sea-level rise is likely to be a significant hazard in a warmer world.

DD1.2-01 CLIMATE CHANGE AND TIDAL IMPACTS ON FLOODS IN THE MEKONG DELTA

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The Mekong Delta is considered one of the biggest estuaries on earth and is annually flooded to a large extent. The chief long-familiar water source causing the inundation originates in the monsoonal rainfalls over large parts of South-East-Asia, mainly Cambodia, Eastern Thailand, and Laos. Besides, two tides with different modes from the East Sea and Gulf of Thailand propagating upstream through the river mouths are also an important factor on floods in the Delta. The tides can possibly change the shape of the flood due to the extremely low topography in this region. General knowledge has shown us that tides in the wet season can be seen even somewhere in vicinity of Tan Chau, An Giang, Vietnam which is about 200km far from the coast. Flood and tide both can cause inundation. Inundations in the low lying deltas as the Mekong delta are typically not a menace to the livelihoods of the inhabitants. However, extreme events composed by extreme floods at high tides could pose substantial risks to the dwellers. These extreme events are likely to occur more frequent in future as a consequence of climate change, as well as the flood intensity is affected both by changing flood discharges and rising sea water levels. The study investigates this interplay by using an available quasi-2D hydrodynamic model for the whole Mekong in order to assess the influence of the tides on the flood processed base. The model is driven by both historical and synthetic flood hydrographs considering climate change impacts as upstream boundary and sea level rise combined with tidal parameters analyzed from different tide modes as downstream boundary. The combination of these approaches lead to an estimate of likely future flood hazards in the Mekong Delta.

DD1.2-02 IMPACT OF CLIMATE CHANGE IN THE COASTAL AREA OF BANGLADESH

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Bangladesh is a low-lying deltaic country in South Asia formed by the Ganges (Padma), the Brahmaputra (Jamuna) and the Meghna (GBM) rivers and their respective tributaries. The country is extremely vulnerable to climate change because of its geophysical settings. Its flat deltaic topography with very low elevation makes it more vulnerable to climate change. Climate change is a global problem. Bangladesh is experiencing climate related hazards like floods, cyclone, storm-surge, tidal bore, river bank erosion, salinity intrusion and drought etc, which are being aggravating following climate change. Currently climate change poses a new threat to life and livelihood of the people of Bangladesh. Climate change is recognized as a key sustainable development issue for Bangladesh (World Bank, 2000). These risks will be additional to the challenges the country already faces.
The coastal zone of Bangladesh is low-lying with 62% of the land have an elevation of up to 3 metres. About 28% of the population live in the coastal zone where polders have been constructed for them. Climate change induced sea level rise poses new threat to the livelihood of the coastal community. This paper presents the impact of climate change specially sea level rise on coastal flooding and salinity intrusion. The coastal area of Bangladesh is endowed with seasonal fresh water and brackish water resources. Saline water intrusion is highly seasonal due to reduced low flow in the dry season.

Sea level rise would increase the extent of saline intrusion by pushing the saline waterfront landwards. The combination of sea level rise and low upland flow will change the present spatial and temporal variation of salinity, which eventually would cause damage to agriculture, fisheries and total echo-system of the coastal area. It has been seen that due to 88cm Sea Level Rise (SLR) increase of inundation (>30cm) area is about 14% in the coastal area compared to present condition for an average monsoon flow. Any rise of sea level will propagate into the river system. High tide level on the Shahbazpur channel (estuary) is increased by 30cm and 80 cm for SLR of 32 cm and 88cm respectively. Drainage congestion may become more severe threat than higher flood risk due to rise of water level in the outfall channel. It has been found that due to sea level rise the deterioration of drainage condition is extensive in the coastal polders (embanked low-lying area) where the current performance is satisfactory. For an example; drainage congestion area for 3days duration and more than 30cm depth in the polder no 37 is increased from 0.0ha to 10,000ha with the SLR of 88cm. Adaptation to reduce the risk of drainage congestion is to increase the embankment level and improve the internal drainage system through revisiting the planning and design of the coastal polders of Bangladesh.

DD1.2-03 CLIMATE-CHANGE VERSUS ANTHROPOGENIC EFFECTS ON UNCERTAINTY: TIBER DELTA EROSION

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A detailed record of response to sea-level rise during the postglacial marine transgression exists for the Tiber Delta on the coast of Rome, thanks to several decades of intensive geological field studies. The response is characterised by the balance between the local wave regime and the alongshore dispersal of a time-averaged fluvial sand supply of about 10.6 x 109 kg yr-1. This supply increasingly offset effects of a decelerating rate of sea-level rise until the delta shoreline switched from transgression to progradation at least 2,400 years ago.
In principle, present and future climate-change effects should eventually reverse this switch back to delta transgression, and the geological record should provide good evidence of what to expect. Unfortunately, several direct anthropogenic effects limit this possibility. Like many other deltas worldwide, sand supply from the Tiber has been reduced by at least half due to construction of water-storage reservoirs throughout the drainage basin in the 20th century. The result has been landward retreat of the Delta in the region proximal to the river mouth during the late 20th century. This retreat constitutes classical shoreline adjustment by which the deltaic protrusion has progressively diminished in compensation for the reduced fluvial supply. The adjustment is ongoing and tends towards a new balance between fluvial sediment supply and wave regime, but is ameliorated by artificial beach nourishment and installation of erosion-control structures over recent decades.
Comparative stochastic simulations of the geological evolution of the delta, historical coastal change, and forecast future coastal responses, show that the anthropogenic interventions can be expected to dominate over climate-change effects for many decades to come. Uncertainty surrounding whether existing interventions will be maintained or extended has greater influence on forecast responses than uncertainties associated with physical processes or even climate-change itself. For example, results indicate efforts to mitigate the effects of reduced fluvial sand supply have involved historical rates of beach nourishment up to eight times greater than additional nourishment required to sustain the Delta shoreline against effects of accelerating sea-level rise over the next few decades. Similarly, simulations show that the presence of the offshore breakwaters causes greater profile recession distances than would occur in a natural system, whilst masking this effect at the shoreline. The effect becomes more prominent with greater sea level rise and is accompanied by up to several metres of deepening on the seaward side of the breakwaters.

Uncertainty about the maintenance, failure or upgrade of existing offshore breakwaters introduce uncertainties of similar magnitude to the combined uncertainties about physical processes, such as the extent to which the shoreface, dunes and reactivated lagoon will accommodate sand displaced from beach due to sea-level rise.

DD1.2-04 CLIMATE CHANGE IMPACT ON DANISH COASTAL AND MARINE INFRASTRUCTURES

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Ports and other vital marine facilities are infrastructure that will be affected by climate change and sea-level rise. Higher sea level and storminess will decrease the effectiveness of breakwaters against wave forces, and wharves may have to be raised to avoid inundation. When such effects are anticipated, countermeasures can be implemented to maintain function and stability. Cases presented will illustrate a methodology to assess the possible structural impacts of climate change for selected harbour and coastal areas in Danish waters, focusing on sea level rise, storm surge and wave climates.
Using the IPCC SRES climate scenario A1B wind and pressure fields were used as forcing data to simulate the historic and future hydrodynamic conditions and wave climate in the North Sea, inner Danish waters and the Baltic Sea area. This was done by using DHI's 2D hydrodynamic flexible mesh flow model (MIKE21 FM) and spectral wave model (MIKE21 SW). The hydrodynamic model where run for the years 1951 to 2099 and the spectral wave model for the periods 1961-1990 and 2070-2099. The effect of a global sea level rise is included in both models and the effect of variable water level is also included in the wave model. The forcing data used is an outcome of the EU financed project ENSEMBLES and where data is available for the period 1951-2099. The forcing data is generated by the HIRHAM climate model operated by DMI (Danish Meteorological Institute). The model results are compared relatively for the periods 1961-1990 and 2070-2099 for the whole model domain. E.g. for the significant wave height some areas are subjected to higher extreme waves compared to other areas, this will be presented. The combined effect of the rising water level and intensifies storms resulting in higher waves will influence the safety of existing breakwaters. Examples are given for selected Danish harbours where design conditions were found to be changed, in terms of armor stone and crest height. The consequences of a changing wave climate and water level on barrier breaching and inland flooding was also illustrated by examples. A simple dune erosion model was forced by conditions corresponding to extreme storms under present and future conditions. Considering a dune profile from the Danish North Sea coast it was found that an increase in the water level was more significant for the dune erosion than an increase in the wave intensity. Different ways of reinforcing a dune was investigated. It was found to be more advantageous to add sand to the dune at the back of the dune crest rather than at the dune front. Flooding of the area behind the dune line was simulated by a hydrodynamic model, showing the sensitivity to the water level and the duration of the flooding event. It was found that a dynamic simulation gave quite different results from a simple analysis based solely on contour lines in the landscape.

DD1.2-05 ASSESSING INSTABILITY OF RIVER BIFURCATIONS AND FLOOD RISK DIVISION OVER DELTAS

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Bifurcations in river deltas distribute water, sediment and flooding risk over two downstream branches. Past modelling, experimentation and reconstruction of the past has demonstrated that bifurcations are not stable. To assess the risk of destabilisation the morphodynamic evolution on a time scale of decades must be predicted, as channel erosion or sedimentation determines flood conveyance flooding risk. However, the factors that determine stability are poorly understood. The objective is to identify these factors.
The methodology was to model bifurcation evolution for two historical catastrophes: the destabilising bifurcations of the river Rhine (Waal and Nederrijn) at Lobith around 1700 AD and the formation of the bifurcation of the Merwede (Beneden Merwede and Biesbosch) after the St Elisabeth floodings in 1421. Understanding the Rhine bifurcations is essential for future management of the present Rhine bifurcations. Understanding the Biesbosch inland delta formation is essential for plans to create river diversions in large river deltas to mitigate coastal inundation risk. Geological data and historical maps were combined with physics-based numerical models. Two models were used: a three-dimensional commercial morphodynamics model to address the detailed morphodynamics and a one-dimensional research model to address evolution of deltaic networks of channels.
Modelled river bifurcations are in principle unstable in agreement with historical data of the Rhine bifurcation and geological data on former Rhine courses through the Dutch deltaic plain. The shorter branch may grow at the cost of the longer branch, but this gradient advantage may be opposed by meander bends at the bifurcation. The bifurcation may be stabilised by combined bank protection and presence of very coarse immobile sediment in the bed of the enlarging branch. Mobilisation of this sediment during extreme floods or modification of the flow division potentially unbalances the bifurcation which would greatly increase flooding risks in one of the bifurcates. This suggests that future modifications of the discharge division should decrease extreme flood discharge through bifurcate with the coarsest sediment to reduce entrainment.
The catastrophic diversion of the river Merwede into medieval reclaimed land was caused by peat mining, compaction and poor dike maintenance due to civil war and increasing bureaucracy. Two storm surges and two river floods within three years forged a new connection between the river and an estuary which rapidly increased in sized due to tides. The river Merwede diverted its entire bed sediment load into the area, forming a deltaic splay of about 10 km radius in two centuries. Meanwhile the formed course of the river silted up as well. The deltaic splay protected the land against new inundation from the sea. However, it also reduced flood conveyance, which raised water levels upstream over tens of kilometers, causing many dike breaches and floodings in two centuries following the catastrophe. The upstream Rhine bifurcation was not affected. This suggests that river diversions aimed at reducing inundation risk should account for unstable bifurcations, long periods of formation and, concurrently, raised water levels during floods over large upstream distance.

DD1.3-02 CLIMATE EXTREME AND FLOOD OCCURRENCE IN COASTAL ENVIRONMENT OF NIGERIA

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This paper aims at examining the occurrence of flooding in relation to climate extremes in Nigeria. There are indications that climate change has impact on human activities on earth. Several evidence abound which show that adverse events such as flooding can result from global climate change. Other examples of such adversities include: increase in temperature; increase in sea level; low yield of agricultural products among others. Several studies have been done on climate change adverse effects, especially its impact on socio-economic activities of man. Thus, this study used geospatial technique to assess the climate change-related flooding occurrence in the coastal environment of Nigeria. Lagos is used as a case study for this research work. Periodic data on flooding occurrence was collected from National Emergency Agency, Abuja (NEMA) in Nigeria. This data was correlated with climate parameters using geo-statistical and geospatial interpolation methods. The results showed that climate change or extreme climate events influence the occurrence of flood in the area. It is evident from the results that there were significant relationship between the rainfall and the occurrence of flood in the area. Aside from the fact that the area is a coastal environment, the area is also known to be prone to regular flooding incidence. Thousands of lives and properties have been lost as a result of this extreme climate event. There is no doubt that government, environmental agencies and non-governmental organizations will find the outcome of the research useful for proper planning and adequate decision-making.

DD1.3-03 RIVER MOUTH DROWNING UNDER RAPID SEA LEVEL RISE: RHINE DELTA GEOLOGICAL LESSONS

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The subsurface of Rotterdam - this venue's host city - has a geology controlled by sea level rise, climate change and land use change. Knowledge of the uppermost 25 meters of 'soft sediments' was important for major urbanization, 'polder' groundwater management and harbour engineering developments in the last 150 years. These activities drove data collection and delivered information of the complex sedimentary architecture. This helped local engineering in the past and will keep doing so in the future. But in addition, more generic lessons can be drawn from the Holocene geology, which is known in a level of detail unmatched in the world. These lessons are the topic of this presentation. A unique time series of maps shows the successive adaptation to the inundating North Sea in prehistoric times, as if they were satellite images monitoring a drowning river mouth today. They provide very good insight in the dynamics of natural coastal adaptation at river mouths under rapid ('over 1 m/century') sea level change and steadily growing human impact on sediment budgets.
The geological sequence below Rotterdam tells the full scale story of a rapidly drowning river mouth, including its long-term aftermath. When sea level last rose rapidly, jumping 4 meters between 8,450 and 8,250 years ago,

Rotterdam saw its river delta plain drown and become estuary. This transgressive event of global importance, initiated the development of the present coastal barrier of the Netherlands. It also caused the Rhine to abandon its former river mouth in favor of a new outlet 50 km further north. Following the two centuries of very fast drowning, it took two millennia, until 6000 yr ago, before the position of the coastline and the various sedimentary environments behind it more-or-less stabilized. From 6000 yr ago onward, the coastal barrier in fixed position built out into the sea by increasing its width, whereas the protected delta behind it did not change much in shape and encased its channels in peats. Marked change occurred 2500 yr ago, when accumulated prehistoric deforestation in the hinterland increased the delivery of fine Rhine sediment by a dramatic 160%. The network of branches between delta apex and coast line reorganized completely and Rotterdam became the Rhine river mouth area again. Peat swamps between the new channels became covered with clay. With hindsight, this greatly facilitated the success of historic delta plain reclamation in Holland that began soon after.
The story of the Rhine river mouth 8500-8000 years ago, may serve as a look into the future for many semi-natural modern deltas. The story of human-increased sediment delivery and coeval reclamation since 2500 years ago is a look into the near future for many deltas in Asia and the Americas that have been reclaimed only centuries ago. Rhine delta geological lessons are not just for adapting Rotterdam or the Netherlands, but can be eye-openers when mitigating foreseen change in many deltas around the world.

PDD1.3-02 OUTLOOK TO NEW CLIMATE CHANGE SCENARIOS FOR THE NETHERLANDS

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In 2006, KNMI developed a set of climate change scenarios for the Netherlands for local adaptation strategies. These KNMI06 scenarios were issued around the release of the 4th IPCC assessment report, and describe changes of general climatological characteristics for 4 different scenarios, discriminating between different global mean temperature changes and changes in the regional atmospheric circulation. They were based on a range of global and regional climate model simulations (from the IPCC-PCMDI-GCM and the EU-PRUDENCE-RCM archive). The scenarios were chosen to cover a plausible range of climate change. extreme scenarios with low probability were not considered.
The KNMI06 scenarios have been used in many climate change assessments and policy inventory studies, but are also considered to lack basic information on specific types of climate variability (such as likelihoods of large interannual or within seasonal anomalous conditions such as droughts or long rain spells), and don't give a likelihood for each scenario.
Currently a new generation of climate change scenarios is prepared by KNMI and co-workers, being issued around the publication date of the 5th IPCC assessment in 2013. To involve users in the process of the new scenarios, a user consultation project team is formed, with representatives from KNMI and different user groups like water management, land use, health and transport. The project team first made an inventory of groups and persons working with climate scenarios. The next step was the consultation of these different user groups with all very diverse type of questions, for which several workshops are being organized.
Pending the results of this user requirement inventory, in this next generation climate change scenarios more attention will be paid to:
- Probabilistic estimates of changes of a number of key variables; an important application in this area is the assessment of flood adaptation measures, which are supported by estimates of the risk of widespread extreme precipitation events

- A stronger focus on extreme precipitation events with time scales shorter than daily totals; this is to support city planning, sewage design and damage insurance applications
- Realistic time series of mutually related weather phenomena; this 'Future Weather' approach allows testing routine operations (traffic control, agricultural yield planning) under realistic future conditions
- Changes in the variability of weather events, both addressing year-to-year and within-season variability; this assessment addresses the likelihood of strong changes in weather regime, such as experienced during the 2006 summer.
- Extreme scenarios with higher impact and less probability for sea level rise, drought, precipitation; this serves assessment of no regret measures affecting very long term investments, such as coastal defence infrastructure.
- One or more climate scenarios directly related to probable greenhouse gas emission policy scenarios; this facilitates synchronization with climate change mitigation strategies.

In the presentation a general outline of the scenario design will be given, and results of the user consultation meetings organized earlier this year will be addressed.

PDD1.3-03 GEOMORPHOLOGICAL MAPPING OF RIVER DELTAS - PRACTICAL AND PROGNOSTIC APPLICATIONS

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A relief is crucial component for deltaic geosystems. In river mouths even difference in heights of 5 - 10 meters (first meters at other times) predetermines changes in types of landscapes, flood risk, building environment. Besides, the genesis of landforms is important. Landforms of various origin and lithology have different stability to erosion, wave-cut, flood processes.
Geomorphological maps show how delta is transforming and evolving now, which factors are influencing on its evolution - sea level changes, sediment transport budget, tectonic movements, water conservation or something else. The method of geomorphological mapping for river mouths is represented. The main types of maps are outlined below.

1. Hypsometric 2D and 3D maps. The airborne LIDAR data can be the source for high-precision hypsometric maps compilation. The altitude of different parts of delta above a sea level associated with their age, genesis, lithological differences. Many important mechanisms can be studied using models of the whole delta including its subaqueous part (avandelta).
2. Morphogenetic maps show the landforms have been formed by various processes - fluvial, coastal (including tidal), aeolian, and tectonic and other endogenous processes. In up-to-day river deltas after a lapse of sedimentation, filling of lagoons, extension into open sea the processes of delta forming now are localized on the shoreline and on the near-mouth waters. On the rest of delta area the reforming of river-beds and riversides by fluvial processes is typical. While climate changes and variations of sediment transport budget can change the course of events. Morphogenetic maps of river deltas (Danube, Dnipro, Evros) created by describing method portray landforms, deposits (classificated by facies) built up them, fluvial and coastal processes, tectonic structures.
3. Maps of modern hydrologic-geomorphologic processes, including maps for river beds and channels deformation. Maps of horizontal river bed deformation are created using remote sensing data - satellite and airborne images and supplemental field-collected data. Maps of vertical river bed deformations are created using echo-sounding observations taking into account a hydrological and hydrodynamical models.
4. Dynamic maps (or time series of maps) demonstrate the evolution of river deltas in time as well as transformation of land using, effects of exploitation of hydraulic and offshore (marine) structures, streamflow regulation etc. Such a maps are known to be created by various authors for many river deltas.

The geomorphological maps and 3D models of Danube, Dnipro, Evros (Maritsa), Po, Mezen' river deltas have been creating using approach described above.
New geomorphological maps of Danube delta including its Ukrainian- and Romanian-owned parts have been created. The maps are applying for territorial planning of these region. It also can be used for navigability improvement.
We can establish a fact that upper and undercurrent parts of Danube, Dnipro, Evros, Po, Nile deltas are evolving under the influence of different processes. A reduction of the transportation of solid material by the flows reduces to erosion of river banks in upper parts of deltas. At the same time the sea level rising and tectonic movements (in Evros, Po deltas) lead to the coastal flooding.

PDD1.3-04 FINE SEDIMENT FEEDING ASSESSMENT AT PARANA DELTA IN TIMES OF CLIMATE CHANGE

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The Rio de la Plata is a very large estuarine system receiving waters of the La Plata Basin. Its main tributary is the Parana river, that discharges through a broad delta, formed by deposition of upper basin sediments. The Parana Delta is characterized by a continuous advancement process, with feed rates of several tens of meters per year and is protruding into the coast of the Buenos Aires Province (Argentine). The Delta dynamics implications on urban environment could be considerable, inducing conflicts between the nowadays uses at the Rio de la Plata, i.e. final disposal of waste-waters, provision of drinking waters, navigation and recreation activities, etc.
The on-going climate changes will drive a different hydrological regime over the Parana river basin, giving arise to sediment feeding modifications at the Parana Delta and the consequent morphology adaptations affecting the mentioned human uses.
In order to predict this morphodynamics, fine sediment transport processes need to be investigated. While the Delta front mainly advances by deposition of the coarse fraction of suspended sediment, we focus on flood periods, during which silts and clays partially settle at the Delta islands. The layer deposition and consolidation of these grain fractions produce in time aggradation of the area.
The aim of this work is the assessment of fine sediment feeding at the Parana Delta as the first step to predict the morphological changes. In order to achieve the results, we implemented and calibrated a one dimensional numerical model to simulate the Parana river sediment transport. The proposed method propagates up to the Rio de la Plata the sediment yield of the Bermejo river, that is the main supply of wash load of the Parana river.
This contribute presents the validation of this method and the comparison of the results in terms of sediment time series for two future most probable scenarios.

Deltas in Depth Theme 1: Regional climate, sea level rise, storm surges, river run-off and coastal flooding
Session DD 1.3: Precipitation, discharge and flooding (part 1) **POSTERS**

PDD1.3-05 THE EFFECT OF A WARMING NORTH-SEA ON COASTAL PRECIPITATION

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The North-Sea has a large influence on the distribution of precipitation over the Netherlands. It is strongest in Autumn, where an increased amount of precipitation occurs over the coastal areas (<50 km from the sea), and in Spring where the effect leads to a relatively drier coast. However, it is not clear how rising temperatures of the North-Sea due to climate change will influence the precipitation distribution within the Netherlands in the future climate. One reason being that the present-day climatological distribution of precipitation is (likely) to a large extend caused by temperature differences between land and ocean, and these may not change much as climate changes. Also, dependencies of precipitation on sea surface temperatures mainly occur under certain circulation conditions, where cold and unstable area is transported with (north) westerly circulation over the land, and it is not clear how these circulation statistics will change. Nevertheless, during the last 50 years the coastal area has become wetter in summer compared to the inland area. Also, the North-Sea remains a strong source of moisture in the future climate, and the moisture content over sea will increase with temperature. Therefore contrasts between the continent, where large scale drying at the end of this century is likely to occur, and the North-Sea may also enhance coastal effects.
Recently, an ensemble of 19 regional climate runs with an high resolution (25 km) for the period 1950-2100 has become available through the ENSEMBLES project. The ensemble is based on the A1B emission scenario. We analyse this state of the art ensemble and focus on 30 year averages of the precipitation over the Netherlands and the effect of the North-Sea on differences in precipitation between the coastal an inland areas.
Consistent with the KNMI'06 scenarios, we find an increase of 20% in average winter precipitation, and a similar decrease in summer in this ensemble. No clear signal was found for spring and autumn. The ensemble is reasonably able to reproduce the observed coastal effect (at the model resolution) for spring and autumn, but 30-40% of the model results deviate considerably from the observations. For winter and summer the majority of models deviate strongly from the observed value, and also the median of the model results is biased.
Changes in the coastal effect are quite small in absolute sense but comparable in size to the effect in the present-day climate, and therefore not negligible. A small positive correlation between the North-Sea surface temperature and the coastal effect is found for all seasons except autumn. The results are hampered, however, by the still relative coarseness of the model data compared to the features of interest. Also, temperature changes of the North-Sea are relatively small (~ 2-3 degrees by the end of this century) which is due to the fact that the regional models use the SST fields from the driving global climate model. Therefore, higher resolution and a better description of North-Sea temperatures are required to improve our estimates of coastal effects in precipitation.

PDD1.3-06 FUTURE CHANGES IN EXTREME MULTIPLE-DAY PRECIPITATION SUMS FOR THE RHINE BASIN

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Characterising changes in multiple-day precipitation extremes is highly relevant for predicting the future likelihood of flooding events. Several factors including the wet-day frequency, intensity, form of the distribution, and sequence of events all potentially influence the multiple-day sum. It is not well understood how these factors interplay or if the one-day precipitation sum scales differently to multiple-day sums. In this study, the 17-member global ensemble data set ESSENCE (1950 - 2100) is used to investigate how the distribution and time sequence of extremes in daily to 20-day precipitation sums over the Rhine basin may change in a future climate.
In Winter, the upper quantiles of wet-period sums are found to show an almost uniform increase from the year 1950 to 2100 with respect to summation time. The behaviour is largely explained by an increased intensity of precipitation events. In Summer, however, the change in upper-quantiles of wet-period sums with respect to summation time is not uniform but tends to decrease, from generally positive changes for one-day sums to generally negative changes for multiple-day sums. Whilst a decrease in the wet-day frequency explains part of the trend with respect to summation time, the sequence of events also plays a role.

PDD1.3-08 REVIEW OF CLIMATE CHANGE IMPACTS ON EUROPE'S DELTA REGIONS

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Much of Europe's coastline is relatively resilient to the impacts of climate change. However, low-lying coasts, often with high population densities and economic values, such as those in north-west Europe and the coastal plains of the Mediterranean and Black Sea, are threatened by sea level rise, changes in river discharge, land erosion and saline intrusion. This paper looks at the implications of climate change for Europe's delta regions and is based on a review of contemporary evidence carried out for the European Environment Agency.
Europe's largest delta systems include those of the River Rhine (The Netherlands), which enters the North Sea, the rivers Ebro (Spain), Rhone (France) and Po (Italy) that flow into the Mediterranean, and the Black Sea's Danube (Romania) and Kizilirmak (Turkey) deltas. These regions are susceptible to river and coastal flooding and to land loss through coastal erosion and changing sediment regimes.
Rises in sea level were recorded in all European seas during the 20th Century. The rate of rise increased in the last decades and this trend is likely to continue throughout the current century. In the Mediterranean, recent sea level rise was considerably higher than the 20th Century average and notably higher than the global average; sea surface temperature also increased substantially more than in other seas and oceans.

Changing precipitation patterns and temperatures in river catchments affect water fluxes and sediment loads. Many rivers are experiencing higher discharge rates in winter and early spring due to increases in seasonal rainfall and enhanced glacial melting in mountain regions. Sea level rise and higher river discharge rates increase the risk of catastrophic inundation. Many cities in the Rhine delta, for example, are already heavily dependent on flood defences. Others rivers are seeing a fall in discharge due to significant but localised decreases in precipitation. Lower discharge rates in the rivers feeding the Black Sea deltas have led to reductions in sediment supply which, when coupled with sea level rise, is resulting in substantial land loss.
Urbanisation, industrialisation and associated infrastructure also significantly alter the dynamics of delta systems. Additionally, aggregate extraction and intensive agriculture can result in reduced sediment supply. Climate change is likely to exacerbate the threats posed by human activities to delta systems and the ecosystem services that they provide. In the Danube delta, for example, human activities have contributed to substantial coastal retreat and scenarios for the rate of future sea level rise suggest that this coastline will retreat further as a result of climate change.
The impacts of climate change on Europe's delta regions highlight the need for adaptation strategies. These should address both the changing dynamics of river and coastal systems and the human interventions that often pose even greater threats to these systems. Increasing awareness of climate change and adaptation to associated risks is a key component of the European Commission's work on Integrated Coastal Zone Management (ICZM). Member States of the European Union are encouraged to produce national ICZM strategies that include climate change adaptation measures.

PDD1.3-09 DETECTING FLOODING FREQUENCY IN THE PAST MILLENNIUM FROM DELTA LAKE SEDIMENTS

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Human impact on climate change, land use and water body ecology is a globally well-studied phenomenon. However, the interaction between human impact on and natural dynamics of landscapes and environments needs much better understanding since climate change is expected to alter important boundary conditions related to rainfall, flooding frequency and strength, and ecological turnover as a result of gradual global warming. These processes often act on decadal to centennial timescales that exceed instrumental measurement records. Specifically, the frequency-magnitude relationship for such river flooding events, is based on statistical extrapolation of measured discharges in the last 100-200 years and consequently far from exactly known and can not be related to (past) climatic changes. For discharge peaks in the low frequency-high magnitude range, extension of event history can be found in the sedimentary archive of the well-studied upper Rhine delta, if targeted research is carried out and modeling and reconstruction approaches are combined. Sedimentary archives from lakes can serve as valuable sources of information for past changes in flooding regime.
We present a variety of biological, geochemical and geophysical proxies to reconstruct past flooding frequency, water quality and landscape change, and relate the results to regional environmental changes in the catchment area of a deep scour hole in the central Netherlands. Scour holes formed during past dike bursts and extensive scouring of sediments, provide excellent conditions for the accumulation of expanded sedimentary records of river flooding, local lake water quality, and human activity. The 18 m deep Haarsteegse Wiel, is located in the lowland Rhine-Meuse delta and was formed in AD 1610 by flood water masses bursting through the embankment. Information from historical sources was used to determine the sedimentary expression and environmental impact of known regional river floods. Two long sediment cores were studied using magnetic susceptibility, organic carbon and sulphur concentrations,

fly ash particles, and micropaleontological (diatom and pollen) proxies. The sediment was dated by combining 137Cs activities, biostratigraphical ages of pollen, microtephra, and historically documented floods, and results in a highly accurate chronology. Water quality changes (i.e., phosphorus concentrations) were reconstructed using a diatom-based transfer function. Results show that the currently nutrient-rich lake has mostly been in a mesotrophic state prior to AD 1920, with the exception of several sharp eutrophication events that are generally coeval with river floods. River floods imported allochtonous components and, triggered by nutrients influx, clearly affected water plant communities and aquatic species diversity. Six documented regional flooding events between AD 1610 and AD1880 demonstrate that river water influx caused temporary eutrophication of the lake. Palynological markers document the flooding levels in the sediment. Combined with sedimentological data, these signals can be effectively used to detect unknown flood events in sedimentary archives.
In summary, the characterization of flooding histories helps to constrain natural river dynamics in older sedimentary archives for which historical sources are lacking. This information is crucial for developing an understanding of river flooding in relation to long-term (decadal to centennial) natural cycles of climatic change, and predicting future change in flooding regime.

PDD1.3-11 CLIMATE CHANGE IMPACT ASSESSMENT ON SOIL WATER AVAILABILITY IN BLUE NILE BASIN

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General Circulation Models (GCMs, currently the most advanced tools for estimating future climate change scenarios, operate at coarse (typically 0.5o) resolutions. Downscaling of GCM output is necessary to assess the impact of climate change on local water management activities. This study was conducted to quantitatively assess variations of water availability and crop production under different climate change scenarios in the Anjeni watershed. This watershed (area 113.4 ha) is located in Northern Ethiopia at 37°31'E / 10°40'N. Within the watershed terracing is a common soil and water conservation practice.
In order to estimate possible climate change impacts on water availability and crop production within the watershed, climate change scenarios of precipitation and temperature were developed for the South Gojam sub basin of area 16,762km2, in which the watershed is located. The outputs of HadCM3 coupled atmosphere-ocean GCM model for the SRES A2 and SRES B2 emission scenarios were used to produce scenarios for the period 2011 to 2070. These outputs were downscaled to the watershed scale through the application of the Statistical Downscaling Model (SDSM). Results indicated that for both scenarios there is an over all increasing trend in annual temperature with A2 scenario shows high increment relative to B2 scenario and significant variation of monthly and seasonal precipitation (i.e. a decrease in average Kiremt precipitation by about 9 and 7% in 2020 and 6 and 5% in 2050 for both A2 and B2 scenarios) from the base period (1984-2001). These changes in rainfall and temperature were used with the Soil Water Assessment Tool (SWAT) hydrological model to simulate future water availability and crop production. SWAT was calibrated with five years of monthly flow data (986-1990) and then the model was re-run using the scenario data as input. The results indicate that for both scenarios there is an increasing trend in potential evapotranspiration as well as a reduction in the soil water content in the watershed.
The study investigate that due to combined effect of projected variation in seasonal rainfall and increase in temperature and then reduction in soil water content there will be over all variation in crop production in the watershed.
Keywords: Climate change, SDSM, SWAT and Water availability

PDD1.3-12 RUN-OFF VARIATION OF THE PAPAGAYO DELTA RIVER UNDER CLIMATE CHANGE

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Problem definition
To estimate the effects of global climate change on the hydraulic and environmental resources in a delta was selected a region close to the coast of the State of Guerrero in the country of Mexico, which is the Papagayo river basin, where pressures on the water resources become more evident due to different factors on the one hand its scarcity and moreover growing demand by the use of water.

Theoretical framework and methods
It was realized a general diagnosis of the basin in study as well as its main physiographic features including: hydrology, geology, geomorphology, climatology, soil, vegetation and fauna. It was effectuated a hydrological study of the Papagayo river basin, where 10 climatological stations were selected by their distribution in the basin and its highest number of registration years and calculated their areas of influence through the method of Thiessen polygons; also was calculated maximum precipitation in 24 h for different periods using 8 functions return probability and chose of minor error for later use. Precipitation regimens were quantified and analyzed, which will be submitted in the future due to global climate change for 4 different scenarios proposed by the Intergovernmental Panel on Climate Change for the years 2050 and 2080 schemes. The variations of rainfall results presented for country of MÃ©xico were obtained of ten recent models of simulation for global climate response. These simulations were performed by seven climatic laboratories located in 6 different countries. Most climate models indicate a process of drought on the Mainland of Central America and the islands of the Caribbean, being the most significant changes for the continent than for the Islands.

Results
Effects on delta of this hydrological basin were specifically quantified by estimating run-off river. Finally the variation equations in the percentage decrease in run-off river with regard to the percentage decrease in precipitation were obtained.

PDD1.3-13 SPATIAL AND TEMPORAL RAINFALL VARIATION OF BANGLADESH

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Rainfall is one of the most important phenomena for agro based country like Bangladesh as it plays significant role for the climatic variation. Being a tropical country, there is a small temperature variation but there is extremely large rainfall variation between winter and summer due to geographical location. There is also exists west-east precipitation gradient In all seasons. The regional analysis was identified two regions in which behave differently, i.e. The southeast and the northwest area. The northwest area is clearly under the influence of processes more typical for middle latitudes, while in southeast region orographic and coastal processes might be work. We also find a positive trend in the rainfall, especially large during the summer monsoon and in the south east region with the rate of 13.62 mm per/ year. The northwest area on the contrary is characterized by decreasing rainfall values both in winter and summer with the rate of -0.13 mm/year and -3.26 mm/year respectively. So it is clear that this region becoming more arid. However, annual rainfall of the country increasing at the rate of 2.8 mm/year.

PDD1.3-14 ESTIMATION OF GREENHOUSE GAS EMISSIONS FROM DANUBE DELTA DEPOSITS

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Although numerous studies regarding evolution of Danube delta and its geo-morphological processes have been developed, they have been materialized in descriptive papers or in thematic bi-dimensional maps (soils, geomorphologic deposits).
Our studies present a tridimensional digital map of top-layer deposits from Danube delta revealing the organic deposits succession (peat, floating reed beds), fluvial and maritime minerals starting from soils and peat deposits maps. The enhancing of top layer deposits spatial distribution, were achieved by ARC/INFO processing of the digital map information with regard to soils and hypsometry. From soil database, information of deposits vertical succession and horizontal distribution was selected. To sustain this application, we combined it with hypsometrical data for depth deposits.
On the basis of tridimensional map GIS the results show an estimation of the biomass of the organic content accumulated in Danube delta deposits and CH_4, CO_2, H_2S concentration emission from the main soils and deposits of Danube delta.

DD1.4-02 CHANGE OF EXTREME PEAK FLOWS IN THE RHINE BASIN ACCORDING TO 8 RCM SIMULATIONS

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Climate change is expected to have an effect on the hydrological behaviour of the river Rhine and its tributaries. The effect of global warming on extreme discharges is of particular interest to the five countries of the Rhine basin. To estimate the effect on extreme river discharges, often the assumption is made that the relative change in the (monthly) mean is equal to the relative change in the extremes. However, the effect of climate change on peak discharges might as well be different from the effect on mean discharges. In this study the effect of climate change on low-probability peak discharges is analysed based on an ensemble of regional climate model (RCM) simulations. Also, the 1250 year return flow is calculated, which is relevant for the design discharge of the Dutch river system.
Within the CHR Rheinblick2050 project, 3000-year series of daily precipitation and temperature have been generated using time series re-sampling of 30-year time slices (1961-1990, 2021-2050 and 2071-2100) from 8 RCM simulations. The RCM simulations were mainly performed within the EU-Ensembles project.
For this study the synthetic 3000 year time series of precipitation and temperature, for each of the 134 sub-basins that are used in the hydrological model, have been used to force the HBV-Rhine rainfall run-off model. Return flows between 10 and 1250 years and 95% confidence intervals have been calculated for each RCM and for each of the three time slices for Lobith, Cologne, Trier, Kaub, Maxau, Raunheim, Worms, and Basel.
The results show how, according to state-of-the-art RCM simulations, peak discharges for different return periods will develop until 2100. In addition an estimation of the bandwidth is given that can be expected based on the ensemble of RCM simulations.
The bias correction and re-sampling of RCM data for the Rhine basin are presented in an accompanying paper in which different non-linear bias-corrections for precipitation have been analysed. Two other related Rheinblick2050 papers deal with a general overview of the project and with the future change in low flows of the river Rhine respectively.

DD1.4-03 FUTURE TIME SERIES: TIMES SERIES TRANSFORMATION VS MODEL DATA

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Climate scenarios are necessary to study impacts of climate change. These climate scenarios are usually generated with the use of a set of climate models and statistical downscaling. Yet, due to biases in climate models, the direct output of these models can usually not be used directly for impact modelling. A climate model is said to be biased when the statistical characteristics significantly differ from the observed climate. In general, even key-parameters, such as mean precipitation, are heavily biased.
Nevertheless impact modellers need future time series. There are roughly three common methods to generate plausible time series for the future:
- The first method applies corrections to the biased climate model output.
- The second method transforms observed climate data according to a climate change scenario.
- The third method develops a stochastic weather generator for the current climate and adapts it according to the climate change scenario.

The bias correction is thought to be superior with respect to spatial consistency and consistency between different climate variables. Indeed, even implicit changes in relations are automatically taken into account. Accordingly, hidden biases within these interrelations will remain in the corrected output. In practice, all statistical properties, like the mean, the standard deviation and higher quantiles of a certain climate variable can be biased. Since all these variables and their characteristics are mutually dependent, corrections of one bias will by definition change other characteristics and relations with other variables. Some other biases will be (partly) solved, but new biases and artefacts will be introduced.
Transformation of observed time series is often referred to as the delta-change method or perturbation method. Precipitation is typically multiplied by a certain factor whereas a specific offset is added to variables as temperature. Of course it is possible to control variability characteristics separately, if more sophisticated transformations are used. The transformation method will not include all important changes. Besides, every transformation may introduce new biases and artefacts. But time series generated by transformation will generally contain fewer biases than bias corrected climate model output.
Stochastic weather generators time series are randomly formed on the basis of a set of statistical moments, temporal dependency etc. Often the generation of precipitation series serves as a conditional basis for the other variables. More complex relations and characteristics are very hard to include in the weather generator. Especially, spatial dependency remains very difficult till date. On the other hand, weather generators are relatively easy and flexible to adapt for future climate. Since only the statistical characteristics and relations have to be altered, no new artefacts will be introduced.
The use of different methods of generating future climate time series may result in different conclusions in the impact studies. Nonetheless, most studies only pay very limited attention to this crucial step. This study compares the influence of the method and the choices within each method on assessed impact. The comparison is both theoretically and by means of hydrological examples.

DD1.4-04 RESPONSE OF RIVER MOUTHS OF PERMAFROST ZONE OF RUSSIA TO CLIMATE CHANGES

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This is a review paper on the conditions at the river mouths flowing into the Arctic seas in Russia. The mouths of the rivers Pechora, Ob, Nadym, Pur, Taz, Yenisei, Khatanga, Anabar, Olenek, Lena, Yana, Indigirka, Kolyma and Anadyr which are located in the zone of permafrost are under consideration. These river mouth areas can be subdivided into three types: estuarine, estuarine-deltaic, and deltaic. Two groups of factors: river and sea - influence hydrological regime of river mouth. The first group (river factors) involves water and sediment flow, water level of the river, physical and chemical properties of river water and ice conditions; the second group involves ocean water level, sea currents and tides, wind waves, physical and chemical properties of sea water, fast ice formation and alongshore sediment transport. Geological structure, climate and landscape also play a considerable role in hydrological regime of river mouths. A majority of arctic rivers are the rivers with predominate snow melt feeding, spring high-water period, summer-autumn rain floods, winter low-flow period. The tide range gradually decreases from west to east along the arctic coast of Russia. Climate changes influence all factors which determine the hydrological regime of the river mouth areas. Climate conditions of the arctic region are characterized by extremely irregular input of solar radiation over the year and intensive cyclonic action. Different types of frozen grounds at the upper and lower reaches of the rivers are described. Climate change impact on the thawing depth and depth of frost penetration at the banks of the mouths and coastal dynamics tendencies are discussed. The increase of mean year air temperature at these reaches is analyzed together with the variations of the long-term discharges at the head of the river mouths. Dependence of ice cover durations at the river mouths on changes of annual mean summer and winter air temperature is investigated. Dependence of ice formation on variations of water salinities in the river mouths is studied. During the period 2001 – 2005 climate warming in the North of Russia is estimated on average as very low - about +0.1°Đ¡ which occurs mainly in the cold season. The increase of the mean annual temperature at the Arctic coastal on the average amounts 0.03°Đ¡/year, with the minimum at the river mouths of Pechora and Lena 0.02°Đ¡/year, and maximum at the mouths of the Rivers Ob and Yenisei 0.05°Đ¡/year. However, the mean annual air temperature of the arctic region at the mouths of the rivers Ob and Yenisei during 1990 - 2005 even decreased. At present the observed changes of air temperature in the coastal zone of the Arctic Seas weakly impact conditions of formation of frozen grounds, compacting of ice, sea level and the rate of shores retreating. It was found that the ice free period fluctuations at the coastal of the Arctic Seas are synchronous with those of the average annual air temperatures.

DD1.4-05 EVALUATION OF DOWNSCALING A CLIMATE DATASET IN WESTERN JAVA, INDONESIA

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The coupled effects of climate and land cover change have the potential to cause significant changes in hydrological processes. An understanding of these changes is important for an understanding of both flood and drought characteristics of river systems. The need for climate data with high resolution for hydrological modeling studies is increasing. Climatic Research Unit (CRU) provides such climate datasets for precipitation and temperature. CRU provides monthly time-series of these parameters for the period 1901 to 2002 at a resolution of 30'[GREEKX]30' (CRU TS 2.1). CRU also provides monthly average precipitation and temperature (1961-1990) at a resolution of 10'[GREEKX]10' resolution (CRU CL 2.0), but not a time-series. In this study we intend to downscale the 30'[GREEKX]30' resolution dataset to 10'[GREEKX]10'. The results will be evaluated against observed data from the Jakarta, Halim, and Kemayoran stations. Observation data is provided by the Royal Dutch Meteorological Institute (KNMI). The spatial domain is located in western Java, Indonesia.
Spatial and statistical downscaling techniques are applied in this study. Firstly, the 30'[GREEKX]30' climate data are linearly interpreted onto a finer grid with a finer resolution (10'[GREEKX]10'). Then, four statistical methods are used to statistically downscale the data based on the higher resolution climatology series at 10'[GREEKX]10' (correction based on annual average, correction based on monthly average, correction based on monthly average with spatially explicit, and correction using the standard deviation). The results of the downscaling are evaluated against observation stations in Jakarta, Halim and Kemayoran.
The agreement is represented by the coefficient correlation for the monthly time-series (r) and the ratio of annual average observed precipitation and temperature to annual average downscaled CRU precipitation and temperature (%). Good agreement is seen for all methods and for all stations; but the best method is seen in statistical downscaling correction based on monthly average with spatially explicit. r ranges from 0.63 to 0.88 and the ratio is between 100 and 123. The downscaled climate data will be used as an input for hydrological modeling in a later study.

DD1.4-06 IS COASTAL RAINFALL IN THE NETHERLANDS BETTER SIMULATED AT A FINER GRID SCALE?

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We will present a quantification of how the North Sea sea surface temperature (SST) may alter the spatial distribution of precipitation extremes within the Netherlands. Recent research has shown that the coastal area climate experiences a strong dependency to SST under specific atmospheric circulation conditions. With a model of intermediate resolution (in both time and space) results obtained for August 2006 showed already that the influence of a warm North Sea can be significant, even leading to an increase in coastal precipitation of 15 % per degree warming of the North Sea (Lenderink et al. 2008). However, these models of intermediate resolution have difficulties in simulating the right amount of precipitation. On a 25 km resolution the precipitation is underestimated in summertime circumstances for coastal area in the Netherlands. The summertime precipitation is characterized by convective showers which are difficult to capture at this resolution. A new generation of regional climate models, which use the non-hydrostatic approach, have the ability to simulate precipitation on a resolution as small as 1 km. This is achieved by actually resolving the microphysics of the atmosphere instead of parameterizing convection. It is also hypothesized that precipitation extremes are much better captured.
With the results of the simulations presented extreme events of climate scenarios for the Netherlands will be improved in many aspects. This will provide better quantification of changes in variability at different time scales and a better representation of the uncertainty.

DD1.5-02 COASTAL DEFENCE COST ESTIMATES; STUDY OF THE NETHERLANDS, VIETNAM & NEW ORLEANS

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A large and fast-growing part of the world's population lives in low-lying coastal zones, especially deltaic coasts. Different coastal defence measures reduce the risk to economic values and populations in these coastal zones, but sea-level rise requires the coastal defence measures to be adapted to higher water levels. This study investigates the unit cost estimates of coastal defence for the full range of hard and soft engineering measures, such as dike, sea wall, nourishment and other measures, for example storm surge barriers. These cost estimates are provided for three case study deltaic areas: the Netherlands, Vietnam and the New Orleans area and interpreted in a more global context.
For the case study areas first the unit cost estimates of coastal defence structures are determined. Next, the relationship of these costs with sea-level rise is analysed. And finally, the costs are applied to determine the optimal defence standards.
The optimal defense standards and coastal defence costs have already been analysed in several studies for the Netherlands (e.g. Kok et al., 2009 - prepared for the Deltacommittee, Kabat et al., 2009), New Orleans (Jonkman et al., 2009) and Vietnam (Hillen, 2008). Based on these studies and an extensive literature survey the cost prices for different coastal defences are determined. Similarities and differences between the unit cost prices for the studied

regions are discussed and the unit costs prices are compared to estimates provided by previous studies (Hoozemans et al., 1993; IPCC CZMS, 1990).
When the unit costs are determined, the data from the existing studies is applied for an analysis and discussion of relationship between sea-level rise and coastal defence costs. It is investigated whether a non-linear relationship between the unit costs prices and sea-level rise exist; i.e. do higher coastal defense measures give an exponential increase in costs? For the case study areas these relationships are determined and the results presented and compared.
To determine optimal defense standards for the case study regions, the unit cost prices are used for cost estimates at a system level. For the case study areas we will demonstrate which factors will determine the relationship between the unit costs price and the overall system costs. It will also be discussed how information on unit costs can be used to determine the economically optimal level of defence standards for different areas, such as the Netherlands, New Orleans and Vietnam.
The overall results of this study are utilized to provide input for a global study on costs estimates of coastal defences.

DD1.5-03 ASSESSMENT OF SOCIOECONOMIC VULNERABILITY TO SLR USING GIS: DAMIETTA, EGYPT

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The Nile delta, which is heavily populated and accommodates significant proportion of the economic activities in Egypt, has important role in daily life and development aspects of Egypt. However, the coastal areas of the Nile Delta are already affected by coastal erosion, pollution, land use pressures and demographic growth. This has created considerable pressure on its resources and ecosystems and consequently coastal population, increasing its susceptibility to any adverse changes in the coastal areas. The Nile Delta is one of the most threatened areas by sea level rise (SLR) not only due to warming of the atmosphere but also with land subsidence. Although the Nile delta has attracted considerable interest of researchers focusing mainly on the biophysical impacts of SLR, little attention was given the socioeconomic vulnerability of the coastal population need to be closely examined.
The paper, in hand, intends to assess socioeconomic vulnerability to sea level rise using GIS in the coastal area of Damietta governorate with particular emphasis on human settlements.In order to attain this objective, the study begins with a brief review of different scenarios of SLR in order to identify the spatial extent of the SLR biophysical impacts. This is followed by studying local baseline socioeconomic conditions and developing an inventory of such conditions. This inventory is then utilised, as well as the outcome of household surveys conducted in the study area to assess socioeconomic household conditions and the attitudes and behaviours of individuals towards sea level rise and its implications, in the assessment of socioeconomic vulnerability in the area. The assessment is based on a Geographic Information System (GIS), which was developed for mapping physical and socioeconomic data of the study area and conducting spatial analysis to evaluate various impacts. Such an assessment could be used in the identification and assessment of potential adaptation options to SLR.
The results revealed massive loss of socioeconomic assets due to SLR with varied degree of vulnerability in different parts of the study area and among different groups of the residents.

DD1.5-04 COASTAL FLOODING RISK IN EMILIA-ROMAGNA: THE INTERVENTION AT CESENATICO

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We present a case study from Emilia-Romagna (Italy), in which the Administration intervened to reduce flood risk in a densely populated area deriving from the combination of storm surge and inland run off.
Emilia-Romagna Region is characterized by low sandy coasts, which suffered in recent years a strong subsidence, that significantly affected the territory security. The presence of extensive areas below the high tide level but also below mean sea level and of beaches subject to intense erosion makes the coastal system inherently fragile. Anthropogenic subsidence, although the trend of soil lowering has undergone a significant decline, still plays a major role in determining danger conditions with increasing frequency. The phenomenon becomes even more worrying when related to the expected sea level rise. In that regard, the Emilia-Romagna Region has released alarming values of hypothetical increases in sea level caused by joint processes of subsidence and adverse weather conditions, that are not based on a combined statistics of processes.
Within the widespread critical conditions characterizing this coast, we have chosen to consider the case of Cesenatico, which suffered subsidence of over one meter in fifty years, the maximum observed along the regional coastline, with consequent flooding of the town from the channel harbour. Cesenatico was considered of primary importance and funds were allocated to secure the area because the risk was exacerbated by the possible simultaneity between a low receptivity of the sea and the occurrence of significant flood events from the inland basin. For the defence of the town from high water, at the sea outlet of the channel harbour a barrage was designed using da_Vinci's doors, that are closed when the sea level reaches 90 cm a.m.s.l.. Since the harbour is also the outlet of a drainage basin, an alternative regulated outlet is designed and expansion areas are scheduled to reduce the peak discharge in the outlet.

The aim of the paper is to analyse the innovative and interesting design solution, and to investigate the residual vulnerability of the area, a common problem all along the regional coast and a symptom of the increasing difficulty of ensuring safety by traditional interventions.
In order to define the risk level that affects the coastal area, the likelihood of scenarios of simultaneous precipitation and high sea level (due to tide and storm surge) is evaluated; in particular the correlation between the significant sea levels and heavy rainfall is analysed, that was never analyzed before. Failure patterns and conditions of the coastal system are investigated with the aid of numerical simulations. The association of hazard scenarios with the collapse conditions allows the identification of the residual risk o a rational basis. We presume the approach can be easily extended to other sites on the coast and form the basis for a preventive management capable of addressing policies and interventions on the coastal system, marked by a considerable economic and societal importance.

Deltas in Depth Theme 1: Regional climate, sea level rise, storm surges, river run-off and coastal flooding
Session DD 1.5: Adaptation, risk, vulnerability **ORALS**

DD1.5-05 SATELLITE MONITORING OF WATER DEFENSE SYSTEMS

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Rising sea level and changing weather conditions impose new requirements for water defense structures, such as dikes and dams. In general, these structures protect the most densely populated areas around the world. Especially the monitoring of the stability of these structures is a demanding task, both from a economic and technical point of view. For example, in the Netherlands alone already 17000 km of dikes and dams are present. Moreover, quantitative analysis is often lacking. We present the application of satellite radar interferometry as a new technique to aid the monitoring of water defense structures.
Satellite radar interferometry enables the measurement of deformation of dikes with millimeter accuracy. As a result, small changes, which may be an early indication of structure instability, can be detected. Because of the global coverage by the satellites used, the technique can be applied world wide without the need of installation of in-situ instruments. Due to the repeat cycle of the satellites, the dikes and dams are monitored on a regular basis, with up to one measurement per day. Because the satellite data is freely available or available at low-cost, the technique provides a very cost-effective source of new information for risk assessment.
To demonstrate the technique, we present the results of the analysis of all primary water defense structures in The Netherlands using radar images acquired by the Envisat satellite. The 3600 km involved incorporate various types of water defense structures, each with their own characteristics. The results show the effectivity and added value of this innovative technique.

DD1.5-06 DELTAS ARE SINKING, BUT HOW TO MEET THE CONSEQUENCES?

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Recent literature suggests net subsidence of the major deltas in the world to be causally linked to human activities. We argue that net subsidence does not necessarily imply an increase in vulnerability, quantified here as land lost and people at risk. This is based on a principal components analysis of co-variability of a range of geophysical and socio-economical vulnerability indicators of 33 deltas derived from two comparable global databases, the World Delta Database and the DIVA tool. Land lost and people at risk of flooding correlated positively with average river discharge, delta area and the maximum storm surge height instead of with net sea level rise or coastal slope. Thus, we argue that societal vulnerability rather depends on short-term, instantaneous risks linked to lowland area, peak discharge and storm surges than on longer-term, slow, net sea level rise, so that the focus should be on precautionary spatial planning, and on maintenance or restoration of historical sediment delivery and aggradation rates. Especially larger deltas with high population densities combine a high risk with the potential to accommodate flood water and mitigate flooding risks. The deltas of the Yangtze-Kiang and Ganges-Brahmaputra share these characteristics. Here space should allow engineering of flood retention, sedimentation and diversion channels as well as refuges and safe economic hotspots. At the other end, in deltas with a high population density and limited space, like the Chao Praya means for adaptation must be sought outside the delta proper. In deltas with low population densities, such as the Lena, Yukon or Fly, natural delta dynamics can prevail.

DD1.5-07 TIDAL RIVER MANAGEMENT IN BANGLADESH COAST IN THE FACE OF CLIMATE CHANGE

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In the south-west coast of Bangladesh, a number of polders were constructed in 1960s to protect the land from regular tidal inundation. These polders confined the flows to the rivers resulting in siltation of the rivers. Consequently, the polders started to suffer from severe drainage congestion. Tidal river management (TRM) was proposed by the local people as a solution to the problem. After a thorough study, TRM was adopted as a semi-natural measure to solve the water logging problem. Under TRM, hydraulic link between low lands in a polder, called tidal basin, and the river is restored. Siltation takes place on the low lands rather than the river keeping the river functional. Land of the tidal basin is gradually raised mimicking the delta building process. Tidal basins are rotated among feasible sites every 3-4 years. TRM started operating in the south-west coast of Bangladesh since 2000 and so far, two rotations have been completed. The performance of TRM is very encouraging. However, during the TRM there were number of social and institutional issues which needed to be resolved. TRM is new concept in tidal flood management and looks very promising for replication elsewhere. Under the climate change scenario, Bangladesh coast is especially vulnerable. Water logging is expected to increase due to back-up effect as a result of sea level rise. Under such circumstances TRM may be looked more favorably to increase rate of delta buildup. This paper will illustrate the experiences of TRM in terms of physical, social and institutional aspects.

DD1.5-08 SAFECOAST: COASTAL RISK MANAGEMENT IN FIVE NORTH SEA COUNTRIES

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Background and objectives
In the 20th century, major North Sea coastal floods occurred in 1916 (NL), 1953 (NL/UK/BE), 1962 (DE) and 1976 (BE). These floods claimed over 2,500 lives and caused considerable psychological, economic and infrastructural damage. After 1976, as a joint result of large-scale coastal protection works, early warning systems and less severe storms, no more lives were lost due to floods. However, this 'safety' ensured an increase in settlement and economic activities in the coastal zone, heightening the vulnerability and risk aversion of our contemporary societies.
In response to this development, coastal managers from five North Sea countries United Kingdom, Germany, The Netherlands, Denmark and Belgium formed the North Sea Coastal Managers Group (NSCMG). One of their actions was to initiate the project Safecoast (2005 - 2009). The aim of the project is to identify best practices by exchanging information on the different approaches to coastal flood and erosion risk management. Faced with an imminent climate change and associated impacts on the coasts, it is important to use the lessons-learned and benchmark the various methods and ideas to best answer the question: 'How to manage our North Sea coasts in 2050?'

Approach and execution
Safecoast aimed at developing views on future management of coastal flood risks by:
- Comparison of available tools for scenario analysis to assess the effect of climate change on future land use and

carry out risk assessments on different scales of space and time. Potential future challenges were defined for different coastal situations;
- Identification of best practices for flood and erosion risk assessments. Results underlined the need for better co-operation between countries & regions and between scientists, managers & policy makers;
- Identification of promising approaches: look 'outside the box' for measures to prevent or cope with undesired consequences of coastal flooding and erosion. Approaches consider a wide range of possible future (planning) strategies and solutions. They can aim either at protecting our vulnerable coasts with measures of "no regret", or at limiting or compensating the negative effects of coastal flooding and erosion.

Results (www.safecoast.org)
The team and NSCMG learned valuable lessons from each others coastal protection philosophies and strategies based on the different contexts and cultures. The main results are:
- Scientific and policy scenarios for sea level rise do not always have to be the same thing;
- Using the term "intermediate"works better than "short-"and "long term";
- Risk assessments are bound by their scale, level of detail and purpose;
- It is often better to choose for minimizing the chance of a wrong decision than to keep looking for the right decision;
- And finally, be very careful when copying specific measures from neighbouring countries.

Presentation
The presentation will give a detailed overview of study results and in particular lessons learned concerning best practices in different countries.

DD1.5-09 THE SAND ENGINE

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A rising sea level, more rainfall and subsiding ground: in short a changing climate. But also increasing pressure for space and a shortage of opportunities for nature and recreation. The Dutch Randstad is one of the most densely populated areas in the world and lies for the greater extent under sea level. These are some of the challenges the province of Zuid-Holland is facing. Worldwide regions cope with the same problems as a result of global trends.
The most current problems that the province of Zuid-Holland faces are climate change, pressure on space and declining economic competitiveness.
We want to present and discuss the new approach the province of Zuid-Holland has developed, together with other parties, to tackle these problems effectively and address the safety problem and the demand of space in one integrated vision for sustainable development of the coastal zone. The Sand Engine is the means to achieve this. The Sand Engine is a huge amount of sand, positioned at a single site offshore. Natural processes spread the sand, creating new land. This principle is called building with nature rather than fighting it: an innovative design concept for the layout and sustainable exploration of coastal areas, in which natural ecosystems and human interventions reinforce each other. New areas of natural beauty and recreation will emerge, which are needed in this densely built up and populated region. A public-scientific alliance is working together.
In the recent past, the design of flood protection schemes was mainly based on engineered and technical solutions. The Sand Engine is similar to this series of innovations. However, the philosophy is now different: work with nature, rather than against it. This is a valuable addition to the arsenal of delta solutions and is an opportunity to improve the appeal

coastal areas. In other words: nowadays we try to combine ecology, landscape and other functions such as recreation into the design of our coastal defense system by incorporating natural elements, such as wetlands or dunes.

Multi-stakeholder approach
Within this pilotproject a lot of stakeholders are involved and work together, under the leadership of the province of Zuid-Holland: the national department on water, nature, environment and spatial planning, the University of Delft, research institutes, representatives of the environmental interests, representatives of recreation and nature, the water board, dredging companies, concerns and inhabitants in the project area, Life Board Association and the World Wildlife Fund. The main reason to involve these stakeholders, from the moment of intention to the actual execution, is that besides the examination of the technical question how the coastline can be reinforced by building with nature, it's also very important to develop agreement by society, to combine safety aspects with needs for extra space for nature and recreation and to find the most efficient way of executing in financial terms. In this way this pilotproject will address the needs of society on a short term.
The execution of the Sand Engine will start in the autumn of 2010.

PDD1.5-01 ENVIRONMENTAL OUTLOOK TOWARDS 2030 FOR THE FLANDERS REGION OF BELGIUM

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Extended title:
Environmental Outlook towards 2030 for the Flanders region of Belgium: possible climate changes and their consequences for the water systems

In the Environmental Outlook towards 2030 for the Flanders region of Belgium, information on the possible climate changes on water systems (rivers and catchment hydrology, urban drainage, coastal zone) and their consequences has been collected and compiled. The information has been derived from eleven research projects recently completed or still underway. In this way, a more define view of the possible changes has been achieved. In addition, new risk calculations for flood damage were carried out according to various scenarios. This information is crucial to allow the government and public authorities, but also industry, agriculture, environmental stakeholders, etc. in the region to adapt in time and purposefully to climate change and to be able to limit the socio-economic and environmental implications of flooding, water shortages or exceedance of water quality standards.
Some key conclusions of the outlook are:
- All climate scenarios for Flanders clearly indicate an increase in the ambient (air) temperature (e.g. by 1.5 °C to 4.4 °C in the winter and by 2.4 °C to 7.2 °C in the summer), a higher evaporation in the winter and summer and finally more precipitation during the winter by 2100. The sea level at the Flemish coast may rise by 20 to 200 cm this century.
- The majority of climate scenarios indicate a drop in the average summer precipitation for Flanders. Combined with higher evaporation this will decrease the lowest river flows during dry summers by over 50% by the end of the 21st century. The chances of severe water shortages increase as a result.
- Despite a drop in summer precipitation, an increase in the number of extreme summer storms may be expected in Flanders. This increases the probability of flooding of sewers.
- The risk of financial damage due to flooding varies greatly, depending on the various climate scenarios: from a drop by more than 50% to a rise of around one third.
- Flanders is located between Northern France, where climate change strengthens the evolution towards more droughts and The Netherlands where an increase in the number of floods is expected to be more likely. In order to deal with the uncertain consequences of climate change, water managers in Flanders must therefore search for flexible adaptation strategies that are useful in any circumstances. This involves strategies that enable both flood risk limitation and prevention of water shortages.

PDD1.5-02 THE SPATIAL MODELLING APPROACH FOR THE IMPACT OF SEA LEVEL RISE ON DELTA COAST

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Increasing global mean temperature will have numerous effects on coastal area. Sea level rise is one of it that has significant impact on relatively flat area such as delta. Sea level rise may cause shoreline retreat, destruction of social economic activities and coastal environmental degradation. Dealing with this condition, a study to see the impact of sea level rise to the delta area was employed. A shoreline retreat model based on Geographical Information System (GIS) was developed to predict the future impact of sea level rise on delta coast. Indeed, some management scenarios to mitigate the impact of sea level rise were also employed for the best future of the delta. Using Mahakam Delta as the study area, the result of the model estimates that for the next 10 years (based on low up to the high scenarios) there will be 1.83 - 41.57 m shoreline retreat within the delta coast. This coastal change affect the lost of 1.90 - 45.63 ha shrimp ponds and residential area or about 1.848 USD - 40.341 USD lost. The policy of silvo-fisheries scenarios with various mangrove coverage percentages, show the best land use management of the delta to adapt the impact of sea level rise. This could be done by implementing more than 60 % of the area for reforestation.

PDD1.5-03 CONSEQUENCES OF CLIMATE CHANGE FOR INLAND SHIPPING

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A strong selling point of the port of Rotterdam is free entrance to the sea and also to the hinterland by the rivers Rhine and Meuse. Although much attention is given to the consequences of climate change with respect to sea level rise and adequate storm defense systems, there may be severe consequences for inland shipping too. Not only because of more frequent occurrence and longer durations of closed storm surge barriers, which may disconnect the free entrance for inland and seagoing vessels to the seaport, but also because the hinterland connections itself may change. In the sense that so called melting rivers with a rather stable and predictable discharge over the year,

may change in fast fluctuating and more unpredictable so called rain rivers. This may sometimes lead to higher water levels, which may give problems for the passage of high inland (container) vessels underneath bridges. What is more undesired are (long) periods of low discharge, which may allow only shipping with restricted shallow draught, which in turn may cause disruption of “lean and mean”logistic chains. This affects container and bulk transport by barge.
At the moment a working group within the research program Knowledge for Climate is studying the involvement of climate change on inland shipping. The working group is not only modeling the future discharge of water and related water levels of the river Rhine at decisive sections. but also the future bottom profile, which is far from stable, because of shoaling, erosion, settlement, etc. At the end a realistic prediction can be made of the local water depth and so the possibility for (partly loaded) inland shipping to bring a certain amount of goods to specific destinations.
Luckily there are many short and long term solutions to anticipate to these future threats. This paper not only focuses on modeling of the water depth and allowable shipping, but also on a few attractive short and long term measures, such as ship properties and infrastructural adaptations (weirs and groins):

- better river management: e.g. retention basins in times of high discharge or in times of low discharge inflow from reservoirs, flow reduction by weirs and adjustable groins, extra draught by dedicated dredging,
- other ship dimensions,
- extra and/or shifted fleet capacity,
- more accurate, actual and predicted river depth information,
- broader logistic buffers, extra stock,
- other transport modalities (if sufficient transport capacity is available).

A final challenge the working group faces is to match the ownership of the problem, to the stakeholder that holds the key to solutions. Some of these measures should be taken in the public domain by (inter)national government(s), local authorities, river managers, etc., while others are the individual responsibility of private transport companies, producers or even ship owners.

PDD1.5-04 FLOOD RISK POLICY ASSESSMENT IN SHANGHAI WITH A COMPARISON TO ROTTERDAM

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Flood risk endangers two of the largest port cities in the world – Shanghai and Rotterdam. Climate change will make the two cities even more vulnerable to flooding due to rising sea levels, storm surges and extreme river floods. Apart from increasing flood probability, both cities also face soil subsidence and advancing economic development, which increases possible flood damage.
Shanghai city is located to the south of Yangtze River, to the north of Hangzhou Bay, to the west of East China Sea and to the east of Lake Tai. The Huangpu River meanders through downtown Shanghai City and connects Lake Tai and the Yangtze River estuary. The main causes of flooding in Shanghai city are the upstream passing of flood water from Tai Lake at times of torrential rainfall and storm surge from the East Sea due to a coincidence of typhoon and tropic cyclone.
The official flood protection level for the main stream of Huangpu river and urban district of Shanghai city is 1/1000 per year; the safety standard for sea dikes in urban Shanghai city is 1/200 p.y. plus preparation strong wind forces of at least 12 on Beaufort scale. However, the exceedance frequency of warning water level in Huangpu River is increasing; furthermore, Shanghai city, with an average elevation of 3-3.5 meters, is expected to more than 1 meter of land subsidence in 2050 due to groundwater extraction and massive construction of skyscrapers, so the flood protection level cannot meet the official requirement in the future without additional measures. Also, it is questionable whether the current flood protection level is in a cost-effective balance with the possible damage of flooding, and in any case this balance will change negatively with further economic growth and climate change.
The Dutch legal system of determining, monitoring and meeting flood protection standards is probably the most developed in the world. The Rotterdam region is currently implementing new measures to deal with extreme rainfall. It has a flood protection level between 1/2000 p.y. and 1/10,000 p.y. for combinations of storm surges and high river discharges, but these norms might change and new projects to keep meeting the norms under climate change are currently investigated.
The objective of this paper is to compare the current flood risk policy in Shanghai to the current policy in the Rotterdam region. It will look both on flood probability as well as flood impact and review the policies according to the latest climate change data and insights.
This paper is the first in a PhD project (2009-2013) of the first author on flood risk and policy analysis in Shanghai and Rotterdam. Therefore, the methods presented in this paper are mostly based on research of existing literature, and on the results of a developed hydraulic model. The paper will further outline future research directions. The ultimate PhD goals are recommendations to improve the current flood policies and standards in Shanghai, and recommendations for new risk reducing projects.

PDD1.5-05 DANUBE DELTA UNDER HUMAN CONTROL

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Danube delta is the largest delta in the European Union. Its importance as a shipping route was recognized early, and after the Crimean War in the 1850s, the European Danube Commission was charged with maintaining the Sulina arm as a shipping channel until 1940s. In the same period, canals were dug to aid fishing in lakes and bring freshwater to brackish lagoons. After World War II, Communist authorities dramatically increased the number of canals for fishing, fish-farming and reed harvesting, and started to reclaim large tracts in the delta for agriculture. Fortunately, Danube delta escaped this “development”fate and remains one of the best preserved temperate deltaic ecosystems and landscapes. Planned new developments related to shipping and tourism remain key threats for the delta; therefore, a good understanding of the history of human control is essential to provide expertise and establish a baseline for future interventions.
Danube delta is largely not affected by subsidence due to active tectonic uplift, but eustatic sea level rise and a >70% decrease in Danube’s sediment discharge following dam construction affects the delta at its coastal fringe. However, results in the internal delta plain suggest that the intensive canalization of the later half of 20th Century led to increased sediment deposition compensating the decreasing sediment discharge linked to damming. Although the sedimentation has kept up and exceeded the sea level rise in short term, shoaling and turbidity in delta lakes is expected to have a strong negative impact in the long run, even if the high connectivity among lakes provided by canalization is currently favorable for the aquatic ecosystem. Furthermore, trappping sediments in the internal delta has lead to a dramatic acceleration of delta front erosion and higher susceptibility of the entire delta coast to sea level rise.

PDD1.5-07 THE EFFICIENCY OF ARTIFICIAL SANDBANKS IN THE ELBE ESTUARY FOR FLOOD PROTECTION

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The Elbe Estuary in Germany is an important federal waterway connecting Hamburg, the largest freshwater port in Europe, to the sea. As a result of flood defence measures and progressive deepening of the fairway the tidal range in Hamburg has doubled over the last century. Especially with regard to future climate change a further increase of tidal energy in the inner estuary is expected with grave implications for sediment transport (dredging), shoreline erosion and flood protection.
The (re)generation of offshore sandbanks represents one option to reduce tidal energy in the estuary. In the framework of the ongoing European THESEUS project the efficiency and stability of such sandbanks is analyzed by means of high resolution hydrodynamical model runs under different regionalized climate change scenario conditions. The effort is based on the Hamburg Port Authority's Concept for a sustainable development of the Tidal Elbe River as an artery of the metropolitan region Hamburg and beyond and represents a joined effort of the GKSS Institute for Coastal Research and the Hamburg Port Authority to meet the future challenges for a highly anthropogenic influenced estuary. Results are given on the modification of current fields, water levels and the resulting tidal energy in the Elbe estuary with and without artificial sandbanks under the various climate change scenarios including storm surge conditions.

PDD1.5-08 FRAMEWORK FOR THE ANALYSIS OF SEA LEVEL RISE IMPACTS ON THE NILE DELTA IN EGYPT

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The Nile Delta in Egypt is one of the most heavily populated and intensely cultivated areas in the world. This makes it extremely vulnerable to impacts of climate change and sea level rise. In particular, sea level rise could destroy or weaken the protection provided by sea defences and sand dunes along the Mediterranean coast. This eventually could lead to severe flooding, loss of lives and economic damages. Given the importance of the Nile Delta, a number of studies looked at these potential damages to estimate the consequences of sea level rise on the Egyptian livelihoods and economy. In general, these studies have used simplified analysis methodologies and assumptions to achieve this goal. Examples of such simplified methodologies include assuming no defences to estimate flood extents, looking at particular defence failure modes or particular storms to estimate the defence probability of failure while ignoring the deterioration of defences with time. Obviously, these assumptions could either lead to under- or overestimation of the sea level impacts on the Nile Delta.
In this paper, a literature review of the previous studies of sea level rise impacts on the Nile Delta will be presented and the strengths and weaknesses of each study will be identified. Following that, a new improved framework for the analysis will be developed to more accurately estimate the consequences of sea level rise on the Nile delta. Concepts such as hydrodynamic flow modelling, land use/value mapping, defence deterioration with time and failure modes, fragility curves, and depth damage curves will be all introduced for the first time into this framework for the Nile Delta. The paper would conclude with a number of recommendations for future actions. It is anticipated that this paper will form the first comprehensive guidance for undertaking such analysis of sea level rise impacts in Egypt.

PDD1.5-09 CLIMATE CHANGE ADAPTATION MEASURES IN THE COASTAL ZONE OF BANGLADESH

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Bangladesh has one of the most threatening and challenging environments for water management in the world. More than 50 rivers flow into Bangladesh from other countries. This includes the huge Ganges (Padma), Brahmaputra (Jamuna) and Meghna rivers, 90% of whose catchment areas are located upstream in other countries. The combination of often torrential monsoonal rains, enormous rivers overflowing their banks, high tides in the Bay of Bengal, and even cyclones, result, annually, in widespread flooding, very slow drainage due to the flat floodplain, and erosion.
Currently climate change poses a new threat to the life and livelihood of the people of Bangladesh. The Inter Governmental Panel on Climate Change predicts changes in the environment of coastal Bangladesh, related to anthropomorphic climate change, including: rising sea level, increased monsoon precipitation, reduced winter precipitation, and an increase in the frequency as well as intensity of tropical cyclones in the Bay of Bengal.
In a medium term perspective (to 2050), a substantial population increase can also be expected.
The Institute of Water Modelling (IWM) has been involved in developing models to determine potential future inundation zones in a changing climate scenario up to 2050. Its results show that inundation will be mainly caused by the overtopping of embankments and increased internal drainage congestion.
This challenge is to be met through a pro-poor Climate Change Management Strategy, which prioritises adaptation and disaster risk reduction, and also addresses low carbon development, mitigation, technology transfer and the international provision of adequate finance (MoEF, 2009).
Euroconsult Mott MacDonald has been involved over the last decades in assisting the Bangladesh authorities in the management of water resources in the coastal zone. It is currently implementing the Integrated Planning for Sustainable Water Management (IPSWAM) Programme, established by the Bangladesh Water Development Board in 2003. The programme developed an integrated methodology for the establishment of long-term, sustainable, participatory water management.
The Char Development and Settlement Project Phase 3 (CDSP III) located in the Noakhali and Lakshmipur district, aims to reduce poverty and hunger for poor people living on newly accreted coastal chars. The project amongst other tries to provide protection from salt water intrusion and flooding via embankments, sluice gates and drainage channels and to protect people and property from periodic cyclones and the effects of climate change with embankments, cyclone shelters, livestock refuges (killas), protective tree belts, and other resilient infrastructure.
IUCN has also been involved in Noakhali, where it implemented the Promotion of Adaptation to Climate Change and Climate Variability Project aimed at mainstreaming climate change into development planning and promoting understanding of the impacts of climate change and climate variability and raise awareness at policy as well as community level.
Experiences gained show that a participatory approach as adopted in these projects can form the foundation of a feasible medium-term strategy for successful adaptation to climate change in the coastal zone as well as providing an effective approach for facing and overcoming the other expected challenges referred to above.

PDD1.5-10 JAKARTA FLOOD: VULNERABILITY ASSESSMENT AND ITS ADAPTATION

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Nowadays climate change is become a serious problem in the world. Almost every country is affected by this with different intensity. It is included Indonesia, which is one of vulnerable area of climate change impact. Climate change caused change on weather pattern and may become extreme. There is shorter of wet season but increasing in rainfall. On the extreme event was the severe flooding which caused devastation in Jakarta and surrounding areas. Urban was the most damaged by the event, there are loss area of houses, financial, food, transportation access, health (hygiene), etc. Most vulnerable people were the people who lack of adaptive capacity to climate change. To decrease the vulnerability, it can be done by increase the adaptation tools in Jakarta projected up to year 2035.
Jakarta's flood could be occurred by three causes of flood based on their area, namely north, center, and south side. This paper will describe such all types of flood more detail as well as vulnerability assessment and adaptation planning. By processing the climate model developed in the previous research, it will be done an overlay method for producing vulnerability map of Jakarta. This maps of vulnerability is combined by 7 types of map, those are social development, rainfall, sea level rise, temperature, topography, prosperity, and land use.
The result of the research shows that vulnerability of climate change in Jakarta will as business as usual increase with index of vulnerability up to 1 relative to all area of its surrounding. By implementing adaptation option as one of increasing adaptive capacity especially in Jakarta is decrease of sensitivity on impact of climate change. Based on projection built by model, Jakarta can be potential to decrease on climate disaster by doing adaptation action recently up to the future. Adaptation option can be referenced to developed countries which be effectively implemented in existing condition.

PDD1.5-11 THE AYEYARWADY DELTA, THE CYCLONE NARGIS AND THE NON-STATE ACTORS

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The Ayeyarwady River (Irrawaddy River), the longest river in Burma-Myanmar, flows 1348 miles (2170 Km) from north to south of Myanmar (Burma). It arises by the confluence of the N'mai and Mali Rivers in Kachin State, which find their sources in the Himalaya glaciers of Northern Myanmar. Drainage area is about 413,000 sq. Km (covers large part of Burma-Myanmar). The average annual discharge, 13,000 Cumec made it possible to rank as one of the major rivers of the world. Since the sixth century it is the most important commercial waterway used for trade and transport. The river is still as vital today, as a considerable amount of (export) goods and traffic moves by river. More importantly, Ayeyarwady division, which is constituted by the delta, was Rice Bowl of Asia in the past. Rice is produced in the Irrawaddy Delta, both rain fed and irrigated by water from the river. The extraordinarily severe Nargis Cyclone hit Burma-Myanmar in May 2008, which caused tens of thousands of lives and hundreds of millions worth properties. The rehabilitation and recovery work have not yet been completed. The negative impact of the Cyclone Nargis was particularly severe due to the direction, timing and the topography of the delta, however, more importantly, due to lack of awareness, capacity and preparation for the major climate change impact. Most of the terrain level in the delta area lies between 3 to 5 meters above the mean sea level. In a paper published in Nature Geoscience on September 20, 2009, Syvitski and his colleagues warn that deltas throughout the world are sinking, and Ayeyarwady delta is one of them. The low elevation makes the delta particularly prone to flooding from storm surges. As deltas sink, storm surges can move farther inland, affecting more people. This paper provides two kinds of information, (a) physical condition and carrying capacity of the delta at present and (b) the political, social, economic and environmental changes that were taken place during the period from 1850 to 2010 from the non-state actor's perspective. The aim of this paper presentation is to begin a meaningful capacity building on Research, Dissemination, Deployment and Development (RDD&D).

PDD1.5-12 INTEGRATED COASTAL MANAGEMENT TO RESPOND TO CC AND SLR - A STUDY IN VIETNAM

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At coastal areas, there are always problems regarding socio-economic development, natural resource and environmental management. Examples are environmental pollution and degradation, especially the degradation of ecological system, degradation of mangrove forest, conflicts in land use, between traditional fishing and aquaculture development, and between aquaculture development with environmental and ecological system conservation. At coastal area, climate change (CC) and sea level rise (SLR) usually does not create new problems, but make existing problems more serious. Thus, the most practical way of responding to CC and SLR is to solve present problems and building the capacity, or in other way, enable the environment for the response to CC and SLR. This approach requires responding to CC and SLR by the method of integrated coastal management (ICM).
With these facts, in the project of "Developing capacity of national focus organization for climate change"funded by DANIDA, the Research Institute for the Management of Seas and Islands (RIMSI) implemented a pilot study at a commune in Hai Phong City, Vietnam. Purposes of the project are determining problems relating to CC and SLR, assessing impacts of CC and SLR, and establishing action plan to respond to CC and SLR, including implementing ICM. Results of the study can be used for institutional and policy development at national scale.
The existing problems at the studied commune include lacking of an appropriate socio-economic development planning, unsustainable development of aquaculture, environmental pollution etc. Also, there are conflicts between traditional fishing and aquaculture development, between aquaculture development with environmental and ecological system conservation. Problems relating to CC and SLR include flooding due to heavy rainfall and dike break during tropical cyclone with high storm surge without an appropriate drainage system, increase of environmental pollution, drought, degradation of mangrove forest and ecological system, increase of coastal erosion, increase of poverty for people etc. The ICM helps in sustainable socio-economic development, harmonize conflicts and interests between stake holders, management and development of natural resources, protect environment.

PDD1.5-13 COASTAL SUBSIDENCE OF JAKARTA (INDONESIA) AND ITS IMPACTS

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Jakarta is the capital city of Indonesia with a population of about 9 million people, inhabiting an area of about 660 km2. It has been reported for many years that several places in Jakarta are subsiding at different rates. The results obtained from leveling surveys, GPS surveys and InSAR technique over the period between 1982 and 2008 show that land subsidence in Jakarta has spatial and temporal variations. In general the observed subsidence rates are about 1 to 15 cm/year, and can be up to 20-25 cm/year at certain location and certain period. The observed land subsidences along the coastal areas of Jakarta are relatively have larger rates, and it will somehow affect the coastal environment and development of Jakarta.
Impacts caused by land subsidence in Jakarta can be seen already in several forms. The differential subsidence nature in Jakarta basin may introduce the cracking and damage in buildings and infrastructure and may change the flow pattern of surface water. Subsidence may also enlarge the flooding inundation areas, and in general will deteriorate their environmental quality. Subsidence along several coastal areas of Jakarta also makes them more vulnerable toward sea level rise phenomena. The combined effects of land subsidence and sea level rise will introduce other collateral hazards, namely the tidal flooding phenomena. Several areas along the coast of Jakarta already have experienced tidal flooding during high tide periods.
Coastal area of Jakarta has been experiencing extensive urban development. Many establishments take places in this coastal region, such as sea port, coastal resort, golf course, residential areas, industries, condominiums, malls, hotels, and commercials and office buildings. Some areas have also been reclaimed to accomodate more coastal development initiatives. The adaptation measures to reduce the impacts of coastal subsidence and sea level rise along the coastal area of Jakarta, therefore should be developed as soon as possible.
This paper analyzes and discusses the impacts of coastal subsidence and sea level rise along the coastal area of Jakarta on environment quality and urban development activities along the coastal areas of Jakarta.

PDD1.5-14 FLOOD RISK MANAGEMENT STRATEGIES IN DELTAS

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In several river deltas over the world the flood risks could increase due to a combination of urbanization, economic growth, inundation and the predicted effects of sea level. It is therefore important to understand how different regions deal with these developments. The objective of this article is to summarize and analyse the flood risk management strategies for three river deltas / regions: the Rhine Delta, the Mississippi delta (New Orleans) and Ho Chi Minh City.

Deltas in Depth Theme 1: Regional climate, sea level rise, storm surges, river run-off and coastal flooding
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Based on this analysis a general framework and typology for flood risk management strategies in deltas will be proposed.
In a comparative analysis the three aforementioned deltas will be analysed. For the three case study areas, the paper will summarize the (physical) situation, the different threats and sources of flooding, existing and implemented measures and strategies for flood risk management, and proposed policies and strategies to deal with future changes, such as sea level rise,increased urbanization and economic development.
The three regions all face both different and common issues and challenges. The Greater New Orleans region is situated in the Mississippi delta and is recovering from the devastating effects of hurricane Katrina in the year 2005. A large-scale, US $ 14 billion, program is currently executed to improve the flood defence system and provide the city a 100 year level of protection. In addition, discussions are ongoing concerning a broader range of measures and strategies, including coastal and wetland restoration, adaptation of buildings, flood insurance and improvement of emergency management.
The Dutch part of the River Rhine already has very high safety standards. At this moment, new (higher) safety standards are considered to take into account the increase of the damage potential and protected population. At this same time it is considered how other strategies than prevention, i.e. land use planning and emergency management, can be implemented in the new flood risk management policy.
Flood prevention has been one of the biggest preoccupations of Ho Chi Minh City authorities in recent years. Residents must confront flooding throughout the year , not only in low lying areas, but also in the central districts. Causes of flooding include flood-tide, heavy rainfall, high discharges of the Saigon- and Dong Nai rivers, insufficient capacity of the drainage system, low ground elevations of the city and land subsidence, spatial planning, policies and regulations, lack of public awareness and participation. Many solutions have already been implemented or are underway, but further measures are urgently required.
Based on this analysis it will be discussed if there is such thing as a balanced strategy for flood risk management. Some key questions will be addressed in this discussion: how can different measures and strategies be combined in a “multiple lines of defence strategy” and what are the factors that will determine the technical, economic and societal feasibility of certain (combinations) of strategies.

PDD1.5-15 RHINE ESTUARY ‘CLOSEABLE BUT OPEN’ - FIRST IMPRESSIONS ON WATER SAFETY

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This paper presents the key results in terms of hydraulics as part of a multidisciplinary research project (civil engineers, urban planners, architects and environmental scientists). This project is conducted under the ‘Hotspot Rotterdam-region’ Knowledge for Climate program (October 2009 - May 2010).
The Rijnmond region in the Rhine estuary in the Netherlands is one of the most urbanized areas in the world. The area is densely populated, and highly utilized by various cities, ports, industry and infrastructure. One of the major challenges of regions like this will be climate change. A big question therefore, is how this region is going to cope with ever increasing pressure from rising sea-water levels, river discharges and precipitation during the next century?
The Netherlands is a country with one of the highest standards on water safety in the world. The measures that protect the people of the Netherlands from high water levels are stipulated in the Flood Defences Act. The act stipulates that the authorities responsible for managing the water defences must assess the quality of the primary water defences once every five years. This is done on the basis of design water levels.

Because of climate change, the design water levels will increase. This in turn affects the effort that is required to uphold the safety of the flood defenses. The paper considers the hydraulic implications of a 'closeable but open' alternative, in which barriers have been introduced in favor of the more traditional dike strengthening measures. Considering (extreme) climate change over the next 100 years, it turns out that the existing storm-surge barriers are almost certainly not going to provide sufficient safety against high sea water levels. Changes to the operation of these barriers, or perhaps a complete redesign are necessary. In addition, the locations that cannot be protected by the existing storm-surge barriers are more vulnerable due to higher expected river discharges. Therefore a series of river barriers to divert part of the discharge to other areas has been investigated. The impact of various climate change scenarios in terms of design water levels of three variations of the alternative has been investigated. The results of this study have been used as input for the cost-benefit analysis that was also part of the 'closeable but open' project.

Deltas in Depth Theme 2:

Fresh water availability under sea level rise and climate change

DD2.1-02 EFFECTS OF CLIMATE CHANGE ON THE PHYSICAL DYNAMICS OF SOUTH AFRICAN ESTUARIES

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Problem definition
Estuaries lie at the interface between coastal and freshwater ecosystems. Changes in the frequency and magnitude of the physical forcing from either the terrestrial or marine environment induce bio-geomorphological adaptation in the estuarine ecosystem. Predicting the effects of alterations in freshwater flow on downstream estuaries therefore forms an integral component of water resource planning studies in South Africa. At present, such studies take the form of detailed assessments of the freshwater requirements of individual estuaries using an array of analysis instruments. The studies are costly and time-intensive and do not facilitate comparison of the potential water yield between catchments. In this paper, we present a model which can characterize the physical dynamics of micro-tidal, wave-dominated estuaries along the South African coast and so predict the effects of changing climatic conditions. The implications of using this policy instrument as a screening tool in water resource planning are also explored.

Theoretical Framework and Methods
A simulation model of the physical dynamics of an estuary is developed using the System Dynamics method. A suite of indicators of mouth condition, stratification state, flushing, and sub-tidal, inter-tidal and supra-tidal area are generated and used to assess the health of the ecosystem. The relationship between the indicators and well known concepts in the estuarine literature such as the Estuarine Richardson number, the Hansen and Rattray stratification diagram are examined. The intermittent opening and closure of the mouth of a case study estuary in response to variations in freshwater flow and wave conditions are examined in the light of successionary theory.

Results
In the Great Brak case study, we are able to demonstrate that the anthropogenic effect of enhanced water abstraction causes the estuary to move along the successionary scale from a partially mixed system with occasional mouth closure to a marine dominated system only intermittently connected to the sea. More fundamentally, we classify the potential effects of different climatic conditions on small, intermittently closed estuaries and indicate how the resilience to extreme events (droughts and floods) is reduced. We demonstrate that the model is also able to predict the response of small, permanently open systems to freshwater (and tidal) fluxes and move on to connect the shifts in estuarine character associated with climate change to the incidence and diversity of estuaries along the South African coast. The implications of shifts in estuarine diversity for water resource development planning are addressed.

DD2.1-03 CLIMATE CHANGE EFFECTS ON VEGETATION CHARACTERISTICS AND GROUNDWATER RECHARGE

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Climate change is among the most pressing issues of our time. Increase in temperature, a decrease in summer precipitation and increase in reference evapotranspiration might affect the water balance, freshwater availability

and the spatial distribution and type of vegetation. Precipitation and evapotranspiration (ET) largely determine groundwater recharge. Therefore, climate change likely affects both the spatial and temporal freshwater availability for nature conservation, agriculture and drinking water supply. Moreover, in the coastal (dune) areas, the groundwater recharge is crucial to the maintenance of the freshwater bell and the dynamics of the fresh - salt interface. Current knowledge, however, is insufficient to estimate reliably the effects of climate change on future freshwater availability. Future groundwater recharge, the driving force of the groundwater system, can only be assessed if we understand how vegetation responds to changing climatic conditions, and how vegetation feedbacks on groundwater recharge through altered actual ET. Although the reference ET (i.e. the ET of a reference vegetation, defined as a short grassland completely covering the soil and optimally provided by water) is predicted to increase, the future actual ET (i.e. the ET of the actual 'real' vegetation under the 'real' moisture conditions) is highly unknown. It is the dynamics in the actual ET, however, through which the vegetation feeds back on the groundwater recharge.
In an earlier study we showed that increased atmospheric CO_2 raises the water use efficiency of plants, thus reducing ET. Here we demonstrate another important vegetation feedback in dune systems: the fraction of bare soil and non-rooting species (lichens and mosses) in the dune vegetation will increase when, according to the expectations, summers become drier. From our calculations it appeared that on south slopes of dunes, which receive more solar radiation and are warmer than north facing surfaces, the fraction of vascular plants may drop from 70 to 20 percent in the future (2050) climate due to increased moisture deficits. ET of bare soil and non-rooting species is much lower than that of vascular plants and thus the vegetation composition feeds back on the soil moisture conditions.
Knowledge on such feedback mechanisms is indispensable in the analysis of climate change effects on the future groundwater recharge. Important questions are how, in the course of time, climate change will affect both groundwater table depth and dynamics, and how water management could adapt to these changes. We pursue a dynamic modeling approach that takes account of the interacting processes in the soil-plant-atmosphere system, including feedback mechanisms of the vegetation. This allows us to analyze climate change effects on groundwater recharge and thus future freshwater availability.

DD2.1-04 WILL ROTTERDAM HAVE TO FIGHT FOR WATER?

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In 2008 the second Delta Commission published its report 'Working together with water' on coping with climate changes and sea level rising in the next centuries. The commission made twelve recommendations on water safety, sustainability and opportunities, but forgot to make a thirteenth recommendation on fresh water availability in the near future. Especially in the South-western region of The Netherlands this will become an important issue for further development, not only for the horticultural and agricultural functions, but also for the industrial and harbor activities and the water quality in urban areas of this densely populated area.
In the National Water Plan (2009) however special attention was given to the fresh water availability on a national level. But the impact of climate change, sea level rise and man-made alterations in the water system on a national scale, can have serious impacts in the region of water authority Hollandse Delta. Therefore Hollandse Delta has chosen for an active participation in the Delta Program.
Advised by the first Delta Commission in 1963 the flood defenses along the coast were shortened by closing most of the delta waters. So the Haringvliet became a large fresh water reservoir for the whole region. Not only horticultural and agricultural development flourished, but also the industrial and harbor activities in the nearby Rotterdam area became dependent from fresh water from the Brielse Meer. The availability of fresh water so near to an harbor for deep-drawing ships is one of the major selling points of the Rotterdam harbor. And in 1988 even the greenhouses in the Westland area were connected to the Brielse Meer. And the availability of a constant fresh water supply made it possible to improve a ecological quality of the urban water systems.
Due to ecological problems, climate changes and sea level rising the possibilities are researched of restoring the former estuarine dynamics between the river and the sea. These measures however mean that the availability of fresh water from the Brielse Meer will be imparted. One of the major issue for Hollandse Delta in the next years will be to cope with these challenges. Momentarily the following options are examined:
- No man made changes in the water system: This option means that for the next fifty years the present Brielse Meer system is sufficient to cope with climate changes and sea level rising;
- Diminishing the need for fresh water: this option will impart not only the highly productive agricultural area but also the industrial and harbor activities of Rotterdam;
- Mitigation the salt intrusion by a special monitoring program and special measures at sluices, ship channels et cetera.
- Compensation measures like a new fresh water channel from 25 - 50 km more up stream. Such a channel has to transport up to 50 m^3/s.

Hollandse Delta is therefore connected to three of the Delta Programs ('Fresh Water Supply', 'Rijnmond-Drechtsteden' and 'Southwestern Delta') to deal with this specific fresh water issue for the future.

DD2.1-05 A NEW ADAPTATION TOOL FOR DUTCH FARMERS TO COPE WITH DROUGHT AND EXCESS WATER

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In Dutch agricultural lands, singular subsurface pipe drainage systems discharging directly into field ditches are common practise, unlike most regions of the world where drainage by composite subsurface (controlled) drainage systems is the prevailing standard. The reason is, that land reclamation in The Netherlands was initiated in the low-lying polders in the Southwest where subsurface drains were introduced at a time when furrows and field ditches were commonplace. For decades, the Dutch have optimised growing conditions for farmers by strict groundwater table control, but the drainage criteria that were used have also induced a permanent lowering of groundwater tables. Climate change has enhanced these effects. As a result, land drainage was gradually considered a disputable practice of the past, and pursuing shallower groundwater tables in agricultural lands and nearby nature areas was put on the water management agenda. Even so, such action would inevitably challenge the environment because of enhanced leaching of phosphates and nitrates into surface waters. The question therefore was: how to re-introduce shallower groundwater tables without challenging the environment and growing conditions for crops? In 2008, a drainage contractor and a committed farmer proposed to introduce controlled, composite drainage systems in the SE Netherlands. They claimed that such action would accomodate conflicting demands posed by Dutch legislation with regard to adaptation to weather extremes (drought hazards, flooding) and the EU Water Framework Directive: (i) maintaining the groundwater table below the upper soil layers that are saturated with phosphorous substances is easier; (ii) denitrification is promoted; (iii) iron ochre can be controlled more easily; (iv) composite drainage systems may lower runoff peaks; (v) groundwater depths are more consistent with time, having a favourable effect on crop yields, and (vi) composite drainage systems with submerged pipe systems at narrow spacings may promote redistribution of groundwater in the soil profile. In order to assess these claims, the Environmental Sciences Group of Wageningen University and Research Centre and Engineering Consultancy 'Grontmij' have developed a number of field experiments on monitoring sites at various locations in The Netherlands in 2009. The research is sponsored

financially by the Dutch Province of Zeeland, Rabobank and the Dutch Foundation for Applied Water Research 'STOWA' who coordinates and commissions research on behalf of local water administrations, including Water Boards, Provinces and the Ministry of Transport, Public Works and Water Management. At the experimental fields, various technical configurations of the new drainage concept are subject to thourough investigations in terms of water quantity and -quality, crop yield, operation and maintenance etc. In the presentation, the first results of these experiments will be reported as well as the outcome of a survey among 20 experienced farmers.

DD2.1-06 SALT WATER INTRUSION INTO SHALLOW AQUIFERS OF THE NIGER DELTA IN NIGERIA

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Saltwater intrusion into shallow aquifers within the Niger Delta in Nigeria has become an important water resources issue, especially with the advent of climate change and its attendant sea level rise. Groundwater is the major source of potable water supply within the Niger Delta and a successful management of this resource will depend not only on its planning and regulation but also on an accurate assessment and prediction of the behavior of the saltwater interface. Water samples were collected from 100 wells in ten different communities scattered around the Niger Delta and analyzed for their physico-chemical properties as well as their major cationic and anionic compositions. The locations of the wells were taken with the aid of a global positioning system(GPS) and imputed into a GIS. The digital elevation model of the study area was generated to map the extent and pattern of saltwater intrusion into the aquifers. Vulnerability maps were also generated and the study area was classified into risk zones. The results of the analysis showed that distance from the sea as well as elevation were major determinants of saltwater intrusion into aquifers within the study area.

DD2.1-07 TOWARDS A MORE SELF-SUFFICIENT WATER SYSTEM IN HAAGLANDEN

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The aim of this study is to investigate the possibilities for the Haaglanden region to obtain a future situation which is more self-sufficient in the supply of fresh water. Haaglanden is the region in the Netherlands where predominantly the greenhouse horticulture is located.
Due to climate change, periods of drought will possibly occur more frequently in summer periods. As a result the Haaglanden region will depend more heavily on the fresh water supply from the major rivers. However, due to the effects of climate change, the intake water from the Rhine/Meuse basin may become periodically brackish due to periods of low river discharge and salinity pressures from rising sea levels. In addition, in order to improve the ecological sustainability of the Deltaworks region, structural management alterations are foreseen and this can have also profound implications for fresh water availability in the Haaglanden region.
One adaptation strategy to ensure future availability of fresh water for Haaglanden is to improve the regional self-sufficiency. This by optimizing the use of alternative water sources and making these sources suitable, through water technology, as fresh water sources for the regional surface water and/or the greenhouse sector. As a result the region Haaglanden will be become less dependend of fresh water from the major rivers. Examples of use of alternative regional sources in Haaglanden are the use of brackish groundwater, the use of excess groundwater of former DSM Delft, rain water and the reuse of waste water. To optimally utilize these alternative sources, water technologies are required for proper removal of suspended solids, dissolved salts and contaminants. Important for matching the demand and supply of fresh water is to investigate possibilities for storage. Investigated are the possibilities of application of aquifer storage recovery (ASR) where fresh water is stored in a saline groundwater environment.
The first results of this study are presented. The focus will be on the inventory with respect to the demand of fresh water by the greenhouse sector and a qualitative inventarisation of the alternative water sources in the Haaglanden region. Moreover, the concept of application of aquifer storage recovery in a saline groundwater environment will be presented.

DD2.1-08 DISCONTINUOUS RECHARGE OF FRESH WATER LENSES ALONG THE ADRIATIC COAST, ITALY

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Currently, a large portion of the yearly precipitation falls during the spring and summer on the Northern Adriatic Coast (Italy). Because of high evapotranspiration rates and mechanical drainage however, not much water infiltrates into the coastal unconfined aquifer. One of the consequences of greenhouse warming for the Adriatic coast is thought to be a more distinct separation of a wet and a dry season. In the future a larger portion of the annual precipitation is believed to fall during the autumn creating even longer drought periods with respect to the current conditions. This study investigates with a double density numerical model (SEAWAT) how discontinuous recharge affects the shape and size of the fresh water lenses in the unconfined aquifer of the Adriatic coast. These water lenses are very small (up to 8 m thick in the centre) and undergo strong seasonal variations in thickness. It is only recently realized that they are important for coastal ecosystems such as the pine forests that are at risk of disappearing together with the fresh water lenses. A series of numerical simulations are performed on a two dimensional grid representing a 7000 m long by 60 m deep East-West cross section, where a recharge is applied in the middle 1000 m. The simulation time is 300 yrs. With this setup we model the formation of a freshwater lens in the unconfined aquifer of Marina Romea, a coastal watershed near Ravenna. The lens started forming here 300 years ago following a major change in coastline.
We created two series of models, one series with a continuous recharge year round and a second series where the total annual recharge is the same as in the continuous case but it is applied in four distinct seasons. The current climate is simulated with a total annual recharge of 136 mm calculated based on climate data from a local weather station and an estimate of evapotranspiration based on the Penman Monteith equation. Other model runs that simulate a possible future include 272mm, 68mm, and 34 mm annual recharge. The models show that both for continuous and discontinuous recharge, the depth to the fresh- salt water interface increases with total annual recharge. By comparing the continuous and discontinuous recharge models, it becomes apparent that for recharges less than 100 mm/yr, if applied continuously, there is no fresh water lens at all. If the same annual recharge is applied over alternating wet and dry periods however, a mall fresh water lens does exist after a simulation time of 300 years. These results suggest that in some cases the presence of freshwater lenses at all, may be due to the strong seasonal differences in aquifer recharge. For our study area, small annual recharges of less than 100 mm/yr are realistic, because of the high evapotranspiration rates and the large volumes of water drained mechanically to prevent flooding of urban areas and pine forests.

DD2.1-09 THE CHALLENGE TO ADAPT TO DRYER AND MORE SALINE CONDITIONS IN THE GROENE HART

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The Groene Hart is part of the delta of the river Rhine. The area is situated between the cities of Amsterdam, The Hague, Rotterdam and Utrecht. It is one of the National Landscapes of the Netherlands containing an important cultural heritage in land cultivation. The ambition is to preserve this typical dutch landscape. It is characterized by peaty meadow areas and so-called droogmakerijen (deep lying areas, up to 6 m below sea level). These droogmakerijen were reclaimed during the last centuries.
Land use in the Groene Hart varies from different types of agriculture, but also glasshouse-complexes and tree and shrub nurseries. Beside agriculture also nature reserves and urban areas each with their own specific water demand features, both on quantity and quality.
One of the main treats of the area is peat oxidation and soil subsidence. Water level rise is one of the measures to be taken, what means more input of (fresh) water in dry seasons. Due to climate change the Groene Hart is confronted with an increasing demand for fresh water. In addition summers will be dryer and surface water is becoming more saline. The latter is caused by an increase of upward seepage of brackish groundwater in the droogmakerijen and by seawater intrusion in the branches of the river Rhine. The area used to have abundant fresh water resources. Now it is confronted with an increase in fresh water demand and a decrease of fresh water resources. Fresh water is becoming scarce. In addition urbanization is going on resulting in competing claims on land use.
In the study the increase in fresh water demand towards 2050 is elaborated using water balances. In addition the changes in water quality are studied. For a number of pilot areas detailed forecasts were made of 2050 hydrological conditions using rainfall-evaporation time series derived from the climate scenarios of the Dutch national meteorological institute (KNMI). The results were discussed with representatives of the pilot areas and high potential measures to adapt to dryer and more saline conditions were defined. Water management measures were related to competing claims on land use. Based on the considered climate scenarios some characteristic results of water balances and changes in water quality are presented.
With the help of a neural network the results for the pilot areas have been upscaled to the entire Groene Hart. Based on the results a clear insight is gained for the development in fresh water demand and high potential local measures to reduce fresh water use and to adapt to more saline conditions. Finally also a minimum cost/maximum flexibility scenario for no regret measures and a long-term strategy for adaptation measures have been defined.
The results are input for a national study. The national study is part of the Delta-program and will result in a proposal for the nation wide distribution of fresh water in dry periods.
Finally the significance of the results for other delta regions like the Mississipi Delta and the Ganges Delta will be discussed.

PDD2.1-01 PERSPECTIVE OF SALINE AGRICULTURE FOR DELTAS IN TIMES OF CHANGING CLIMATE

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Gradual and irreversible salinization in the Dutch delta due to global climate warming threatens conventional agriculture. Measures to combat salinization require vast amounts of fresh water at high costs. Fresh water from lake IJsselmeer and Markermeer is used to flush salinizing polders and to suppress upward seepage of brackish water. Recently developed national (National Waterplan 2009) and regional (Waterbeheersplan 2010-2015 HHNK, 2009) policy, aims at saving fresh water during periods with increased drought and salinity.
The Knowledge for Climate project “Adaptation to dry and saline conditions in a warming world: crop cultivation exploitating brackish water and saving fresh water”evaluates the possibilities of agricultural exploitation of brackish (and saline) water by cultivation of suitable crops, without yield and quality losses. As a result, vast amounts of fresh water will be saved, to be used for other purposes. The project indicates the possibilities of adaptation to increased salinisation rather than combatting salinisation. More in particular the project explores the possibilities of agricultural use of brackish and saline water. It is expected that vast amounts of brackish water can be used for the cultivation of crops, while yield and crop quality do not or only slightly decrease. Use of brackish water for agriculture will save large amounts of fresh water, to be used as drinking water, industrial process water, for specific agricultural and horticultural practices and for the maintenance of a sufficiently high water table of IJsselmeer and Markermeer and in rural and urban areas in the Netherlands. Flushingh with fresh water of polders to suppress increasing salinity due to seepage of brackish ground water, can be significantly reduced. This will save vast amounts of fresh water and enormous maintenance costs in the watereconomy of the waterboards.

PDD2.1-02 STOCHASTIC RISK ANALYSIS OF SOIL AND GROUND WATER SALINITY IN RIVER DELTA AREAS

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Many coastal and in particular river delta areas are densely populated regions, that are important for agriculture. Often, they are characterized by both sedimentary deposits and saline ground water. This saline ground water may be of connate or fossil origin (due to the Holocene transgressions), but may also derive from sea water intrusion or secondary (irrigation related) salinization. Due to evapotranspiration, salts may accumulate in the topsoil if they are not leached regularly by infiltrating water. Such a salt accumulation may pose a problem for agriculture. Whereas salt accumulation as such may in some cases be reversible, the chemical changes that may be associated with salinity (sodicity, alkalinity) may be poorly reversible. In this presentation, we develop a risk analysis methodology, that is based on an ecohydrological systems analysis approach of soil and ground water. In particular, the water and salt balances are considered for arbitrary soil, crop/vegetation, and climate properties. Rather than risk analyses of soil and ground water contamination, our approach is explicitly taking into account that weather patterns have a distinct erratic pattern, that may alter due to climate change. To accommodate this erratic behaviour, we use a stochastic framework to analyze and quantify salt accumulation associated risks. We show that for several meaningful cases, the risk assessment may even be done with explicit mathematical solutions of the governing mass balance equations, which makes the analysis very transparent and quickly to evaluate.

PDD2.1-03 THE NETHERLANDS HYDROLOGICAL MODELLING INSTRUMENT FOR FRESH-SALINE GROUNDWATER

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Introduction
To make The Netherlands Climate Proof for the coming century, fresh water supply is one of the top priorities in the Delta Programme and in the Dutch National Water Plan. The Netherlands Hydrological modelling Instrument (NHI, [1]) will be one of the instruments within the Delta programme to assess the impacts of future stresses to the water system and to come up with feasible strategies for future water management. In the Dutch coastal zone, brackish to saline groundwater is an important driver for salinisation and for the water quality of the regional to local surface water system. Within NHI, a fresh-saline module on a national scale is created to take into account these fresh-saline processes. The NHI fresh-saline module simulates variable density groundwater flow and coupled salt transport in the subsurface, and considers the following physical processes: 1. the autonomous internal salinisation due to past hydraulic head differences in the top system (e.g. high sea level relative to low-lying polder water levels), 2. climate change (the KNMI 2006 scenarios), 3. land subsidence (up to 1 m per century), and 4. strategies such as water level variation in the large fresh water lake IJsselmeer.

Method
The NHI fresh-salt module is largely based on the NHI model [1], which is based on the on-line coupling of the groundwater system (MODFLOW) with the unsaturated zone (MetaSWAP), and can optionally be coupled to a national surface water module (MOZART-DM). The data is derived from several national databases, including geological, groundwater extractions, top soil, land use, drainage, water distribution, water management and meteorological data. The NHI fresh-salt module is created with the MOCDENS3D code [2] to simulate 3D salt transport. It has 20.6 million active model cells of 250*250m^2, which makes it the largest regional fresh-salt model worldwide. The used initial chloride and density data are based on several national resources, such as analyses, VES, borehole measurements, and the national brackish-saline interface from the ZZREGIS database. A 3D interpolation has been executed using geostatistical procedures.

Results
The NHI fresh-salt model is used for simulating the most important processes for salinization in the Netherlands. The model shows that variable-density effects on groundwater flow must be considered in the coastal zone, as otherwise wrong head and flow patterns are simulated. The zone of influence of sea level rise appears to be limited to areas within ~10 km of the coastline and the main rivers. Salt load to the surface water system in the coastal zone is severe in the low-lying polders where seepage values are large and the chloride concentration is brackish to saline. Model results are compared with satisfaction to earlier studies in the polder Nieuwkoop, Haarlemmermeerpolder, and polder Mijdrecht. This NHI fresh-salt module will be an important tool to validate feasible strategies for future water management in the coastal zone.

References
[1] URL: http://www.nhi.nu/nhi_uk.html (most in Dutch). Detailed information: http://www.nhi.nu/referenties/Modflowandmore_Netherlands_hydrological_modeling_instrument.pdf
[2] Oude Essink, G.H.P. 1999. Simulating 3D density dependent groundwater flow: the adapted MOC3D. Proc. 15th Salt Water Intrusion Meeting, Ghent, Belgium: 69-79.

PDD2.1-04 SALINISATION AND FRESHENING OF PHREATIC GROUNDWATER IN ZEELAND, A MODELING STUDY

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Problem definition
The fresh water resources in the groundwater system of the Province of Zeeland, The Netherlands, are at present jeopardized by various causes. Floods, droughts, eutrophication and salinisation of the ground and surface waters are some pressing topics. Moreover, sea level rise and climate change threaten the groundwater system even more. The Province, in collaboration with Deltares, has initiated this study to get a better insight in the salinisation and freshening processes in the top of the water system. The main goal is to analyse what measures can be effective to make the fresh water supply climate proof. Special attention is given to the shallow rainwater lenses in agriculture plots (De Louw et al., 2008; Oude Essink et al., 2009). Agricultural crops in this brackish to saline environment depend on these shallow vulnerable water systems. In this abstract, the emphasis is focused on the development of the large 3D numerical model of the region, and on the determination of the initial chloride distribution.

Methods

A 3D numerical regional model is constructed with the code MOCDENS3D (Oude Essink, 1999) to simulate fresh, brackish and saline groundwater. With a 64 bits compiler, a large number of model cells can be used to merge two necessary features: to simulate details in the top groundwater system (necessary to get enough detailed information for salt damage to crops) and to determine changes on a regional provincial scale. The dimension of the model is 70 km by 67 km by 142 m thick, whereas over 15 million model cells (100*100m2) were used in 40 model layers. As we are interested in the salinity at the top system, we modeled this top part of the system with very thin model cells (viz. 10 model layers have model cells of 0.5 m thickness), which causes long computation times to simulate 100 years. On top, one of the most difficult parts of modeling variable density groundwater flow and coupled solute transport on this regional scale is the determination of the initial fresh-brackish-saline distribution. Here, we were able to combine various (geophysical) techniques, such as groundwater samples, geo-electrical borehole logs, electrical CPT, VES, EM31, EM34, groundwater extractions, CVES and TEC probe data, to improve the first estimate of the distribution.

Some preliminary results

Up to now the following steps were executed to determine the initial fresh-brackish-saline distribution (Goes et al., 2009): 1. 3D interpolation of analyses, VES and borehole measures via geostatistical procedures; 2. penetrating this 3D distribution with a mapped brackish-saline interface (of 1000mg Cl-/l) and 3. implementing salinity values of open surface. In addition, for the future, helicopter-borne geophysical systems and empirical relations for shallow low lying rainwater lenses (De Louw et al, 2010) will also be used to improve this distribution. With this improved 3D fresh-brackish-saline distribution the current fresh water resources can be estimated and with the 3D model the influence of climate change, anthropogenic processes and compensating measures on the salinisation of groundwater and surface water can be determined.

PDD2.1-05 ASSESSMENT OF SOIL SALINISATION RISKS UNDER IRRIGATION WITH BRACKISH WATER IN THE SEMI-ARID TUNISIA

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The salinity problem is becoming increasingly widespread in arid countries. In these regions, water is the most limiting factor of agricultural production. In the semi-arid Tunisia, the water resources are largely inadequate for the growing population. Among the conventional waters, 50% has a salinity superior to 1.5 g/l and 30% is > 3 g/l. As fresh water is allocated in priority for drinking purposes, irrigation water is often of poor quality. Because of the risks associated to climatic change, poor water quality as well as poor soil and water management, about 50% of the irrigated land in Tunisia has been considered as highly to very highly sensitive to salinization (DG/ACTA, 2007). While only about 8% of the Tunisian farmland is irrigated, around 35% of the agricultural production comes from irrigated agriculture. In addition, about 65% of the Tunisian population is associated (directly and indirectly) to the agricultural sector. Hence, the negative impacts of soil and water degradation in the irrigated areas on farmers' income, the environment and the overall economy. To reduce and avoid the risk of salinization, it is important to control the soil salinity and keep it below plant salinity tolerance thresholds. To reach that goal, field and laboratory measurements of soil and water composition and properties have been conducted to establish the causes of irrigated soil salinization; the functional homogeneous areas (F.H.A) could hence be determined. Whatever the climate of the irrigated areas (semi-arid to Saharan) is, it was found that groundwater constitutes one of the main soil salinization risk factor. This paper aims at showing how FHA, which differ by their risk salinization level, can be used to select the appropriate soil and water management strategies (salt tolerant crops, water leaching fraction, irrigation systems.

DD2.2-02 'PROMOTION OF ALTERNATIVE WATER OPTIONS IN THE COASTAL ZONE OF BANGLADESH'

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Safe water problems in coastal region of Bangladesh indicate severe scarcity of safe water that will make people's life deadly miserable in near future. Conventional hand pumps, both shallow and deep are not viable in this region. There are little scopes for slow sand filters, but this opportunity is gradually narrowing. People take saline water into wetland for shrimp-culture, which contaminate pond's water. Besides, continuous presence of saline water in the shrimp-lands contaminates under-ground water. Increasing trends of sea level contaminating new areas.

The coastal wetlands situated in southern part of Bangladesh covers about one-fourth of total lands of the country. Magnitude of safe water problems in coastal region caused by excessive saline intrusion and the current increasing trends of sea level indicates severe scarcity of safe drinking water that will make people's life deadly miserable in near future. Shallow and deep tube-wells are not viable in this region to install due to excessive salinity in ground water. There are little scopes to install slow sand filters (psf) in few areas, but this opportunity is gradually narrowing, as many of wetlands have gone under brackish water for shrimp-culture. In many cases, saline water is taken into wetland for shrimp-culture through polders, which causes contamination of sweet water in pond. Moreover, continuous presence of saline water in the shrimp-cultivation lands is also contaminating under-ground water mixing with salinity. Rapidly increasing trends of salinity are creating vulnerability for saline intrusion in the new areas. In these circumstances, people who used pond water instead of tube well water or used tube well water for drinking purpose are now compelled to fetch safe drinking water from long distances of their living places. Generally, women and children have to walk on an average 5/6 km or more daily to fetch drinking water. This unexpected situation does not only create health hazards of them but also lead them to various social problems. These situations are more aggravated in the coastal-urban due to rapidly growing number of population.

Despite Bangladesh claims commendable success in creating access to safe drinking water for about 98% rural people, scenario of coastal area is quite different. According to the available data, an average of 700 persons depends on a single safe water source. There are few community-based options installed by the government and some ngos. Unfortunately, the well-off people are occupying those since the poor people could not afford those options due to high installation costs. Many of those remain non-working and under utilized caused by poor maintenance. Compelled by this unexpected circumstance, people use brackish and unsafe surface water for drinking, cooking, bathing, child washing and other domestic purposes.

In this circumstances, concern universal started implementation of disaster resilient watsan program in Bangladesh, which is already highly recognized and appreciated. Now we are planning more innovative approach to meet up the above – mentioned crisis, which could be shared in this platform to gain more learning and experiences.

DD2.2-03 SALINITY AND LIVELIHOOD IN A BANGLADESH VILLAGE

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Bangladesh, a low lying alluvial country with 150 million population straddles the fertile Ganges-Brahmaputra Delta facing 710 km long coast to the Bay of Bengal is one of those countries which is responsible least but victim most of global warming or climate change. Different projections show that a large coastal portion of this country will be severely affected due to sea level rise related impact. One major such consequence is salt water intrusion in the coastal region which is already happening and thousands of traditional farmers have been struggling to adapt with salinity in different walks of their lives such as drinking, sanitation, livelihood etc. This paper deals with exclusively the ways local people respond to salt water intrusion regard to their livelihood or subsistence pattern. The findings come out from a minor field work and to make sense my observation I have used my anthropological insight more specifically how people respond to the changing environment for their subsistence. The paper can be placed under the umbrella of 'Anthropology of Climate change', a growing and relatively new field in Anthropology.

DD2.2-04 DEGRADATION OF INDUS DELTA AND ITS CAUSES: A CASE STUDY OF INDUS RIVER DELTA

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Indus river delta and its Mangroves are fighting a combat of their survival, due to shortage of fresh water, from Kotri downstream since last two decades. Life on the delta is facing a lot of troubles, especially the flora and fauna. Mangroves are very famous forest of the world; they take plenty of water for their survival. Saline Sea water is increasing on surface and sub-surface toward the coastal districts of the Sindh. Fertile land is converting in sterile land. Local inhabitants are shifting from the region. Mangroves are washed away from the area. Sea water intrusion is increased day by day, per day rate of intrusion is 80 acres of delta land. About 38 percent area of mangroves forest has been reduced in last twenty years. Main cause of the degradation of Indus river delta is increase of water level of the Arabian Sea, due to climatic change. Some minor causes are construction of dams, canals, and barrages on the Indus River before the Kotri barrage. The study shows that fresh water in the River may push backward to the sea water intrusion and will help for the survival of the mangroves forest.

DD2.2-05 CLIMATE CHANGE SIGNALS IN EASTERN HIMALAYAS AND IMPLICATIONS FOR GBM DELTA

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The Ganges-Brahmaputra-Meghna (GBM) Basin region of South Asia is home to over 500 million people. Water is intricately linked with the overall development framework of this region. The strong seasonal and inter-annual

variability of these large eastern Himalayan rivers pose a great challenge for efficient and sustainable water resources management in the basin. Lately, concerns about region wide climate warming and early signs of glacial retreat have raised questions about the long-term flow availability of these rivers. In addition, possible seasonal shifts in the regional streamflow patterns may lead to major changes in environmental impacts and water management and usage practices. We focus on identifying climate induced changes in precipitation and streamflow patterns of the GBM Delta region. We compare precipitation, streamflow, and related atmospheric changes for the upper Brahmaputra and the Ganges basins at monthly, seasonal, annual and decadal scales. We investigate recent trends in regional hydroclimatology and analyze impacts on river basin management, water-borne disease outbreaks, agricultural, and ecosystem parameters. We find that a strong warming signal is already evident in the recorded discharges of the Ganges and Brahmaputra rivers. While we see no trend in total annual streamflow or precipitation, seasonal flow values for both basins show a significant shift; dry season flow has risen significantly, while monsoon flow volumes have decreased. Evidence points to increased amount of winter precipitation falling as rainfall in upper catchments as well as early snowmelt in spring due to regional warming.
Increased dry season flow may provide relief for water scarcity in downstream delta areas, coastal salinity problems, and spring cholera outbreaks. On the other hand, lower monsoon flow may contribute to reduced flood damage and fewer water-borne epidemics in summer and fall. While these hydroclimatic changes may lead to short-term benefits for the region, long-term viability of such changes and associated benefits will remain questionable. It is thus imperative to understand the shifting flow patterns of the large rivers in this climate sensitive region and associated impacts on agriculture, navigation, public health, and ecosystem needs.

DD2.2-07 INTEGRATED POLICIES ARE A MUST TO FACE FUTURE WATER SCARCITY IN EGYPT

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"Egypt is a gift of the Nile", wrote Herodotus, and indeed, without the Nile there would be no Egypt as the world knows it. Rainfall is negligible and Egypt completely depends on its annual share of Nile water, 55.5 BCM (Billion m3) annually, that originates from the upstream headwaters of the Nile in the humid Ethiopian and East African highlands. Its sustainable water resources are the agreed fixed share of the River Nile discharge and the rainfall on the northern coast of 1.3 BCM annually. There is limited possibility to augment Egypt's water supply. Climate change may result in either more or less water for Egypt.
The growth of the Egyptian population and its economy in the near future will lead to an increase in the demand for water, and water is the key for stability and prosperity in Egypt.
Future water allocation will have to be done with keeping all water using sectors in mind. The overall priority sequence is: first drinking water, then industry, and whatever is remaining will be available for agriculture and nature. The increasing demand for the limited water resources puts pressure on the Government to formulate policies and programmes to adjust water allocation among various water users, with the agriculture sector using more than 80 percent of available water. The main option available in the short term to reduce water scarcity in the priority sectors of the economy is to reallocate (less) water within the agriculture sector.
However, the issue of water scarcity has consequences and implications that can no longer be adequately addressed by any of the Ministries alone. Many other government departments and agencies must be involved and decisions will have to be made at the highest political level.

All policies in Egypt must be conscious of the severe limitations in water availability, and water policies need to address technological developments as well as the full range of other issues, including e.g.: macro-economic factors, economic issues that influence farm-level decisions, development of human capital, governance, and financial risk management.
Notwithstanding the fact that 'water solutions"alone will not be enough, in Egypt as well as many other arid and semi-arid countries, this is still an urgent need to work towards an increase in water productivity, leading to "more crop per drop", "more cash per splash", etc. There is an urgent need for innovation in the field of water and agriculture, and the Government role in the process could be to reward the front runners for their entrepreneurship by sharing the risks or subsidizing initial investments if required, and to provide access to Universities and Research Institutes to solve urgent research questions.
The Government will be well equipped to deal with future uncertainties if it prepares a 'scarcity outlook' that addresses the situation in 2050.

DD2.2-08 MAPPING DEFUNCT CHANNELS IN THE NILE DELTA AND THEIR IMPACT ON THE GROUNDWATER

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The historical description of the River Nile Delta by Herodtus (484-425 B.C) is probably the oldest available document suggesting drastic changes in the paths and number of channels in this Delta. It is believed that most of the original Holocene distributaries of the Nile Delta were silted up and buried and reduced from seven branches to only two branches (Damietta branch in the east and Rosetta branch in the west). Currently, several large relict segments and abandoned meander channels can be traced on recent satellite images and topographic maps. These inactive channels are disconnected from the main branches and are located within the agricultural fields. In the present work, the oldest available topographic maps, produced in 1937 at a scale of 1: 25,000, were digitized and compared with maps produced from recent Egyptsat1 satellite images. This enables the detection of the most significant hydrological changes in the southern Delta.
The rapid and non-planned urban expansions in the study area during the past few decades have encroached several buried channel courses and cutoff meanders. Man-made drainage channels that collect drainage water of agricultural fields, raw and partially treated sewage and solid wastes from urban areas are often overlaying and crossing these buried channels. The exposed inactive segments are often used as disposal sites for agricultural and urban wastes and even, in some cases, for fish farming. Moreover, the municipal water supplies of most villages and cities in the Nile Delta are derived from the Pleistocene aquifer underlying the top fertile silt and soil layer. Therefore, seepage and recharge to the groundwater aquifer from the polluted drainage channels is serious and significant, particularly where defunct meanders and buried channel segments are directly overlain by the drainage channels and in contact with the aquifer.
It is recommended to use tracers and geophysical methods to monitor ground water flow in the aquifer and related abandoned channels. This will enable better control of contamination (pollution) hazards.

DD2.2-09 AQUIFERS AS A STORAGE AND REACTION VESSEL: A CURE-ALL FOR CLIMATE CHANGE?

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Groundwater bearing strata with sufficient permeability, so-called aquifers, are increasingly used for storage of both water and energy, in order to mitigate the global water and energy crisis. In addition, climate change is expected to strongly amplify fluctuations in the discharge of rivers and thereby also in water quality (e.g. increasing salinization of coastal areas). This will raise the need to store high quality river water when abundant, for later use in periods of extended and severe drought. In deltas like the Netherlands, above-ground space for water storage is very limited or too expensive, whereas aquifers are extensive and easily accessible. In case of polluted surface water and treated sewage effluent, aquifers also assist in selfpurification and thus save on treatment costs while producing a more 'biological' than 'industrial' water product. Seasonal heat changes can be stored in the underground and recovered when either heating or cooling is needed while using heat exchangers to boost the temperature contrast.
In addition, new combinations are explored like ATES (Aquifer Thermal Energy Storage) in areas where soil/aquifer remediation may profit from the higher temperatures that stimulate the biodegradation of organic pollutants. In that case the aquifer can be considered as a heated reaction vessel.
Aquifers therefore look like a cure-all for various problems related to water scarcity, water pollution, the energy crisis (by storing green energy and reducing CO_2 emissions) and climate change.
In this presentation historical developments in the use of aquifers are given, while the various processes, advantages and disadvantages pass in review. Special attention is paid to the sustainability of aquifer recharge, operational aspects of ASR wells (both small and large scale) and to potential adverse interactions between ATES and groundwater abstraction for drinking water supply.

DD2.3-02 POLICY OPTIONS FOR SUSTAINABLE FRESH WATER SUPPLY IN SALINE DELTA AREAS

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The SW delta area in the Netherlands consists of the estuaries of the rivers Rhine, Meuse and Scheldt. Interactions between sea, rivers and inland waters are characteristic for the whole area. While naturally a brackish area, the almost unlimited external fresh water supply created opportunities for extensive development of agriculture and industrial water use, thereby boosting economic development. However, it is expected that due to climate change and policy measures aiming at restoration of estuarine dynamics, a shortage of fresh water may develop in the future, as water supply will decrease whilst water demand is still rising. The main question is if and how the current and future freshwater demand in delta areas can be safeguarded under the changing circumstances.
Based on projected water demand and supply under climate change, a qualitative water balance analysis has been

carried out for a number of areas in the SW Delta area. The analysis clearly shows low usage efficiencies with respect to fresh water supply. Only a small percentage of the total fresh water supply is essentially used for irrigation or industrial and drinking water. The largest part is used for sustaining the designated water levels and for flushing out the salt load (originating from upwelling of brackish ground water). In other words, a huge volume of fresh water is used to keep the system fresh, while only a small percentage is used for irrigation or potable water.
Given these analysis results, the policy options for sustainable water supply to the delta are:
(1) resisting salinization; supply follows demand. Given the small water demand compared to the total intake, it seems rational to look at measures that limit the volume of water required for flushing. The dependency on external supply will decrease while the self-sufficiency will increase.
(2) adaptation to salinization; demand follows supply. The system is no longer maintained fresh implying that the intake of fresh water is no longer required. This implies separation of the fresh water supply from the inland surface water system and will boost technological solutions for water supply (desalination, re-use of effluent water from sewage purification, etc.).

The challenge is to select the most viable strategy, or a combination of strategies. The preference mainly depends on the characteristics of the area.
In order to develop sustainable strategies to cope with climate change in areas sensitive to salinization and in demand of fresh water, it is essential to understand the water balance both in terms of quality and quantity. It has been illustrated that in some areas the inefficient fresh water use is the major challenge while in other areas sustainable water supply requires only limited interventions. The approach developed in this study is applicable to more low lying delta areas with high fresh water demand.

DD2.3-03 USE AND AVAILABILITY OF FRESH WATER IN THE SOUTH-WEST DELTA OF THE NETHERLANDS

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Introduction
The Delta Works, which have been protecting the land and the inhabitants from the sea since the disastrous floods of 1953, have ensured safety. However, they have also had a downside for nature, water quality and the regional economy. A familiar example is the water-quality problem (blue-green algae) in the Volkerak-Zoommeer lake.

Problem definition
The best solution to the blue-green algae problem in the Volkerak-Zoommeer fresh-water lake is converting it into a salt-water lake once more with gentle tidal movement. This will have an enormous impact on the fresh-water supply in a large area. In the long term, we will face the effects influenced by climate change and the trend towards more intensive agriculture. How will we face these challenges?

Approach
In the South-West Delta, an extensive fresh water area-specific process has been implemented for areas directly influenced by the increasing salinity of the Volkerak-Zoommeer lake. This has led to an unanimously supported (stakeholders and administrators) delta-wide Fresh Water Advice. The advice consists of a package of measures to restrict as far as possible the adverse consequences (at an acceptable cost level) of a salt-water Volkerak-Zoommeer for all fresh-water-dependent functions. In parallel with this development, the supply and demand of fresh water in the long term have been explored. The expected climate change was based on the driest of the four Royal Netherlands Meteorological Institute scenarios, the W+ scenario, and water and salt balances were drawn up.

Results
Fresh water supply for the short and medium term (up to 2050)
The Fresh Water Advice solutions consist of a combination of measures: supplying fresh water from elsewhere, restricting salt-water penetration in the Haringvliet and Hollandsch Diep lakes with innovative fresh-salt water separation in the Volkeraksluizen locks, salt-restriction measures in the Rijnmond area, as well as technological solutions. The Fresh Water Advice consists of a total package of 18 measures, summarized in the enclosed table.

Fresh water supply for the long term (>2050)
For the long term there are two conceivable policy strategies: either continuing to combat salt and maintaining functions, or admitting salt to parts of the delta and adjusting functions. The time ('turning point') at which a change of policy is required may occur even before 2050.
As things now stand, it may be concluded that for the long term, there is not sufficient fresh water available to combat both the increasing internal salinity and the fresh-water demands of all sectors. The choice between continuing to combat increased salinity together with improved water efficiency (and therefore greater regional self-supply), or admitting salt in parts of the delta and adjusting functions, will have to be addressed at some time. However, the choice is not urgent at present.
By implementing the Fresh Water Advice, the fresh water supply will be sufficient in the medium term. We can use the coming years time for a more effective quantification of the effects of climate change and to supervise area-specifically the fresh-water-dependent sectors in the case of any transition.

For illustrations see website: www.climatedeltaconference.org/results

DD2.3-04 EFFECTS CLIMATE CHANGE ON COASTAL GROUNDWATER SYSTEMS, FOCUS ON THE RHINE DELTA

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Introduction
Climate change in combination with increased anthropogenic activities will affect coastal groundwater systems throughout the world. In this presentation, we focus on a coastal groundwater system that is already threatened by a relatively high sea water level: the low-lying Dutch Delta. Nearly one-third of the Netherlands lies below mean sea level, and the land surface is still subsiding up to 1 m per century. This densely populated delta region, where fresh groundwater resources are used intensively for domestic, agricultural and industrial purposes, can serve as a laboratory case for other low-lying delta areas throughout the world. Our findings on hydrogeological effects can be scaled up, since the problems the Dutch face now will very likely be the problems encountered in other delta areas in the future.

Method
To quantify changes in the coastal groundwater flow regime, the transient variable-density groundwater flow and coupled solute transport was modelled in three dimensions with the software code MOCDENS3D. The study area is situated in the southwest of the Netherlands in the delta of the rivers Rhine, Scheldt and Meuse. It has a surface

area of 100 km by 92.5 km. This coastal area is the most densely populated part of the Netherlands (more than 8 million people) and includes the four largest cities: Amsterdam, Rotterdam, The Hague and Utrecht. We calculated the possible impacts of future sea level rise, land subsidence, changes in recharge, autonomous salinisation, and the effects of two mitigation countermeasures. We considered the effects on hydraulic heads, seepage fluxes, salt loads to surface waters, and changes in fresh groundwater resources as a function of time and for several scenarios.

Results
Our numerical modelling results show that the impact of sea level rise is limited to areas within several km of the coastline and main rivers because the increased head in the groundwater system at the coast can easily be released though the highly permeable Holocene confining layer. Along the southwest coast of the Netherlands, salt loads will double in some parts of the deep and large polders by the year 2100 AD due to sea level rise. More inland, ongoing land subsidence will cause hydraulic heads and phreatic water levels to drop, which may result in damage to dikes, infrastructure and urban areas. In the deep polders more inland, autonomous upconing of deeper and more saline groundwater will be responsible for increasing salt loads. The future increase of salt loads will cause salinisation of surface waters and shallow groundwater, and put the total volumes of fresh groundwater volumes for drinking water supply, agricultural purposes, industry and ecosystems under pressure.

DD2.3-05 SOCIAL LEARNING FOR FEASIBLE SCENARIOS OF FRESH WATER SUPPLY IN THE DUTCH DELTA

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Climate change poses immense challenges on deltas and their users in preparing for the future. One of these challenges is guaranteed fresh water supply. We concentrate on the southwestern Delta in the Netherlands. In this region as in other deltas, fresh water supply is under pressure due to an increase of drought periods and due to (expected) increased salinization as a result of sea level rise. Next to that there is the environmental problem of blue algae in the southwestern Delta which brings up a societal discussion on the fresh water supply. Decisions need to be made on how to cope with the fresh water supply in the future, when looking for sustainable solutions. Besides the decreased fresh water availability, the fresh water demand increases. For example, agriculture is developing and expanding and nature reservoirs require sufficient fresh water. In adapting to climate change, solutions need to be found to balance the fresh water supply and demand. Finding these solutions is not only a technical challenge, but also a matter of governance. It is a collective assignment among involved stakeholders. Due to different perceptions on possible solutions and lack of insight in perceptions of other stakeholders this is a challenging task. In this paper, we promote an approach of social learning to realize feasible scenarios for climate adaptation. Social learning is about participation, but not just participation. It is also about a continuous and iterative process in which stakeholders learn to know each other, identify relevant problems, identify and accept uncertainties and explore possible solutions. The approach of social learning was applied in two projects in the southwestern Delta. In these projects, the goal was to find feasible and affordable scenarios for a sustainable fresh water supply for agricultural purposes in the year 2030, together with stakeholders. We draw lessons on the process, steering on the preferred alternative, knowledge within the process and the influence of contextual factors. We identified two types of learning in the projects: cognitive and strategic learning. Both types of learning are necessary and are stimulated by means of an interactive process. During this process, stakeholders' perceptions are explored and connected to the available knowledge base. The process design influenced the possibilities for learning by means of the distinction between a diverging (creative) phase and converging (making decisions) phase. Based on the results of the projects we improved our understanding of the application of social learning in practice. We present social learning as an approach for developing feasible and sustainable scenarios when dealing with the challenges of fresh water supply deltas face in adapting to climate change.

Deltas in Depth Theme 2: Fresh water availability under sea level rise and climate Change
Session DD 2.3: Salinisation in South West Netherlands **ORALS**

DD2.3-06 CLIMATE EFFECTS ON SHALLOW RAINWATER LENSES ON TOP OF SALINE GROUNDWATER

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Problem definition
A sequence of transgressions in the Holocene resulted in a salt to brackish groundwater system in the province of Zeeland, The Netherlands. Saline groundwater with chloride concentration exceeding 10,000 mg/l is found within five meters below soil surface. Upward seepage of this saline groundwater leads to salinization of surface waters. Fresh groundwater in the region is only present in the form of so-called rainwater lenses floating on top of the denser saline groundwater. These rainwater lenses prevent upward seeping saline groundwater to reach the root zone and make the cultivation of crops possible. However, climate change may have major impacts on the characteristics of these rainwater lenses deteriorating conditions for agriculture. Changing precipitation and evapotranspiration patterns will negatively affect the recharge of fresh rainwater and sea level rise will increase seepage fluxes.

Methods
To asses the impact of climate change on these shallow rainwater lenses we started a combined field and model study at an agricultural site in the province of Zeeland, The Netherlands. It is a small area (1 km2) with a large gradient concerning the thickness of the rainwater lens. To map the present characteristics of these shallow rainwater lenses in both saturated and unsaturated zone, we used the following field techniques:
- TEC-probe
- EM31
- CVES
- Groundwater sampling

We modeled the spatial variation of these rainwater lenses in three dimensions with the variable-density groundwater flow and coupled solute transport model code MOCDENS3D. The period of 1990-2010 was modeled to calibrate the present situation by reproducing the results of the monitoring campaign (2009-2010). With the calibrated model, we calculated the effects of several future climate change scenarios which include sea level rise (G,W+) for the next 100 years.

Results and conclusions
Field measurements show a large spatial variation of the thickness of the lenses caused by geomorphic differences. The area is a reclaimed salt marsh (clay area) which is intersected by a higher elevated fossil sandy creek ridge. Here, seepage is absent and infiltration of rainwater occurs until a depth of 15 meter. In the lower clay area, groundwater of 16,000 mg/l chloride is found within 2.5 meters depth. Saline seepage is mixed with fresh rainwater in the upper

2 meters of the soil resulting in the total absence of fresh groundwater in this part of the study area. We were well capable of reproducing our field data with the numerical model. The model results show almost no effects for the G climate scenario, whereas the average chloride concentration in the upper 2 meters increase dramatically with the more extreme W+ scenarios. Sea level rise has little impact in the clayey seepage area whereas the thickness of the rainwater lens in the higher elevated sand area decreases with about 2.5 m.

DD2.3-07 VULNERABILITY TO SALINIZATION OF THIN FRESH WATER LENSES FOR DIFFERENT CLIMATIC AND HYDRAULIC CONDITIONS

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Salt water intrusion and upward seepage of salt groundwater is a widespread problem in low-lying areas of coastal zones that are important for agriculture or ecologically, such as the North and West regions of the Netherlands, Southwest Florida, and many other deltaic areas such as the Camargue in France and the Nile delta in Egypt. Where the soil surface is situated below sea level, saline groundwater moves upward into superficial water networks. On the other hand, infiltrating rainwater forms small-scale fresh water lenses. These lenses have a thickness of less then 1 up to several meters, their length and width depend on drainage density (generally 20-200 m). Field data show that the transition zone can be as thick as the fresh water lens itself. Agriculture is largely dependent on these small buffers of fresh water, especially where availability of freshwater from elsewhere is limited (e.g. Zeeland province in The Netherlands).
Seasonal variability, climate change, sea level rise and human influence, through water level control and/or pumping, cause these lenses to grow or shrink (Schot et al. 2004). Since these variations occur on a shorter time scale then the time it takes for such lenses to reach steady state conditions (Eeman et al., submitted), they are always in a transient state. Due to more vertical flow patterns under transient conditions, this means generally an even shallower freshwater body, and a significantly thicker mixing zone than can be predicted from steady state solutions.
We are therefore assessing the response of such small systems to changing boundary conditions like seasonal variation, climate change or sea level rise. Our aim is to develop an overview of situations where boundary changes may affect current agricultural practice. Given the different settings in terms of climate, soil parameters, water management and species salt tolerance, many parameters are involved in this assessment. We use two software packages, SWAP (Kroes et al., 2008) and SUTRA (Voss and Provost, 2003) to assess vulnerability of systems to salinization of the rootzone and associated crop/ecosystem damage. Results of this analysis should be available by the end of September.

References

Eeman, S., A. Leijnse, P. Raats, S.E.A.T.M. van der Zee. Submitted. The transition zone between a fresh water lens and underlying saline water.
Schot, P., S. Dekker, A. Poot. 2004. The dynamic form of rainwater lenses in drained fens. Journal of Hydrology (293), pp. 74-84.
Kroes, J.G. et al. SWAP version 3.2, Theory descriptionand user manual. Alterra report 1649. Wageningen, 262 pp.
Voss, C.I., A.M. Provost. 2003. SUTRA, a model for saturated-unsaturated variable-density groundwater flow with solute or energy transport. USGS, Manual No. 02-4231, Reston, Virginia.

Deltas in Depth Theme 3:

Climate change and estuarine ecosystems

DD3.1-02 THE TIDAL ELBE ON ITS WAY INTO THE NEXT CENTURY

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Based on the situation of increased dredging necessities in 2004- resulting from strong tidal pumping- in the Port of Hamburg, which is situated 130km inland of the mouth of the tidally influenced Elbe estuary and facing the challenge of new European environmental guidelines as well as climate change, the Hamburg Port Authority together with the Federal Water and Shipping Administration has developed a concept for the sustainable development of the tidal Elbe river as an artery for the metropolitan region of Hamburg and beyond. The concept not only indicates solutions to ensure the long term use of the great benefits resulting from the Hamburg seaport being situated far inland, close to the markets, but also shows answers to cope with climate change and even enhancing the environmental value of the estuary as well as fishery, urban development, flood risk management or recreational uses.
One cornerstone is the optimization of the sediment management, considering the Elbe system in total, including the source orientated improvement of the sediment quality and adapted relocation strategies.

Another essential of the concept is to create as much as possible additional tidal volume, e.g. by realignments, dredging of silted areas or (re)connection of tributaries and side channels. These measures are most effective when realized in the Hamburg region, unfortunately the most densely populated area at the estuary. But even here innovative visions, following a landscape architects approach, are indicating attractive synergies.
Finally, in the mouth, where the Elbe meets the waddensea, from today on sand banks can be nourished, following the principle of “working with nature”, to reduce the incoming tidal energy which is responsible for the unfavorable upstream migration of sediments. These sandbanks can grow with the rising sea level, protecting the mudflats and the coastline behind, and some day, maybe in the next century when sea level rise has topped two meters, be the base of an innovative sustainable operating flood barrage still allowing large vessels to approach the Port of Hamburg.

DD3.1-03 IMPACT OF CLIMATE CHANGE ON THE COCHIN ESTUARY

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Estuarine systems face serious challenges from the changing climate and increasing human interference. Conservation and management of estuaries are becoming increasingly difficult issues, especially in developing countries like India with large and dense population, inadequate finance, poor administrative mechanism and after all high vulnerability to climate change. In the Cochin (Kochi) estuary in the south-western coastal State of Kerala, two major rivers carry large quantities of sediments, mostly polluted, threatening the existence of its major port and rich biodiversity. The Cochin estuary connecting to Arabian Sea is about 90Km in length and 250Km2 in area, and it is the largest of its kind that exists all along the coastal belt of Kerala. This region is economically important, highly productive and plays an important role as nursery grounds for many commercially important fishes. The region receives more than 300cm rainfall from monsoons and local systems. Two major rivers Periyar and Muvattupuzha and numerous canals join this estuary. Steep slopes of the Western Ghats Mountains where the rivers originate allow the rainwater falling in their upper reaches to flow fast to reach the estuary in few hours, carrying tremendous sediment load. Rainfall in this region is becoming more seasonal and intense, causing more erosion and changes in the estuarine water characteristics. Large raindrops from convective clouds enhance erosion in the mountains

where encroachment and deforestation have already degraded the soil. High rainfall seasonality results in reduced runoff for longer period, resulting in salinity intrusion far inland. The estuary as well as the city of Kochi surrounding is threatened by sea level rise and changing tracks and intensity of tropical cyclones. Anomalies in sea surface temperature and changes in coastal circulation in the Arabian Sea affect the existence of habitats in the estuary. Impact of climate change on the estuary largely affects the socio-economic conditions. It affects the life of thousands in the region who depends on the estuary for livelihood and the fisheries that is vital in national economy. This paper assesses the direct and indirect impacts of climate change on the estuary. Trends in climate and changes in sediment have been analysed. A critical review of existing acts, policies and strategies related to estuaries and coastal zones have been made. Results point towards drastic changes in the estuarine environment in near future. Current policies and strategies are unresponsive to changing climate and the implementing mechanism is weak. Legal and administrative mechanisms are slow and the implementation of rules often fails due to political and social reasons. Guidelines for an appropriate policy and adaptation strategy have been provided.

DD3.1-04 VEGETATION SHIFT IN GERMAN ESTUARIES DUE TO CLIMATE CHANGE?

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Problem definition
Marsh and bank vegetation along tidal waterways provide services for the natural balance as well as for human demands e. g. habitat, filtering, food, and bank protection. In historical perspective, structure and species composition of the estuarine vegetation obviously have been shifted successively by interference of agriculture, hydraulic engineering, and water management. Climate change and its related impact on river hydraulics is assumed to cause an additional pressure to vegetation as well as its services. Increasing frequency of extreme hydrological events, more extreme storm-surge events in the southern North Sea as well as rise in tidal range is supposed to affect dynamics of bank and marsh vegetation. As a consequence, for instance bank protection may be degraded due to narrowed or fragmented reed belts.

Theoretical framework and methods
To arrive at identifying marsh areas of the tidal rivers Elbe and Weser being sensitive to future climate scenarios methods of remote sensing will be combined with field research. Disturbance ecology of tidal reed beds and the role of key species including invasive alien plants will be studied. Development and application of vegetation distribution models along the estuarine gradient will give an idea of how future climate and hydrodynamic scenarios will influence bank and marsh habitats. In addition, effects of land use will be examined. Recommendations will be derived, how the current maintenance strategy of the estuaries as well as the marshes should be adapted to changing boundary conditions in order to safeguard and develop favoured ecosystem services.
This project is part of the Governmental Research Programme ‘KLIWAS - Impacts of Climate Change on Waterways and Navigation - Development of Adaptation Options’ (2009-2013), initiated by the German Federal Ministry of Transport, Building and Urban Development (BMVBS).

Results
Results will be presented concerning a) competition experiments of invasive alien plant species and common reed, b) filtering effects of different plant species of the tidal reed bed regarding pollutants, and c) land use analyses. Conclusions for the marsh maintenance in times of climate change will be outlined.

DD3.1-05 SEA LEVEL RISE AND MORPHODYNAMIC EVOLUTION OF INTERTIDAL AREA IN TIDAL BASINS

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Estuaries are a vital part of deltaic areas. Their tidal flats, varying water levels and the salt-fresh water interface form a unique environment that accommodates multiple human activities, such as port development, recreation and fishery. Furthermore, morphologic features of the estuarine system (channels and shoals) form the basis of ecological systems present at salt marshes and intertidal flats. This morphological system is under constant pressure, partly because of the interaction between anthropogenic and ecological functions and partly because of longer term developments. Access channel dredging may have impact on the available intertidal area valuable to bird migration. A rising sea level may disturb the sediment budgets and availability, finally leading to a depletion of salt marshes. The possible consequences of sea level rise on the morphodynamic system have not been studied in detail.
The current study aims to investigate the impact of sea level rise on the morphological system of tidal embayments. Use is made of a 2D, process based morphodynamic model (Delft3D). It describes the tidal water motion and sediment transports and couples this to morphodynamic developments. The advantage of this modeling approach is that it can analyze morphodynamic developments with a high level of detail and on a long (~century) time scales. For the current study we will focus on a parameter relevant to ecosystems, namely the evolution of intertidal area present in a tidal embayment under conditions of sea level rise. We will investigate whether or not intertidal area is depleted and what relevant processes are involved. Is the basin importing or exporting sediment or is sediment re-allocated with the tidal basin? What possible measures (channel/flat nourishment , bank protection) are effective? Focus will be on case studies like the Western Scheldt, different basins in the Waddenzee and San Francisco Bay.
Despite the schematized approach, the study provides a first step in assessing the morphodynamic evolution in tidal basins. More in particular it gives insight into the characteristic reaction time scales of the morphological estuarine system on current rates of sea level rise.

DD3.1-06 RESPONSES OF THE MEGHNA ESTUARY OF BANGLADESH TO CLIMATE CHANGE

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The Bengal delta is one of the largest modern deltas in the world and presently, the delta building activities are very intensive in the Meghna Estuary. Every year great rivers such as the Ganges and the Brahmaputra, bring about one billion tons of sediment, a major part of which gets used for both vertical and lateral accretion of the delta plain. Flood embankments constructed along many of the large rivers and coastal polders in the 1960s and 1970s restrict the

vertical accretion of the floodplain and tidal plain, thus causing a higher rate of lateral accretion in the Meghna estuary in recent decades.
The expediting rate of climate change has become evident now and the Bengal delta would be the worst victim of the phenomenon. On the other hand, Bangladesh, comprising of a major part of the Bengal delta, is a very densely populated country. Due to its low elevation and flat terrain, a substantial amount of land would be fully or seasonally inundated due to a sea level rise of 60 cm in the next 100 years. As a result, millions of people would directly be the victims of climate change. Owing to its poor economic background, coping with the new situation would be a great challenge to the nation. A long-term strategic plan based on sound knowledge on the morphological responses of the delta to climate change is a pressing need for the country.
Understanding on the fluvial responses to climate change elsewhere in the world, responses of the Bengal delta to the sea level rise during the Holocene and long-term sediment balance in this delta, provide an outline of how the system of major rivers and the Meghna Estuary could respond to sea level rise. Analytical models have been used to assess the morphological time-scale, which is required to assess fluvial adjustments in the scale of decades to centuries.
It appears that morphological responses of the major rivers of Bangladesh and the Meghna Estuary would be very rapid, if the present rate of sediment input or more from the upstream is assumed to continue in the future. The response of the estuary to sea level rise would be close to instantaneous near the bay, with increase in time lag at the distance upstream. But such quick morphological responses could not be transformed into a good coping mechanism with sea level rise unless an efficient and effective means of sediment injection process is introduced into the coastal polders and sediment starved areas.

DD3.1-07 TWO COUNTRIES, ONE RIVER, ZERO WATER: THE COLORADO RIVER DELTA AND ESTUARY

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The Colorado River once delivered 17 billion cubic meters of water per year to the upper Gulf of California, creating an estuary that extended 70 km from the river's mouth. Ninety percent of the river's water is diverted within the United States; Mexico uses the remaining water for its farms and cities. Today, the trickle of water that sometimes reaches the estuary is salty runoff from farmers' fields and effluent from water treatment plants. Most of the economic benefits of river diversion are evident north of the border while most of the environmental costs to the delta and estuary are on display in Mexico. No pre-diversion studies provide a baseline, but the rich record of shell accumulations and kitchen middens document the estuary's former productivity, diversity, biotic interactions and the importance of river water to the life history of two species of commercially important sciaenid fish. Shrimp catches and shrimp larvae increased in the years following the rare, controlled releases of water that reached the sea. Many commercially important fish require low-salinity water during their early development. Healthy fisheries and ecotourism provide badly-needed jobs. Isotopic and sclerochronological analyses of shells and otoliths provide guidelines for habitat restoration in the estuary. Salinity requirements, and thus minimum river flows, can be estimated for species that are now rare or endangered. While overfishing and bycatch in the upper Gulf of California also threaten habitats, fish stocks and the vaquita (Phocoena sinus, an endemic harbor porpoise), effective fisheries management alone will not restore the estuary. Effective river management is also needed. Five percent of the river's flow could restore some of the estuary; one percent of the river's flow and periodic pulse flows would sustain riparian and wetland habitats.
To date, restoration efforts within Mexico are upstream of the estuary: in the Ciénega de Santa Clara, a large wetland supported by agricultural return flow from the U.S.A., along the mainstem of the Colorado River and in the Río Hardy corridor, supplied by water from Mexican return flow and water treatment facilities. Wetland, riparian and estuarine restoration is a challenge because of invasive species (Tamarix ramosissima), the increased demand for water because of population growth in border cities and the decreased supply of water because of climate change. Reconnecting the river to its estuary requires only modest dredging of the remnant channel and secure allocation of water not currently suitable for agricultural or municipal use. Finding water for nature is difficult because of over-allocation, existing treaties, interstate agreements and the limited geographic scope of U.S. environmental laws. Nevertheless, new binational cooperative efforts among water agencies, universities, environmental agencies and environmental NGOs show promise for cross-border efforts at restoring ecosystem services in riparian, wetland and estuarine habitats.

DD3.1-08 FROM SALTY FOE TO SILTY FRIEND

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The fertile sediments and good access from overseas and to the hinterland make estuaries ideal areas for human settlement. In the Wester Scheldt 15.000 hectares of estuary are lost to mainly agriculture between 1800 and 1970. Dredging further distorts the balance between erosion and sedimentation. Low dynamic, shallow sediment-rich areas have diminished with about 30% since 1970. It's exactly these areas that contain a high soil biodiversity associated with foraging birds. Besides the human pressure, sea level rise challenges the resilience of the habitats in estuaries.
CSO Consultancy, in cooperation with CLM Research and Consultancy and H+N+S Landscaping, has tried to shed a new light on these matters with their proposal 'From salty foe to silty friend' ('Van zoute vijand naar zilte vriend'). We propose to bring agricultural land and areas of conservation at the edge of the estuary in a rotation scheme. The function of a zone will change over time. Agricultural land will become an area of conservation to which the water has access. Former areas of conservation will be disconnected form the water and will be taken into agricultural use. In any particular area there is an alternating development of biodiversity-rich tidal flats and fertile agricultural soil. The land will be raised through sedimentation while connected to the water. The rotation will take place on a time scale of generations.
Areas of conservation that that are raised above the high tide level of the estuary lose the dynamics characteristic to an estuary. Low-laying agricultural land faces problems by salt water seepage . This problem is enhanced by the subsidence caused by drainage. By trading the least valuable agricultural lands for the higher elevated least interesting areas of conservation both agriculture and ecosystem conservation will gain.
By creating wide zones of low land and double diked area´s along the shore, flood protection will be improved. In times of storm the sea will lose part of its strength while passing the first dike, while the second will protect the hinterland.

Delta Water Award
The concept 'From salty foe to silty friend' has been developed for the Delta Water Award, an award initiated by the province of Zeeland. The team was supported by experts of the Knowledge for Climate network. The jury judged this concept as the most innovative and original entrance. According to the jury this plan is an example of 'principle, conceptual and cyclic thinking, which can in the end provide the answer to rising sea-level by using natural sedimentation. The discussion about flooding polders will end. Instead, we will speak about raising and reclaiming land.'

DD3.1-09 CHALLENGES AND OPPORTUNITIES: A SOUTH AMERICAN CASE OF ESTUARINE DELTA

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In estuarine delta systems takes place the complex coexistence of natural environment and urban patterns, both influenced by climate changes and socio-economic events. The resulted landscape differs from one region to another depending on ecological, political, economical and technological frameworks.
This paper analyzes the system of the ParanÃ¡ Delta and the Estuary of the RÃo de la Plata, through which drains the second major hydrographic basin of South America -"Cuenca del Plata""-, which covers 3.1 million Km2 distributed in five countries (Argentina, Brazil, Bolivia, Uruguay and Paraguay). The complex system of delta + estuary constitutes a dynamic sedimentary geologic-hydrologic unit located between the coasts of Argentina and Uruguay, draining to the Atlantic Ocean. It has a vital relevance not only for the region (a high populated area with more than 22 million inhabitants) but also for the Hydrology of the South American continent. According to the Intergovernmental Panel on Climate Change, the Río de la Plata, the Amazon and the Orinoco carry into the Atlantic Ocean more than 30% of the renewable freshwater of the world. Nevertheless, Latin-America is threatened by unequal distribution of water resources, stress on water quality, lack of infrastructures and strong climate changes. The studied case, the Río de la Plata, is considered one of the world's top ten rivers at risk due to its lack of infrastructures and high hydrological alterations. In addition to these threats, the impact of non planned urban growing processes plays a relevant role for the future of the area considering political, economical, institutional and technological limitations that lead into an unsustainable use of the land.
Three issues will be presented in this paper: the ecological function of the estuarine system, the relationship between natural environment, urban patterns and socio-economic dimension, and the possible future changes of the area due to urban growing processes and climate change. First, the ecological characteristics of the hydrologic system will be analyzed to understand the relevance of the area, the role that it plays for South American environment, the threats of the system and the need for management of natural resources. Second, the socio-economic scenario will be presented, followed by the analysis of different urban patterns (in their historic evolution until the present times) and their relationship with natural landscape. Third, the possible future climate –natural- variations and –induced- changes will be described, taking into account the multi-scaled climate drivers and their associated impacts on the environment.
The uncertainty nature of climate and socio-economic changes challenges local governments to develop mitigation and adaptation strategies to minimize the negative consequences on the population and natural resources.
Although adaptation addresses an action referred to a past event, it can be a future planning instrument as well, for pre-empting the changes thinking in advance about possible impacts and coherent policies. Finally, this paper will contribute with the presentation of a Latin-American case to the international urban debate, suggesting a set of planning adaptation strategies for a natural balance of the development of natural system and urban growing processes.

PDD3.1-01 ECOLOGICAL DEGRADATION AND COMMUNITY ADAPTATION: STUDY OF CHILIKA LAGOON IN INDIA

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Climate change combined with human activities poses significant risks to peoples' livelihood especially those are depending on the coastal ecosystem. Coastal wetlands are among the most productive livelihood systems having immense socio-economic and ecological importance to humankind. In their natural setting, wetlands provide fishes, forest products, water, flood control, erosion buffering, plant gene pool, wildlife, recreation, tourism etc (table 1). In the recent past, it is increasingly noticed that wetlands are being destroyed or altered, on a global basis. This is a result of the process of blatant commercialization leading to over exploitation of the benefits provided by the natural resource systems. Besides, global climate change, pollution, recreation pressures, increasing grazing and fishing activities have also added to the deterioration. Underlying causes of degradation of coastal wetlands and fisheries are, among others, price distortions, income distribution inequalities, policy failure, market failure, lack of property rights and population/urbanization growth and consequent encroachment. Scientific and Technical Research Panel of Ramseur Bureau are of the opinion that there are key gaps in current knowledge and information on the possible impacts of climate change upon wetlands, and on wetland adaptation, and on the ways in which wetlands can mitigate climate change impacts.
To examine a few of these issues the study has selected Chilika lagoon, a Ramsar site, in India. In Chilika, different regions have different socio-economic-ecological characteristics. Therefore, to facilitate the survey, Chilika has been divided into three geo-ecological zones. The study followed an unique kind of method of data collection to understand multifaceted socio-economic-ecological system of Chilika lagoon. We have chosen three levels of fieldwork for the purpose of our analysis i.e. village level, senior citizens and household level.
Chilika, unique aquatic system, has been facing ecological degradation. The degradation of Chilika has been attributed to the ecological problems, over exploitation of the fishery resources and global climate change. In order to understand the ecological problems of Chilika, the study has analyzed changes in ecological parameters namely changes in salinity, problems of siltation, declining depth, weed proliferation and declining bio-diversity.
The decline of the productivity in the lagoon adversely affected the livelihood of the local community. The changes in fishery resources have been attributed to both techno-institutional and ecological changes; both the factors are intertwined. The study finds the current-leasing system broke down completely under commercial pressure and thus spawned the seeds of a simmering conflict among communities. The changes in fishing practices imply that diversified fishing methods developed by different communities in response to varying situation are dying out; the fisher-folk have switched to the mechanical system irrespective of caste, community, regional or ecological requirements. The major constraints are; ill-defined property rights, lack of rational and equitable distribution of fisheries, widespread illegal subleasing of fisheries, uncontrolled Mahajans (money advancer) activities and lack of technological regulations. The merit of the study stands on the pluralistic understanding of the Chilika livelihood and ecosystem inter-linkages, which most of the policy studies and papers failed to perceive.

For illustrations see website: www.climatedeltaconference.org/results

PDD3.1-02 ADAPTATION TO CLIMATE CHANGE AND COMPETING LAND USE IN THE WESER ESTUARY REGION

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The German North Sea coast that currently already lies in part below the sea level and in particular the estuaries are extremely sensitive to climate change. The latter will not only manifest itself in the form of a more rapidly rising sea level, but also increasing temperatures, changes in precipitation and wind distribution as well as higher CO2 concentrations. Precautionary research on the complex interactions and determination of adaptability are necessary. For this reason various interdisciplinary research projects have been investigating the vulnerability of the natural and socio-economic system of the Weser estuary region for over 10 years. The results generated with a differentiated set of disciplinary tools are analyzed and presented in summary form with respect to competing land use.
The results show that the climate scenario will lead to a broad spectrum of impacts, both on the natural and the social system. For example, limitations concerning cooling water use and agricultural usability of the foreshore areas as well as dike security will occur. Water management has to reckon with increasing expenditure for water feed and drainage measures. Positive impacts can be expected for agricultural yield potential in inland areas and for tourism. Changes are likely for the aquatic and terrestrial food networks as well as biodiversity. Overall, the impacts of the climate scenario examined can be assessed as weak to moderate.
The accelerated rise in the sea level is identified as a key parameter of climate change for the region and because of a higher probability of failure in the coastal protection system, there is need for action, especially in terms of coastal protection. Due to the historically developed social and agricultural structures and forms of use, the adaptability of the Weser estuary region is generally high. However, the necessary adaptation measures, particularly with regard to coastal protection, will change the conditional framework for present-day land use and aggravate existing land use conflicts. Above all regional planning has to develop appropriate concepts at an early stage in this context.

PDD3.1-03 COASTAL AND ESTUARINE ECOSYSTEM OF BANGLADESH: MANAGEMENT AND CONSERVATION ISSUES

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The coastal area of south eastern area of Bangladesh includes a number of bays into which different types of rivers empty, creating an estuarine ecosystem adjacent to the shore. The main estuarine systems are Karnaphuly, Matamuhuri, Bakkhali and Naf river estuaries which are comprised of mangroves, salt marshes, seagrasses, seaweeds, fisheries, coastal birds, animals, coral reefs, deltas, salt beds, minerals and sand dunes. The extent of these estuarine environments varies according to the volume of discharge of the river and tidal ranges; they serve as feeding, breeding and nursery grounds for a variety of animals. These estuarine environments are highly productive in terms of nutrient input from different sources that promote other living resources in the estuary. Although, almost 70-80% of the vicinity population is depends on this renewable living resources, the harvesting rates of these resources are still unknown. Habitat destruction and over-exploitation of these natural resources have resulted in decaling the fishery resources and its catch trend as well as degradation of coastal ecosystems. There is lack of awareness among the resource users about the interaction of various coastal ecosystems while do not have enough knowledge about the resource and its importance, utilization and conservation. Besides, climate changes issues may cause for flooding

of low-lying deltas, retreat of shorelines, salinity intrusion and acidification of soils, siltation, and changes in the water table and inter-tidal zone in this area. These changes have raised serious concerns for the well-being of coastal peoples and the resources they depend upon. This paper assesses the issues affecting on the estuarine and coastal resource in response to human activities, climate change and sea level rise in the estuarine ecosystem of south eastern coast of Bangladesh.

PDD3.1-04 PATTERNS IN MACROZOOBENTHIC ASSEMBLAGES OF THE CHANGING RHINE-MEUSE ESTUARY

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During the 60s and early 70s the open system of the Rhine-Meuse estuary with a free salinity gradient has been converted into a series of stagnant fresh water basins (nowadays called Haringvliet, Hollandsch Diep and Biesbosch) separated from a pre-delta by sluices. For the last 50 years, the macrozoobenthic communities have been monitored intensively. This leads to an extensive overview of developments on long temporal and large spatial scales in macrozoobenthic communities responding to strong disturbances (e.g. transitions in salinity, currents and dynamics) and gradual changes (e.g. changes in pollution and nutrient levels). The developments, however, also co-insights with a gradual increase of the water temperature (1.6 to 2.4 degrees in 50 years) and an increase of the number of exotic species and their quantities in the system. The current study analyzes patterns and developments in macrozoobenthic compositions in terms of community descriptors (e.g. density, richness, evenness and diversity) and proportional distributions over feeding guilds (suspension feeders, deposit feeders, surface deposit feeders, herbivores, omnivores and predators). The usefulness of the historic communities of the early 60s as a reference for an undisturbed state of the estuary is tested, and the historic and present situation are compared. It is shown that communities respond in similar ways (viz. peaking densities co-occurring with decreasing richness and diversity) to large disturbances and that the distribution over the feeding guilds indicates the state of the environment. This study shows particularly the value of an undisturbed estuary in terms of total macrozoobenthic diversity over the series of nowadays fresh water lakes separated from the pre-delta system. A regulated salt water inlet that will be restricted to only 11.5 km land inwards as planned for the end of 2010 will be discussed with the scope on expected river runoffs in the future.

PDD3.1-05 COASTAL POLDERS IN BANGLADESH TURNED INTO GREEN REVOLUTION TO BROWN

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In 1960s during green revolution declared by United Nations, coastal polders were constructed in southwestern part of Bangladesh for protecting cyclone and tidal surges with support from Netherlands. In 1980s, the outsiders started shrimp farming into the polders due to tremendous demand and lucrative price of shrimp at the international market. Still the shrimp farming areas is gradually expanding not considering the environmental concern. Unplanned

shrimp cultivation creates hazards within the coastal community. It has proved the conflict of interest with agriculture system. The coastal community are facing severe problem like drinking water, fuel wood, health related problems, water logging, salinity intrusion and drainage congestion. It also creates people jobless because shrimp farms are not labour oriented compared to any other agricultural activities. The devastation of recently occurred super cyclone SIDR and AILA have badly impacted in this region. Because, the saline water entered into the polders during tidal surges but it is not possible for removing the saline water which also creates water logging and therefore vast area of land have failed to grow sufficient crop production. The southwestern part of Bangladesh is known as the Ganges tidal plain, comprises the semi-active delta and is criss-crossed by numerous channels and creeks. The topography is very low and flat. During each monsoon season almost all the Bengal Delta is submerged, much of it for half a year. The sediment of the lower delta plain is primarily advected inland by monsoonal coastal set up and cyclonic events. One of the greatest challenges people living on the Ganges Delta may face in coming years is the threat of rising sea levels caused mostly by subsidence in the region and partly by climate change Md. Abdur Rahman, 2009).

DD3.2-02 CLIMATE CHANGE MODIFIED SEDIMENT FLUX FROM THE BRAHMAPUTRA TO GBM DELTA

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The second largest GBM delta is one of the geologically youngest and tectonically active drainage basins of the world. More than 1 billion tons of sediment is discharged into the Bay of Bengal annually, mostly from the Ganges-Brahmaputra river (Milliman and Meade, 1983). Sediments in the northern part of the Bay are terrigenous deposits, discharged by these large rivers draining the slopes of the Himalayas. Sediment deposits on both shelf and slope have been modulated by glacio-eustatic sea-level fluctuations, climatic change, and tectonic activity (Flood et al, 1995). With a changed climatic scenario, temperature and precipitation changes potentially have wide-ranging effects on sediment generation and transportation process. Climate change could significantly affect water discharge (Nijssen et al., 2001; Menzel and Burger, 2002), soil erosion rate (Pruski and Nearing, 2002; Michael et al., 2005) and sediment flux (Xu, 2003; Syvitski et al., 2005). Due to significant location at the transitional zones between different climatic regions and different distinct geomorphologies, the Brahmaputra basin is comparatively more vulnerable to climate change impacts (Mahanta et al., 2007). Since 80% flow and 90% sediment contribution in the Brahmaputra takes place during monsoon (Purkait, 2004), seasonal change in rainfall intensity due to climate change is of significance. In Brahmaputra, 12% river flow is due to glacier melt (IUCN, 2003); climate change induced glacial melt would increase summer flows for few decades, followed by reduction in flow as glaciers disappear (IPCC, 1998). Climate change could increase sediment flux in the Brahmaputra river mainly by increased run off and synchronization of heavy rainfall over smaller time windows. Indeed the picture is unclear now, due to paucity of data, yet potential climate change impact has rather added further complexity to the less understood colossal sediment flux regime of the Ganges-Brahmaputra. Existing limited data suggests that the modified sediment flux to the GBM delta can have significant implications to the coastal ecosystems of Bay of Bengal. Riverine discharge injects both soluble and particulate nitrogen and phosphorous to the estuary, which has substantial impact on the coastal productivity (Hu et al., 1998) as the Bay of Bengal marine ecosystem is considered a Class II, moderately productive (150-300 grams of carbon per square meter per year) ecosystem based on SeaWiFS global primary productivity estimates (Dwivedi et al., 1993). Southeast Asia accounts for 30% of the coral reefs and about 60% of the reefs are already destroyed or on the verge of destruction and sedimentation is one of the major causes (Wilkinson et al., 1993). Considering that climate change will have major implications on the dissolved load quantity and quality along with the nutrient

and trace element carrying capacity of the sediments, focusing currently lacking in-depth research attention to the sediment fate and transport in the Brahmaputra floodplains deserves priority. Well implemented Integrated River and Coastal Zone Management program appears to be the future tool to secure coastal resources on a sustainable scale and to mitigate future threats addressing key issues.

DD3.2-03 CONSEQUENCES OF GLOBAL CHANGE ON THE ECOSYSTEM SERVICES OF THE SCHELDE ESTUARY

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The Schelde estuary is one of the most studied estuaries in the world as it is very important as the access to the port of Antwerp, as it was for long very heavily polluted and as the risks of flooding are very high. In this presentation we will present an analysis of the changes that occurred in the system over the last decades as they might give a very good indication of future changes. Indeed, the upstream parts of the estuary experienced already a sea level rise of more than 1 cm per year! The impact of this on the morphology, the hydrodynamics and the ecosystem functioning is discussed. Habitats are now subject to very severe erosion and the tidal dynamics increased. Over the past few decades we see also a marked reduction in fresh water discharge to the system as more and more water is deviated to different canals in the river basin. In some periods even no hresh water enters the estuary. This has important consequences on the water residence time and this in turn on the phytoplankton populations and the whole ecosystem functioning. In the mean time we see a landwards increase of salinity. Based on the analysis of a 13 year monitoring program of different compartments of the system possible future changes due to climate change will be discussed.

DD3.2-04 ECOSYSTEM-BASED DISASTER RISK REDUCTION IN AN ESTUARINE ECOSYSTEM IN INDIA

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Estuarine social-ecological ecosystems, one of the most productive life-supporting ecosystems are albeit vulnerable ecosystems to climate-induced transformations and changes. Such changes have severely impacted the ecosystem services which support and strengthen the livelihood security of many coast-dependent communities. The coastal state of Orissa in India has become the ground-zero for natural and climate induced disasters, very often described as the 'disaster capital of India.' The Orissa Super Cyclone of 1999 brought in unprecedented ecological and socio-economic transformations. Post Super Cyclone has witnessed a systematic increase in the intensity and frequency of low pressures in the Bay of Bengal and many transforming to cyclonic storms. Many of the coastal villages are gradually vanishing under the sea because of coastal erosion. Vulnerabilities of such communities-at-risk are further compounded by the inequalities and uncertainties associated with economic globalization.
Economic liberalization policies of the state have heralded in huge financial and technological investments, both public and private. The government of Orissa has signed around 14 Memorandum of Understandings (MoUs) for development of ports along the coast, one of them being promoted with the highest Foreign Direct Investment (FDI) in India. The combined impacts of such global environmental changes and economic globalization have created situations of 'double exposures' and thereby severely undermining the adaptive capacity of the coastal-communities

at risk. With gradual erosion of their traditional rights over the coastal resources including the sea, many traditional coastal communities have started migrating to distances near by and far off.
Orissa's estuarine ecosystem is also biologically diverse, the Bhitarkanika mangrove ecosystem being the second largest mangrove forest in South Asia next to the Sunderbans. Ecosystem services from mangrove ecosystems are many, from being effective against low-intensity tidal waves to supporting a rich nursery of fishes and prawns. By building on the institutional mechanisms of mangrove resources conservation and triangulating this with the of disaster risk management approaches, an ecosystem-based disaster risk reduction framework has been developed in three selected communities around the Bhitarkanika mangroves in Orissa. Effective, equitable and sustainable institutional mechanisms have been identified and developed which are community-based. Aspects of livelihood security have been addressed through the design and development of mangrove-based enterprises with women self-help groups (SHGs) and cooperatives. Through the development of mangrove nursery and plantation many community members have been able to secure an additional income for themselves. The mangrove belts developed around these villages are effective eco-shields against cyclonic storms and tidal waves. Subsequent growth of the mangroves will further ensure the provisioning of the ecosystem services in terms of increase in fish catch and more scopes for eco-tourism. By highlighting the emerging scopes for the design, development and delivery of an integrated ecosystem-based disaster risk reduction framework, this paper discusses the opportunities of such an approach for climate change adaptation.

DD3.2-05 CLIMATE CHANGE VULNERABILITY ASSESSMENT AND ADAPTATION IN MANGROVE SYSTEMS

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Mangrove deltaic and estuarine areas include the most extensive, diverse and productive examples of this coastal ecosystem type, and are valuable coastal resources, providing coastal protection, wood, and fishery resources to many developing countries. Mangrove ecosystems are sensitive to climate change impacts, particularly projected sea level rise where this in not compensated for by sediment accretion rates. Many mangrove deltaic areas already experience relative sea-level rise owing to coastal subsidence, resulting in dieback at the seaward edge and inland recruitment. While climate change impacts on mangrove ecosystems are well known, adaptation options to date have been speculative. With support from UNEP Global Environment Facility and in close collaboration with a range of stakeholders and local communities, WWF is working in Cameroon, Tanzania and Fiji to build and strengthen the capacity of local managers to assess mangrove climate change vulnerability and use results to adapt to climate change. Key sites include the Rufuji river delta in Tanzania which has the largest single block of mangrove forest in East Africa (532 km2), in Cameroon the Douala-Edea Wildlife Reserve (1,284 km2) at the mouth of the Wouri and Sanaga rivers, and in delta/ estuarine mangrove systems in Fiji on both the windward and the drier leeward sides of the largest islands. Detailed vulnerability assessments are being conducted, which combine baseline survey of species zones and community structure, survey of elevations relative to sea-level, reconstruction of recent spatial changes using historical aerial imagery, stratigraphic analysis of long term relative sea-level trends as our sites lack tide gauges, measurement of sedimentation rates, and monitoring of mangrove structure, productivity, mangrove condition and human interaction. Site information is being used to formulate and a test a range of adaptation strategies. These include the designation of strategic protected areas and improved management of sustainable use areas, rehabilitation of degraded areas, reforestation with "climate-smart".

DD3.2-06 TRANSFER TIMES IN RHINE DELTA (1900-2008): LOBITH DISCHARGE & WADDENSEA SALINITY

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To study the relative impact of Dutch water management and water works, and climate variability, on transfer and retention times through the Lower Rhine delta, Lobith discharge measurements were linked with salinity measured in the Wadden Sea (Marsdiep) from 1900 to 2008 using a simple transfer function model. In the Netherlands large-scale coastal infrastructures have been constructed for protection against the sea including the closure-dike completed in 1932 resulting in the IJsselmeer. At the same time, mitigating river inundations and river navigability has been an important aim since the beginning of the 18th Century and has significantly altered the Dutch waterscape. Recently, Dutch river management is focusing on giving more space to natural river systems for environmental and flooding-prevention reasons. These interventions have had an impact on the transfer and retention times of water through the Lower Rhine Delta. Rhine water at Lobith affects the salinity of the Wadden Sea through the Rhine river plume along the Dutch coast as well as through the IJsselmeer which discharges freshwater into the Wadden Sea. The reduction of salinity in the Wadden Sea relative to the salinity of the North Sea depends largely on freshwater discharge, weather conditions and wind direction. Transfer function theory allows describing the distribution of travel times of a natural system where substantial variability exists in water transport properties (van der Velde et al., 2006). Here, a transfer function model is used to describe the convolution of averaged monthly variations in discharge measured at Lobith with the monthly variations in the reciprocal of linearly-detrended salinity measured in the Wadden Sea from 1900 to 2008. A lognormal probability density function was chosen for the transfer function. The simulated variation in salinity obtained with the transfer function model yields a R2 of 0.76 when compared with measured salinity and is shown in Figure 1. An approximate 5 year oscillation can be observed in the measured and modeled salinity. Transfer function models were derived for the periods from 1900-1932 (when the closure-dike was completed), 1933-1971 (when IJssel discharge increased from 12 to 17% of Rhine flow rate due to the operation of three lock weirs in the Nederrijn in 1971; van Aken, 2007) and 1972-2008. The peak time (mode) associated with each period suggest that Lobith discharge affected Wadden Sea salinity more directly before 1932 likely related to changes in retention times due to the construction of the closure-dike. Understanding the impacts of past interventions and the impact of discharge variability on transfer and retention times of water in the Dutch Lower Rhine Delta may aid in climate-proofing the Dutch Delta.

References

van Aken, H.M., 2008. Variability of the salinity in the western Wadden Sea on tidal to centennial time scales. Journal of Sea Research 59, 121-132, doi:10.1016/j.seares.2007.11.001.
van der Velde, M., Javaux, M., Vanclooster, M. and Clothier, B.E., 2006. El NiÃ±o-Southern Oscillation determines the salinity of the freshwater lens under a coral atoll in the Pacific Ocean. Geophysical Research Letters, 33, L21403, doi:10.1029/2006GL027748.

For illustrations see website: www.climatedeltaconference.org/results

DD3.2-07 ESTIMATING IMPACTS OF CLIMATE CHANGE ON THE OXYGEN BUDGET OF THE ELBE ESTUARY

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The oxygen budget of an estuary is directly linked to biogeochemical processes. Therefore, the oxygen content is an integrative descriptor of its water quality. Because the highly dynamic oxygen budget is dominated by local processes, the longitudinal gradient of oxygen along an estuary cannot be described by conservative mixing schemes. Main external drivers of the oxygen budget in the mesotidal Elbe estuary are river runoff and the loads of organic matter and nutrients. Other abiotic factors influencing the oxygen budget are the bathymetry and the tidal regime which both determine the reaeration rate as well as the underwater light climate which limits the biogenic oxygenation. Under these external forces, temperature-dependent biological processes produce or consume oxygen in the water body and the sediments. Therefore, the oxygen budget can only be understood in the context with the organic carbon fluxes through the existing food web structures.
Climate change may affect the external forces which influence the oxygen budget. Change of temperature and river runoff as well as sea level rise may directly impact hydrodynamic and biogeochemical processes. As one consequence, inorganic and organic nutrient loads from the river may be altered substantially. A model-based approach is chosen to describe and quantify the impacts of climate change on the oxygen budget. Using a 1-d hydraulic model (HYDRAX) coupled with a water quality model (QSim) it is possible to estimate the transport and utilisation rates of carbon and oxygen as well as the phytoplankton biomass. This approach was first applied to a 585 km long stretch of the River Elbe. Generally, the relationships between climate change and nutrient inputs with phytoplankton growth, losses and turnover of nutrients were shown to be complex and non-linear. Under climate change scenarios, a conspicuous longitudinal component in phytoplankton dynamics was found. While today the highest phytoplankton biomass develops in the lower section of the River Elbe, under scenarios with low discharge and increased temperature the plankton maximum shifts upstream. Therefore, the highest effects on phytoplankton biomass can be found in the middle sections of the Elbe. In the lower sections, limiting factors like self-shading of phytoplankton, zooplankton grazing and nutrient limitation become more relevant. However, as the altered conditions in the middle reaches of the River Elbe (i.e. higher load of plankton born organic carbon) determine the boundary conditions for the Elbe Estuary, the oxygen budget in the estuary may also change. This approach will be upgraded in the research program KLIWAS of the German Ministry of Transport. A multi-model approach will generate a range of feasible climate change scenarios for the whole River Elbe, its estuary and the coastal regions. It will be analyzed how changing boundary conditions (i.e. meteorological forcing and river discharge) may affect the oxygen budget of the Elbe Estuary.

PDD3.2-02 COASTAL FLOODING IN JAKARTA: CRITICAL ANALYSIS ON MANAGEMENT OF MANGROVE AREAS

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Flooding in Jakarta is annual problems especially in the rainy season. The government could not make significant effort to tackle this problem effectively. The impact of this flooding is not only damaging economic activities and property but also causing health problems in community. One of the major causes to this flooding is the land use change in coastal areas and sea level rise. The reclamation and shifting of mangrove areas into development for human settlement and industries is the biggest contributor to the cause of flooding in coastal area. The root to this massive conversion of mangrove areas is sectoral approach in development and conflicting and overlapping of laws and regulations on the management of marine and coastal resources. This paper will examine problems and challenges to management of mangrove areas in Indonesia and propose possible solution to this problem. The method of this study is literature review and reviews to the policy and legislations. The study found that Integrated Coastal Zone Management (ICZM) is one of the solutions to the degradation of coastal ecosystem. However it is not easy to implement integrated coastal zone management while there is still sectoral ego between institutions involved in management of marine and coastal resources. At this stage ICZM in Indonesia still remain in infancy due to hard to resolve the conflicting laws and legislation.

PDD3.2-03 SANBANZE NATIONAL PARK - A PROJECT FOR THE FINAL TIDELAND AREA OF TOKYO BAY

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The sea level will be 18-59cm higher in 100 years (Fourth Assessment Report of IPCC). Although it is important for local projects to contribute the global climate, the global issue does not always fit the local situation and the demands. It is a significant effort to create a new planning model that enables us to integrate local projects with global climate issues. In this thesis, I introduce a design proposal of the final tideland, “Sanbanze”of Tokyo Bay, to regenerate as a national park, as a case study for multidisciplinary estuary management.
Since the policy of isolationism ended in 1868, Japan started to acquire large and efficient spaces for industrialization through the reclamation of Tokyo Bay. After WWII, the country experienced intensive industrialization. The final natural tideland, Sanbanze (1200 ha), remained between industrial areas unintentionally in the northern east of Tokyo Bay. The unique urban nature Sanbanze attracts Tokyo citizen as a popular recreational spot to participate in the traditional activity of “shellfish gathering”. Sanbanze plays also an important role as a relay spot between Southeast Asia and eastern Russia for migratory birds since this is the only tideland for feeding in the Tokyo region. However,
In the reclamation process of Tokyo Bay, the seabed was evacuated and then it was used for reclamation. The physical modification causes hydrogen sulfide contamination which occurs through the process of eutrophication and inappropriate tidal movement. The contamination simultaneously extinguishes all the creatures in the tideland and damages the marine ecology, seaweed cultivation and human activities on the tideland. Then, how is it possible to regenerate the final Sanbanze tideland as a national park that integrates local problems and global demands?
In the design proposal, I introduced three basic strategies. 1) Topographic change: the soil from useless reclaimed land can be returned into damaged seabed and extended room for the rising sea level. 2) Pollution control: Water

pollution can be controlled by partitions between evacuated deeps and the tideland, aeration system for the non-oxygen volume of evacuated deeps and floating reed for the red tide. 3) Ecological enhancement: restored tideland can revitalize the seaweed cultivation, the feeding area of the migratory birds and the recreation to stimulate the local economy and to consume the excess nutrients. The restoration of the urban estuary needs the structural change of the region in general. It is necessary to integrate the local problems with global issue to lead the politics. The model of sanbanze national park suggests three basic strategies which can be mutual benefits between local and global.

PDD3.2-04 OPENING THE HARINGVLIET DAM: ECOLOGICAL, ECONOMIC AND SOCIAL CAUSES AND EFFECTS

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In the past decades there has been a significant change in the way water is perceived in the Netherlands. Rather than an enemy that has to be fought against, now it is seen as a friend with whom we need to learn to live with. Moreover, nature conservation is playing an increasing role in governmental policy due to imminent climate change. For this reason, the government has been developing projects such as the opening of the Haringvliet. The motivation behind this particular project is a return to estuarine conditions, which will enhance the water quality and make it a livable area for migrating fish once again. Nevertheless, the execution of this program has been delayed due to problems with stakeholders. There are many affected parties, as well as many land-water system and policy processes that have to be taken into consideration. This student research project seeks to understand the ecological, economic and social causes and effects that the opening of the Haringvliet sluices would encompass. Ultimately, it hopes to provide a good review of the situation in order to provide recommendations to stakeholders.
The panel of students performing this research is an international team of six undergraduate students at the Roosevelt Academy, who come from different academic backgrounds. Because of the Liberal Arts and Sciences philosophy of the university, the research group has individuals majoring in ecology, earth sciences, mathematics, physics, law and public policy. This interdisciplinary approach will provide originality and context to the way the problem is dealt with. The team is further separated into three pairs, focusing on ecological, hydrological, and socio-economic aspects respectively. The approach to the problem will be to assess the past, present and future conditions (including a null hypothesis) of the Haringvliet area related to the aspects mentioned previously. To do this, the team will do excursions to concerned locations, conduct interviews with experts on the subject and thorough literature review, as well as using existing models to predict the hydrological effects of the opening of the Haringvliet dam.

PDD3.2-05 THE KIERBESLUIT:VALUE ANALYSIS OF THE CONTROLLED TIDE PROJECT IN THE HARINGVLIET

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In a country where water has such a huge influence on the daily lives of the population such as in The Netherlands, specific situations call for an advanced water management system. Decisions concerning water have to be made on a daily basis to ensure the safety of the people, while at the same time taking the system sustainability into account. After the big flood in the Netherlands in 1953, the Haringvliet was closed with sluices to protect the land and the people living there. However, closing the Haringvliet (Province of Zuid-Hollland) has had a big impact on the estuarine environment that was originally there. To restore nature a controlled tide approach is taken. The Government has therefore decided that the sluices of the Haringvliet should be opened. This so-called “Kierbesluit”will have implications with respect to the availability of fresh water for various actors. The Haringvliet is currently a source of fresh water for both local agricultural companies and other local industrial companies. Moreover, the water treatment companies whose supply area includes Rotterdam, one of the largest cities in the Netherlands, might also be affected by this “ Kierbesluit”.
In this research it was investigated what the current vision is on land and water when making choices between economy and nature in the Haringvliet area. This vision is based on how water and land are valued . For this multi-disciplinary case we used a system analysis approach. This involved investigating different aspects such as decision-making and communication of actors (e.g. informing local civilians), law-making, the weighting of economical values versus ecological values, the implications for water management and treatment, and the effect on the environment. The research was mostly literature-based, but also included fieldwork, and interviews with and surveying of local civilians. All findings were analyzed to determine how the value associated with different landscapes influence the decisions being made in the case of Haringvliet.

PDD3.2-06 RHINE ESTUARY ‘CLOSEABLE BUT OPEN’ - POTENTIAL EFFECTS ON THE ENVIRONMENT

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Problem definition
To protect the Rhine estuary the next century from flooding new measures need to be implemented. Raising and strengthening our dikes is one of the main options. But, strengthening of dikes is undesirable in most urbanized areas and may be very expensive. A major part of the urban area in Rotterdam as well as Dordrecht is situated outside the dikes Strategic positioning of closeable dams combined with a channel between the rivers Lek and Waal may be used circumvent strengthening of the dikes in the highly urbanized areas in the Rhine estuary. This option allows for the potential development of the large waterfront area outside the dikes while the new channel could enhance the ecological connectiveness of the waterways.
The main objective of the study was the feasibility of the so-called Rhine estuary ‘closeable but open alternative. In this study the potential effects on the environment have been evaluated.

Theoretical framework and methods

In this study the results on future flooding levels strengthening the dikes versus the strategic positioning of closeable dams have been used to evaluate the effects on the human activities in the area outside the dikes. These future flooding levels have been used to evaluate the potential flooding of urban and industrial areas including the environmental dangerous activities but also the flooding of contaminated sites using a geographic information system.
The potential effects on the wetland habitats of the various scenarios have been evaluated by expert judgment as well the potential effects on fresh water supplies, salinization and release of toxic chemicals due to changing river patterns and sedimentation processes

Results

The results will show the differences in the flooded areas in the various scenarios concerning urban areas, industrial sites various type of environmental dangerous activities and contaminated soils. The expert results concerning ecology, fresh-water supplies, salinization and sedimentation/re-suspension processes and their impact on the release of toxic substances will be discussed.

Deltas in Depth Theme 4:

Climate change and climate proofing urban areas

DD4.1-02 COPING WITH CLIMATE CHANGE IN DELTA CITIES BY ADOPTING THE AFD CONCEPT

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Deltas have been appealing locations for settlements since time memorial. Water provides drinking water, provides nourishment of crops, enables navigation and has become an important aspect of the quality of especially developed delta cities. However, water can also cause a threat to mankind. Floods could cause damaged goods, disconnected traffic facilities, power loss and a disrupted society. Hence, delta cities are often protected by a range of flood defences like quay walls and stop logs to cope with floods like storm surges, fluvial floods and pluvial floods. A major challenge is to maintain the current safety level against floods when climate is changing, and the population and economy are still growing. Unfortunately, flood protection and urbanisation seem to have conflicting objectives. The current city layout leaves hardly any space for flood control and flood defences are bound to cause visual and physical hindrance for urban activities. The objective of this paper is to prove that flood protection and urbanisation can be synergetic sustainably combined in the shared urban realm by adopting the concept of Adaptable Flood Defences (AFD concept).
This research is based on the historical development in relation to flood protection of a number of Dutch Rhine cities and on the current state, flood safety and urban quality, of the riverfronts of those delta cities. The AFD concept is developed by looking at realised projects on multifunctionality in the Netherlands and Germany, and by conducting a literature study on adaptable buildings.
The result of this research is that the AFD concept is a promising solution in delta cities to cope with the conflict between flood protection and urbanisation while taking climate change into account. The AFD concept aims to integrate several functions into one multifunctional structure. Strength of this concept is that it creates the opportunity to redevelop the riverfront of delta cities. The existing conflict between urban functions and flood protection is decreased and the multifunctional structure contributes to the urban quality. The multifunctionality of the concept enables physical synergy. Adaptability is essential when coping with climate change and economic changes. Creating physical synergy should not be a snapshot, but a sustainable affair. Therefore, the AFD concept ensures adaptability of the urban elements and the flood retaining elements of the multifunctional structure. Types of adaptability are extension, overcapacity, conversion and refurbishment. A combination of flexible and robust elements leads to sustainable structures which anticipate on uncertainties like climate change.

DD4.1-03 ADAPTING WHERE WE CAN, INSTEAD OF WHERE WE HAVE TO

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Cities are highly vulnerable to climate change. High density of people, functions and assets make them highly sensitive to exposure to increasing average and extreme climate hazards such as flooding, drought and heat. Present day adaptation efforts to reduce vulnerability to climate hazards and to make cities more resilient are almost always using vulnerability assessments as a starting point. Limits to predictability, difficulties to deal with complexity and incapability to quantitatively assess the sensitivity of cities and the effectiveness of measures make operationalisation of such approaches in practice extremely difficult. In particular, these difficulties express themselves around the aspect of timing of adaptation. In this paper we present an alternative approach to adaptation that uses opportunities emerging from autonomous urban dynamics as a starting point. We define the moments that these opportunities occur as 'optimal' adaptation moments.

Analysis of approximately 100 adaptation measures to flooding, drought and heat has shown that around 50% of the measures can be taken without additional cost in comparison to conventional urban (re)development projects. This opens the opportunity for free-riding of adaptation with new urban development and renewal of existing areas. Analysis on the adaptive potential of all cities in the Netherlands has revealed that currently 37% of the total existing building stock has reached the end of its technical lifespan. By 2050, this number will increase to 88%. Upgrading or replacing this building stock offers a large potential for adaptation, both immediately and on medium and longer timescales. On the short and medium timescale, such opportunities are driven by economic recovery plans, mitigation efforts, regeneration programs and urban shrinkage policies. However, analysis of renewal cycles of neighbourhoods if opportunities for large scale free-riding are not being taken new ones will on average only arise after a time period in the order of 50 years. This value depends on typology of urban environments, such as peripheral business areas and suburban residential areas.

Understanding the underlying processes of renewal cycles in different types of urban areas helps to identify 'optimal' adaptation moments and to extend the time horizon of adaptive urban development strategies. By tackling problems to find 'optimal' adaptation moments operationalisation of adaptation strategies can be simplified. At this point however, scientific knowledge about adaptive potential is still in its infancy. This paper discusses the advantages and limitations of opportunistic adaptation in comparison to vulnerability based adaptation. We conclude that both approaches are complementary to each other.

DD4.1-04 CLIMATE CHANGE ADAPTATION IN NEW YORK CITY: RISK MANAGEMENT PROCESS & PROGRESS

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New York City is at risk from many dimensions of climate change, including rising sea levels, storm surge, rising temperatures, heat waves, inland flooding and more frequent droughts in upland watersheds. New York City and regional agencies have been concerned with climate change, its impacts, and adaptation and mitigation for many years The first comprehensive study was published in 2001 as the Metro East Coast report, part of the National Assessment of Climate Variability and Change; the New York City Department of Environmental Protection established a Task Force in 2004 to review its vulnerabilities and has since established a program for dealing with climate change in its operations and infrastructure investments. More recently, as part of the City's long-term sustainability plan (PlaNYC), Mayor Michael Bloomberg in 2008 convened the New York City Panel on Climate Change (NPCC). This panel of experts, chaired by Cynthia Rosenzwieg and William Solecki, is charged with advising on issues related to climate change and adaptation. The NPCC has assisted the New York City Climate Change Adaptation Task Force, also established by the City in 2008, to develop a coordinated adaptation plan for the City; the Task Force consists of over 40 public- and private-sector stakeholders. The NPCC prepared climate change scenarios for New York City and has examined how climate change has the potential to affect the city's critical infrastructure. It has suggested approaches to creating an effective adaptation program for critical infrastructure, including ways to assess risks, prioritize strategies, and examine how standards and regulations may need to be adjusted in a changing climate. The NPCC's report takes a risk management approach, with emphasis on flexible adaptation pathways: strategies that can evolve over time as climate risk assessment, evaluation of adaptation strategies, and monitoring continue. The report, published in Spring 2010 by the New York Academy of Sciences, includes, in addition to chapters on key topics by experts on the NPCC: the Climate Risk Information (CRI) workbook, which presents climate trends and projections for New York City and identifies potential climate change risks to the City's critical infrastructure; the Adaptation Assessment Guidebook (AAG), which outlines a process through which stakeholders can develop and implement effective adaptation plans; and the Climate Protection Levels (CPL) workbook, which evaluates certain policies, rules, and regulations that govern infrastructure in New York City to determine how they could be affected by climate change. Overall, based on the work of the Task Force, the NPCC, and other stakeholders, the City has developed an effective approach to climate change adaptation that encompasses a number of best practices, including: high-level proactive leadership; links to larger sustainability activities; and involvement of multiple layers of government and a wide range of public and private sector stakeholders and experts. It is hoped that the work of the NPCC, within the larger context of the City's efforts, will contribute to an effective program of adaptation to climate change both immediately and over the long term.

DD4.1-05 VULNERABILITY AND ADAPTATION OF ALEXANDRIA, CASABLANCA AND TUNIS

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The countries of North Africa are heavily urbanized, and this urbanization is located primarily on the coast-line. Demographic forecasts to 2030 predict an average increase of their urban population of 60 percent, which will be primarily concentrated on the coast. This will increase very significantly the size of the population and the amount of infrastructure and economic assets which will be exposed to the specific impacts of climate change to which coastal areas will be subject. The IPCC reports tell us that the Southern coast of the Mediterranean is one of the areas of the world at major risk. Extreme weather events, such as urban floods, have already been manifesting themselves in these coastal areas in the past decade with increased frequency and severity.

The World Bank is conducting a regional study on the vulnerability of three important coastal cities of North Africa: Alexandria, Casablanca and Tunis, aimed at assisting them prepare adaptation action plans. The $ 1m study started in June 2009 and will be completed by December 2010. It focuses on the 2030 horizon, addressing: sea level rise, coastal erosion and storm surges; increases in ambient temperatures and related consequences on urban quality of life; decreases in overall precipitation with their consequences on water supply; and extreme weather events, such as droughts and floods.

The methodology of the study comprises: a) detailed analysis of the present vulnerabilities of the urban locations to extreme weather events; b) dynamic downscaling of climate futures for the three locations; c) forecasting urban expansion scenarios and related land-use; d) producing comprehensive urban vulnerability maps incorporating forecasted climate change impacts; e) an economic valuation thereof; f) institutional assessment of emergency planning and response capabilities; g) identification of priority remedial actions in the form of adaptation action plans. These would primarily consist of urban planning and land-use policies, of investments aimed at protecting, reinforcing or relocating essential urban infrastructure; and of measures to improve the institutional capacity of central and local governments to plan for and manage adaptation and emergency responses.

The study is being conducted in partnership with the Egyptian, Moroccan and Tunisian Ministries of Environment and with the Local Governments in charge of the three cities. The technical work is being carried out by a consulting group comprising Egis-BCEOM, BRGM and IAURIF. In addition, technical contributions are being made by the Arab Academy for Science, Technology and Maritime Transportation and by the European Space Agency for Earth Observation applications.

The paper would present the results of the study as they will have been validated by July 2010: these will comprise the urban vulnerability assessments for the three cities, and the priority areas for the urban adaptation action plans resulting from the local workshops that will be held in Alexandria, Casablanca and Tunis between May and June. The action plans are being considered as the stepping stone towards the design of investment operations to increase the resilience of the cities by the respective Governments.

Deltas in Depth Theme 4: Climate change and climate proofing urban areas
Session DD 4.1: Adaptation strategies in urban areas **ORALS**

DD4.1-06 RISKS OF CLIMATE CHANGE IMPACTS IN MAJOR BANGLADESHI CITIES

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Bangladesh tops the 2009 Global Climate Risk Index, a ranking of 170 countries most vulnerable to climate change compiled by Germanwatch, an international nongovernmental organization that works on environment and development issues. The nation is particularly at risk because it is a vast delta plain with 230 rivers, many of which unstably swell during the monsoon rains. The way global warming emanating from greenhouse gas emission is impacting on the climatic changes, it is apprehended that by the end of this millennium half of Bangladesh may go under water. Climate and cities have long relationship that is now becoming more complex and unmanageable in developing countries like Bangladesh. Though major portion of Bangladesh's greenhouse gases are generated from the four metropolitan cities (Dhaka, Chittagong, Rajshahi and Khulna), still the contribution is negligible relative to total global emissions. The metropolitan cities of Bangladesh are vulnerable, in general, due to the over population, unbalanced city growth, inadequate infrastructure, weak and inadequate government policies. This paper highlights the changes of climate over time in some major Bangladeshi cities and the probable threats to the human environment. At the same time, this paper tries to bring the international focus on such issue for Bangladesh as most of the coastal areas of Bangladesh may disappear according to some literatures by 2070. To know such important issues like: trends of temperature and rainfall pattern over time, extent and number of natural disasters, sea level rise and overall the impacts on human environment have been incorporated in this paper. Most of the cases, secondary data sources have been used from meteorological department and from some other research works. However, some field investigations over last one year have been experienced to record the temperature and rainfall data to cross check the data from meteorological department. Recommendations have been incorporated at the end to build people's awareness so that the threats can be combating in future. Some institutional measures and possible planning interventions have been brought into light so that the extent of the climate change problems in one of the poorest nations like Bangladesh can be well-understood before the international community.

DD4.1-07 GOVERNING CLIMATE CHANGE RELATED RISKS: RESPONSES OF DUTCH URBAN PLANNERS

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Climate change is associated with a number of risks, such as flooding, heat stress and vector- and rodent-bound diseases. While some of these risks are new, the large majority of them rather imply an intensification of already existing risks. In either case, dealing with climate change related risks in terms of adaptation requires a critical evaluation and, most probably, a redesign of governance strategies currently in place.

Thus far most research has concentrated on the identification and quantification of climate change related risk and the exploration and development of measures to reduce these risks, in proactive as well as in reactive ways. Yet much less is known about how planners and decision-makers actually perceive and deal with climate change. This paper focuses on governance of two climate change related risks in urban areas in the Netherlands, namely heat stress and flooding. Three questions are addressed: How do urban planners and decision-makers frame the risks of intensified heat stress and flooding and what are the similarities and differences with scientific framings of these risks? Are

strategies to govern these risks in accordance with what scientists consider to be adequate strategies? And what explains the recognition of these risks and governance strategies developed or under consideration? Exploring the ways in which urban planners frame the two climate change related risks and the contingencies that they face when developing adaptation strategies not only fills a knowledge gap, but also may facilitate science-policy interfaces in this area: to what extent is knowledge about the two risks adequately communicated and to what extent do the proposed measures fit into the planning context in which they have to be implemented?
Our first research question will be answered by a comparison of how both scientists and planners frame the risks of intensified heat stress and flooding as a consequence of climate change in terms of occurrence and consequences. In order to answer the second research question, we will first identify effective governance strategies that are proposed in the academic literature. Defining characteristics include the framing of risks and adequate risk levels, decision-making procedures, division of responsibilities for risk management, stakeholder involvement, knowledge sources and risk management instruments. The International Risk Governance Council's (IRGC) framework will be employed in order to assess the adequacy of governance strategies being developed or considered by urban planners. The IRGC framework distinguishes between four idealtypical risk governance strategies that are considered adequate for risks with varying degrees of certainty and contentedness (see Renn, 2006). The framework will be supplemented with studies such as those by De Bruin et al. (2009) proposing specific risk management instruments for the two risks at issue.
In order to explain why in practice governance strategies for intensified heat stress and flooding are (not) in line with those proposed in the academic literature, we will validate the importance of hypothesised stimuli and barriers as suggested in literature on climate adaptation and more general literature in planning and policy.

DD4.1-08 CLIMATE RESILIENCE FOR HO CHI MINH CITY

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This paper and presentation describes the C40 UrbanLife project for Ho Chi Minh City, the preparatory engagement with the city, preparations for the project workshop and the final outcomes. Based on Ho Chi Minh's needs and concerns, the topic addressed is "Climate Change Adaptation for Water Infrastructure and Management". Preparatory work started in March, with the city workshop planned for May, and work concluding in June, 2010.
The Ho Chi Minh City metropolitan area, home to more than 9 million people, is expected to grow to a population of over 20 million by 2020. It is situated on the northern boundaries of the Mekong river delta region and, based on its size and growth expectation, the City has enormous demands for clean drinking water and must maintain strong water system operations into the future.
A strong water resource management system, with a safe and stable water supply and resilient water infrastructure considered across the whole water cycle, is a key issue for the City, especially given the climate change forecasts. Additionally, the City, with a 15km coastline and many key areas less than 1.5m above sea level, is extremely vulnerable to climate change impacts. Extreme weather events, such as typhoons, are expected to occur at greater frequency and severity. A 1m sea level rise would result in the loss of 2,500km2 of mangroves and 1,000km2 of farmland.
Highly aware of these conditions, the City, under the leadership of the Chairman and Department of Natural Resources and the Environment, has planned and enacted several programmes and policies on climate change, including a multi-departmental Climate Change Network, and government official training programmes. However, the City wisely recognized that more can be done to improve the City's water infrastructure and management against climate change, and that the Arup-C40 team could assist with this as part of the C40 UrbanLife initiative.

As presented in the paper, working closely with the Department of Natural Resources and the Environment, and other key water infrastructure stakeholders, Arup's technical experts conducted research and site visits to map out the water cycle issues and problems identified by the City and assembled key data, specific to Ho Chi Minh City, to understand, amongst other things:
- existing regional water resources;
- flooding mechanisms and how they impact at a catchment scale;
- existing and proposed water supply and wastewater infrastructure in the City and its environs;
- how this water and wastewater infrastructure operates;
- the perceived vulnerabilities to climate change and climate variability;
- stakeholders' concerns and suggestions; and
- water sector best management practices and policies relevant to the City.

The paper describes relevant city and stakeholder meetings and discussions, the research and analysis conducted, the high level presentations and interactive discussion sessions given to the City government at the UrbanLife Workshop, the main findings and recommendations, the expected future outcomes such as the capacity for action within the local government and specific proposals for City action.

PDD4.1-01 THE URBANIZED MEKONG-DELTA IN VIETNAM FROM 'LIVING WITH FLOODS' TO ADAPTATION

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The Mekong River Delta in Vietnam is one of the largest deltas on the world. Approximately 17 million people live concentrated around a vast and dense system of rivers and canals; it has been an attractive area for economic and urban development. However, it is currently a vulnerable area which is always facing with natural hazards. Climate change, rising sea-level and a rapid process of urbanization accompanied by dramatic land-use changes, reduced water-areas in urban structures and destroyed natural environment are challenges for a sustainable development of the Mekong River Delta. Since 300 years ago, when the first Vietnamese inhabitants explored and settled in this lowland area, their lives face with natural effects such as storms, increasing salinity, subsidence, and especially frequent floods. Deltaic urban environment is a clear result of the mutual relationship between human and nature. It illustrates how conditions of economic, culture and social life are coping with and adapting to natural disasters through many centuries. Nowadays, these means have been become a living culture as a significant character - 'living with floods'.
Based on the analysis of the urban environment of several cities in the Mekong River Delta, Vietnam throughout theirs historic development and present-day changes, this paper discusses the experiences of adaptive and control-oriented approaches and argues that 'living with floods' as a major strategy for facing with natural damages. This strategy results not only in the creation of the urban built environment with a deep understanding of a site's geography, topology, hydrology, climate and ecology but also in distinctive urban patterns with alternative methods of individual adaptation and disaster response. Besides, the paper will argue that these "traditional" planning approaches will be important values contributing to comprehensive strategies in order to develop a future safe and sustainable urban development in this area, which will be useful to other deltas as well.

PDD4.1-03 MODELING: IMPACT OF URBANIZED SURFACE SCHEME VERSUS BOUNDARY LAYER TRANSPORT

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Urban weather is hot! The anomalously warm summers of 2003 and 2006 has given us a look behind the curtains for what could be normal summer weather in the future in case the projected climate change will be realized. In order to understand what this future climate means for the human comfort of inhabitants of modern European cities, meteorologists require suitable equipment to downscale climate model output to the scale of a city.
The increased horizontal resolution of nowadays high-resolution mesoscale meteorological models has led to the realization that urban areas cannot be neglected anymore in such models. Moreover, these models have become more and more popular to forecast urban weather and human comfort. In order to do so, many different approaches (ranging from basic towards highly sophisticated) have been suggested to urbanize these model's land-surface schemes to account for the urban meteorological aspects, i.e. enhanced surface drag due to buildings, increased absorption of solar radiation, limited sky view and evapotranspiration, anthropogenic heat production etc. However, a recent intercomparison study for a variety of land-surface schemes has shown that increased complexity is not a priori fruitful for the model skill. It was found, that only a number of ingredients are required for a reliable forecast, i.e. anthropogenic fluxes and vegetation.
Inspired by these results, this study hypothesizes that that the choice of the atmospheric boundary-layer scheme, that transports heat, humidity and momentum away from the surface to higher atmospheric levels, is as important as the application of an urbanized land-surface model. In order to verify the hypothesis, a hot summer day in Rotterdam in 2009 is modeled with the mesoscale model WRF for 2 different boundary-layer schemes, both with and without an urbanized land surface scheme. Model results will be compared with field observations with the focus on the forecasted urban heat island effect and on human comfort.

PDD4.1-05 STUDYING THE URBAN HEAT ISLAND IN THE NETHERLANDS USING OBSERVATIONS BY AMATEURS

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In cities, it is usually warmer than in the rural areas that surround them. In summertime, this 'Urban Heat Island' (UHI) can increase heat stress during heat waves, and increase energy use for cooling. In wintertime, it can decrease cold stress and energy use. Not much is known about the strength of the UHIs of Dutch cities. For planning effective adaptation and mitigation measures quantitative information about the UHI in the Netherlands is needed.
A study of the UHI in Dutch cities is carried out, using in-situ observations. In The Netherlands, very little 'official' meteorological observations are available in cities. However, there are hundreds of weather amateurs, observing temperatures in their, often urban, living environment. They use semi-professional equipment. In this study carried out by KNMI, we store hourly temperature observations from more than 200 locations, of which a large number is located in urban space. Comparing these measurements with observations from rural sites, an estimate is made of the UHI in Dutch cities. Emphasis is put on obtaining a quantitative description of the UHI, including its variation over different weather types, seasons, times of the day and other parameters.

Some first analyses have been carried out. The outcomes show that for locations in urban regions like those of Rotterdam and Den Haag, the UHI is strongly dependent on wind speed, temperature and time of the day. The UHI increases with smaller wind speeds and lower temperatures, increases during nighttime and decreases during the day. The project continues until the end of 2010, and during the conference results based on the data collected until the end of the summer of 2010 will be presented.

PDD4.1-06 THE URBAN CLIMATE MACHINE

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As human beings we are living objects, we need sun and water. When you look in a different way at urban areas, you won't see a dead building or a non living parking garage. You can see an urban climate machine. All the buildings, all the roofs, all the parking lots and all the public areas can become living objects too, with the help of sun and water. Looking at your city as an urban climate machine gives way to innovative ideas for climate proofing our urban area. Three big Dutch cities in Noord-Brabant ('s-Hertogenbosch, Breda en Helmond), followed by Tilburg and Eindhoven, are looking at their communities through climate eyes. Small steps have already been made, they are ready for the next big step. With the help of scenario planning they look forward to the 22nd century. The use of extreme scenario's helps them and their stake holders, to change their view and see beyond our present way of organizing cities. It takes a lot of effort to change a city into a living climate machine. People have to believe in what they are doing and it has to become part of our culture. Changing takes time and courage. Brabants five big cities (B5) are leading the way. This paper will describe the B5-results in how they want to make their existing urban areas climate proof, how they manage to find advantages in climate proofing their communities and in what ways they can help each other out. Most important, it will present how they are able to communicate the need for adapting their cities, even if not everyone is convinced that our climate is actually changing. It shows how looking with different eyes can lead to different views. It's about looking at our cities as an urban climate machine.

PDD4.1-07 TIDAL CITY CONCEPT HAMBURG

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The metropolitan region Hamburg is in flux, as the relationship between the dynamics of the tidal Elbe estuary and the dynamics of economic activities require a new urban design paradigm under the influence of climate change and the effects of the human transformation of the river. Due to human modifications of the river morphology over the last century the tidal range increased by around 120 cm and heights of storm surges rose by around 70 cm. Is there a way to reinterpret the prevailing conditions toward a new paradigm, relating to the increasingly dynamic character of their deltaic environment, questioning the notion of control over water and (re)considering measures of adaptation? Addressing this challenge of rising risks, Hamburg is taking the opposite approach from cities like Rotterdam and London who are moving their harbours out to the sea and closing their river estuaries with storm-surge barriers to

protect their cities. In order to strengthen its flood resilience, Hamburg is allowing storm surge and the tides into the city as part of its urban design dynamics. This means on the one hand to adapt building and landscape structures to withstand flooding and on the other hand to give more space to the flood in order to reduce its height. By presenting design frameworks and projects from Hamburg, this lecture introduces how landscape architects and urban designers can get involved in the formative creation of future delta landscapes with a clear connection between the underlying dynamics of hydrology and topography as the major structuring foundation of urban form.

New mixed typologies emerge through the spatial and temporal overlapping of various uses and processes, so that the present one-sidedness of harbour, housing and farming along with the monofunctionality of the dykes can be suspended. The existing diversity of landscapes along the Elbe is deliberately developed into new spatial images and possible uses of urban landscapes. This strategic approach creates new synergies betweeen technical, economic and functional possibilities as well as beauty and meaning – in order to create visions of new tidal landscapes, new tidal cityspaces and new tidal lifestyles.

For illustrations see website: www.climatedeltaconference.org/results

PDD4.1-08 CLIMATE CHANGE, URBAN DYNAMICS AND (LACK OF?) GOVERNANCE: A LATIN AMERICAN CASE

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According to the Intergovernmental Panel on Climate Change, Latin America is the most urbanised region in the developing world. Covering a surface of around 20 million Km2 full of natural resources and biodiversity, it plays a relevant role for the planet (the RÃo de la Plata, the Amazon and the Orinoco carry into the Atlantic Ocean more than 30% of the renewable freshwater of the world). However, Latin America is very sensitive to climate variations and urban dynamics, and the smallest change can cause the biggest impact. This vulnerability is related to weak political, legal, economical and infrastructural frameworks together with income inequality, high poverty levels and population growth. The negative socio-economic scenario leads to an unsustainable use of the land and to a polarization of metropolitan areas. Considering that most of Latin American metropolitan regions are located on coastal territories, which are naturally sensitive to climate changes, it remains necessary to think about adaptation measures in terms of governance, to prevent climate variations in a context of cooperation and participation of multiple governmental and nongovernmental actors.

This paper will present as an example the case of the system of the Paraná Delta and the Estuary of the Río de la Plata, through which drains the second major hydrographic basin of South America -"Cuenca del Plata"-, covering 3.1 million Km^2 distributed in five countries (Argentina, Brazil, Bolivia, Uruguay and Paraguay). This example has been chosen because it is a high populated area with more than 22 million inhabitants which plays a vital role in the Hydrology and Economy of South American continent.
The methodology of approach will be based on the assumption that the Delta is a complex geological system that has been altered through history not only by natural processes but also by human activities and land appropriation modes. The interrelationships within the system need to be regulated by public policies in order to guarantee sustainability, life quality for the inhabitants and urban-economic development.
This presentation will describe climate change events that take place on the area such as floods, hails storms, increase of precipitations and sea level rise, land degradation, warming, salinisation and water stress, in order to study their impact on urban patterns. Then, the paper will explain the consequences of (planned and unplanned) urban development and human activities on the area (overexploitation of natural resources, changes in land uses and crops, increase of cattle productivity, etc.), and socio-economic vulnerabilities (overcrowding, widespread unemployment, lack of health and education services, inequity, etc.). The paper will also address the relevance of infrastructures and politic frameworks and will describe adaptation policies to deal with climate and urban variations in a context of demographic change.
Finally, the presentation will try to demonstrate the difficulties of designing and implementing urban adaptation measures in a context with lack of regional and metropolitan conscience, where politic-administrative fragmentation of the space leads to a polarization of resources, being an obstacle to the mitigation of impacts on territory and society in a context of governance.

PDD4.1-10 MALL SCALE URBAN DREDGING: ESSENTIAL TOOL FOR CLIMATE CHANGE MITIGATION

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Problem Definition
The Indonesian capital of Jakarta suffers from severe flooding causing major social disturbance, economic setbacks and sadly even the deaths of people. The forecast for the next years is not promising. Land subsidence rates along the Jakarta coast are extremely high and together with climate change induced higher sea levels and larger peak runoffs from river runoffs, they greatly increase the pressure on the capacity of the existing drainage channels. This old, but extensive network of channels has a back-log in maintenance causing relatively more flooding than necessary. Modelling showed that if they were maintained properly, they should be able to reduce the amount of flooding by up to 40%.

Theoretical framework and methods: The Pilot Dredging Project, Jakarta
Modern dredging methods and logistics are needed to clean up these often small, difficult to access channels filled with sediment and waste, and intersected with a multitude of low bridges, dams, cables and pipelines. The Indonesian authorities asked a Dutch consortium lead by DHV to demonstrate their expertise on the dredging of small urban canals through a visible and practical 'hands-on' Pilot Project.

Results
Within a period of a few months, the pilot was started in Jakarta together with the Indonesian Authorities. The pilot demonstrated the use of silt pushers or floating bulldozers as a cost-effective flood mitigation solution for the regular flooding in Jakarta. The waste and sediment were removed and the channels could operate at full capacity again. Equally important, the pilot contained a large portion of non-structural aspects such as community participation projects and dredging training courses. These were very well received and successfully adopted by the local authorities and community. The physical dredging works were crucial and acted as a (political) catalyst and unique opportunity for hands-on, learning-on-the-job training. Examples of results are:
- Training of Indonesian operators with the donated dredging equipment ensured that the local authorities now dredge independently and initiated a large-scale rehabilitation of all important channels in the city;
- Transfer of knowledge on preparation of dredging projects and long-term maintenance philosophies and -plans (planning and budget reservation) ensured that a separate division was set up by the Public Works Department of Jakarta that follows up and carries out the dredging works;

- Intensive cooperation with the local community resulted in community committees in charge of re-opening, cleaning and regular maintenance of the micro-drains in the small narrow streets within the neighbourhood. They are now more than ever aware that clean drainage channels (free of waste and sediment) are essential to help lower the chances of flooding of their houses and reduce health risks. Again, the presence of dredging material helped in stimulating the contact and visualizing the extent of the problem.

4. Presentation
The presentation will demonstrate the dredging techniques and logistics used and present the results of the non-structural measures including the lessons-learned in obtaining them.

PDD4.1-11 THE APPLICATION OF HIGH RESOLUTION WEATHER FORECASTS IN CLIMATE PROOFING

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The Rotterdam Climate Initiative is an ambitious program of the City of Rotterdam to adapt to the effects of climate change while guaranteeing safety, economic growth and an attractive living environment (1). One of the adaptation initiatives Rotterdam is developing in conjunction with the province of Zuid-Holland is the development of high resolution regional weather forecasts. This capability is based on the combination of a high density meteorological observation network provided by the municipalities in the Rotterdam Rijnmond region, a network of mobile weather stations fitted on public transport, and a high resolution numerical weather prediction model HARMONIE (2) provided by KNMI.
HARMONIE is the next generation numerical weather prediction model that has been developed in a scientific cooperation between the meteorological institutes of 27 European and North African countries. It contains a Town Energy Budget module (3) that models the effect of the built environment on local weather. The purpose of HARMONIE in this framework is threefold:
- to provide local weather forecasts that resolve the effects of the heterogeneity of the landscape, in particular the effect of the coastal zone and the contrast between the city and its surroundings;
- to analyze the observations from the high density networks through data assimilation;
- and to provide initial and boundary conditions for the more detailed engineering models that are used in the analysis of adaptation strategies at the level of neighborhoods, streets and individual buildings.
At the Deltas in Times of Climate Change conference we present the results of our implementation of HARMONIE to the Rotterdam Rijnmond region by comparing model outputs with local observations in a study of the Urban Heat Island effect and selected case studies of significant weather events. In addition we report on sensitivity studies with the Town Energy Budget model that are aimed at modeling the effect of adaptation strategies, such as greening of the city, at the scale of the city.
In our discussion of these results we focus on the quality of the model forecasts and the uncertainties in these forecasts that are inherent in the physics modeling, the model resolution and the initial and boundary conditions. We discuss the implications this has on the use of current high resolution numerical weather prediction models for city weather forecasts and for the downscaling of climate scenarios to the city scale. We furthermore explore the application of high resolution modeling in the development of adaptation strategies through spatial planning and the potential benefits of high resolution forecasts to economic activities in the region.

(1) Rotterdam Climate Proof, brochure of the Rotterdam Climate Initiative, http://www.rotterdamclimateinitiative.nl, 2008
(2) General description of the HARMONIE model, the Hirlam Consortium, http://www.hirlam.org, 2009
(3) Masson, V., A physically-based scheme for the urban energy budget in atmospheric models, Boundary Layer Meteorology 110 (1) pp. 99-137, 2000.

PDD4.1-12 ASSESSMENT OF THE ROTTERDAM URBAN HEAT ISLAND USING MOBILE MEASURING PLATFORMS

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The Netherlands has a mild Cfb climate and is situated close to the sea. As a result, the Urban Heat Island (UHI) effect was never considered an issue for urban planning even though the level of urbanization began to increase rapidly. This view was altered following the heat waves of 2003 and 2006 that caused an excess in mortality in The Netherlands of between 1400 and 2200 people. Climate projections predict that heat waves in The Netherlands will likely become more frequent in the next decades, which will add to the environmental stresses of urban life and lifestyles. However, information regarding UHI in Dutch cities is completely lacking, both from observational and model perspectives, which hampers the design of suitable adaptation and heat mitigation strategies. In this study, an assessment of the intensity of the UHI in Rotterdam was carried out. The goal was to assess whether or not heat stress already is or will become a critical issue. Traverse measurements were performed in the city using two cargo bicycles as a mobile platform, equipped with innovative instruments to quantify the heat stress in urban canyons. The cargo bicycles facilitate data acquisition through the narrow streets. They were equipped with a thermometer, a humidity sensor, a 2-dimensional sonic anemometer and 12 radiation sensors to measure solar radiation and infrared radiation exchange from six directions. The data were recorded at 1 Hz, and connected with concurrent readings from a GPS device. The instruments were powered by a solar panel mounted on the baggage carrier. Measurements were performed along two previously determined routes through a number of characteristic urban districts, including an industrial area, an older residential area, a city park and harbour area. The routes were photographed at fixed intervals from 50 cm above the ground with a fisheye lens pointing upwards. The observations were carried out during three 1-2h time intervals on warm days with maximum temperatures of about 30°C. Data from the traverse measurements were compared with recordings from a nearby synoptic weather station outside the urban area. Heat stress parameters were calculated from these measurements. Preliminary results show how effective urban parks and greenery is in reducing the UHI. The maximum UHI was about 7 K warmer than the rural area whereas greener urban configurations were less than 3 K warmer. City parks show marked cooling effects during daytime. The preliminary results clearly demonstrate the presence of a considerable UHI in Rotterdam, which is most likely to be found in other Dutch cities and confirms the important role of green spaces in mitigating urban heat stress.

PDD4.1-13 INNOVATIONS IN URBAN WATER MANAGEMENT TO REDUCE THE VULNERABILITY OF CITIES

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Introduction
Current urban water systems are criticized by many scholars. Negative aspect of the current urban water system include: effects of urban runoff on aquatic ecosystems, the lack of recycling of nutrients, the use of purified water to transport waste, land subsidence, high investments and maintenance costs, and the lack of flexibility to cope with future challenges. Cities show parasitic behavior. They extract all required resources from the surrounding area and after using them, discharge the pollutants to this area. Cities hardly use internal resources of water, energy and nutrients and require more and more space. Envisaged future urban water systems that are documented in literature, aim to reduce the vulnerability of cities and ecosystems.
This paper describes the results of a four year collaborative research project (2005-2009) of local governments, waterboards, consultants, research institutes and universities. The research was focused on surface water and groundwater within cities. In particular, opportunities that these components of the urban water system offer to reduce water related vulnerability of cities were studied. The overarching aim of this research was to develop understanding and insight how innovations in urban water management can be realized. This research applied vulnerability theory to contribute to better understanding of the current situation. Additionally, the technical feasibility of concepts that use the urban water surface water and urban groundwater to reduce the vulnerability of cities was studied. Finally, this research studied mechanisms that influence the adoption and mainstreaming of these technical concepts.

Methodology
n-depth interviews and analysis of policy documents in the city of Rotterdam were executed to analyse enabling factors and stakeholder attributes in order to successfully integrate water management with urban planning. In addition, results from a national web based survey on receptivity for change among urban water professionals indicate essential conditions for changing urban water management practice and mainstreaming innovations.

Results
The outcomes of this project include: (1) feasible technical concepts for more sustainable urban water management, (2) application of these concepts in three casestudies in the Netherlands and (3) recommendations for policy makers and urban water professionals to successfully mainstream these concepts into day-to-day practice. It was found that the receptivity of professionals toward innovations determines the eventual application instead of the technical and economic feasibility.

PDD4.1-14 MAPPING LOCAL VULNERABILITY ON A NATIONAL LEVEL. CASE STUDY: THE NETHERLANDS

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Advanced understanding of the potential negative long term consequences of climate change on urban areas, has caused a necessity to lead a proactive adaptive policy. The consequences of climate change on cities should first be determined though in order to choose an adequate adaptation strategy.
Although extensive attention has been given in the past years to the effects of climate change, there is limited quantitative information available that expresses the vulnerability to the consequences of climate change to urban areas. This limits the possibilities to frame the consequences of climate change for setting up appropriate regional and national policy.
At present, climate vulnerability assessments often stand at the basis of adaptation strategies. Vulnerability can be expressed as a function of hazard, exposure and sensitivity. Hazard is the stressor caused by climate change (e.g. extreme events of rainfall or drought). Exposure is determined by physical location, spatial distribution, soil characteristics and other characteristics which determine to what extent an urban area is exposed to the effects of climate change. Sensitivity expresses the extent of the consequences to a climate impact mostly in terms of damage. This assessment framework for the vulnerability of urban areas has been applied to the Dutch cities.
The study was performed on request on the Netherlands Environmental Assessment Agency (PBL), within the framework of the project 'developing adaptation strategies for a climate change proof Netherlands'. The aim of the study was to roughly determine the vulnerability of urban areas on a national level to the effects of climate change on water safety, water nuisance, drought and heat stress. Data mining and cartographic analysis revealed the relative vulnerability on these 4 themes. Analyses were first made on the scale of a neighborhoods and were then scaled to provide insight at a national level.
The effects of climate change on urban area are actually effects on the elements specific for the urban area. Special attention was therefore given to the relationship between vulnerability of urban areas and the spatial distribution of certain functions or types of neighborhoods:
- What is the relationship between vulnerability to climate hazards and characteristics of neighborhoods such as function or age?
- To what extent do regional geographic characteristics determine the vulnerability of urban areas?
- Is it possible to translate these relation into indicators to predict the vulnerability of a neighborhood according to its typology?

All Dutch cities show vulnerability hotspots within the city boundaries for at least one of the 4 climate themes. Even the relative young cities of Almere and Lelystad prove to be vulnerable if one considers that restructuring will not occur within the next decades, in which the effects of climate change will manifest themselves. No clear relation was found between the vulnerability and urban typology as defined by the Netherlands Environmental Assessment Agency except for Heat stress. Regional differences in urban vulnerability were found for the theme's Water safety, water nuisance and drought. These are related to the geophysical characteristics of the soil and ground elevation.

DD4.2-02 CREATING A WATER ROBUST ENVIRONMENT FOR VITAL AND VULNERABLE OBJECTS

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The province of Utrecht has a policy, stated in the 'provincial waterplan' for the reduction of the consequences of flooding from rivers (Neder-Rijn en Lek) and lakes (Randmeren) in the province of Utrecht. The province primarily focuses on preventing areas from flooding. The first cornerstone of the flood risk policy is prevention. However, a levee breakthrough can never fully be excluded. In 1995 parts of the province have been evacuated due to high river discharges and the possible failing of the levees. The possible consequences of flooding increases if flood risk is not an issue in the development process of new buildings and areas. Therefore the province has embedded in the water plan that for vital and vulnerable developments an infrastructure flood risk should be considered in planning and design.
The strategy of the water plan is based on three elements, as described in the National Water Plan: prevention, damage reduction and damage response. The location of new vital and vulnerable buildings is of great importance. The location is an important contributor to the safety of objects. If objects are being built in areas with a flood risk, the development of objects focuses on damage reduction. If nevertheless buildings or areas are damaged, reconstruction brings the objects to an equivalent state as before the disaster. Because flooding is not anticipated on in the design, operation and maintenance of vital and vulnerable objects, buildings and infrastructure, the province wrote a handbook for flood resilient development.
Vital and vulnerable objects, infrastructure and buildings can cause disruption of society when they fail. That's the main criterion for the selection of vital and vulnerable objects. Based on research of the national government and others, the province listed vital and vulnerable functions. Examples are electricity network, communication networks and health care.
In order to reduce damages during floods several measures can be taken. The three-step approach which links planning, design, construction and exploitation can be used to choose the appropriate set of measures. The three-step approach is to be applied three times during an urban development or rehabilitation project. For vital and vulnerable objects, buildings and infrastructure the operation and maintenance phase is of utmost importance. In that way, awareness for flood risk is secured, during the life-cycle of these areas.

DD4.2-03 TOWARDS WATER ROBUST URBAN ENVIRONMENTS BY USING A THREE STEP APPROACH

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Changes in climate will likely have major implications for the future layout of cities, for individual properties and buildings and for the residents. A three step approach has been developed to plan and implement these changes in a structured way. The approach is applied to steer urban expansion and redevelopment toward water robust urban environments through integrated planning and action at local level. The three steps are (1) a vulnerability analysis, (2) selection of a strategy to improve the protection level and (3) selection of an appropriate set of measures. Measures can be selected from a list of over 180 hard and soft optiens.The approach deliberately leaves much freedom to the parties involved in a specific urban development projects. Local conditions to a large extend determine what can be done. It is up to these stakeholders to select a vulnerability reductions strategy. An appropriate set of measures provides a level of robustness that is applicable for all stakeholders and that stakeholders are willing to pay for, both for the investments and for the maintenance costs.
Creating a water robust environment is not a single moment effort. Continuous attention is required of different people and organizations, often including the residents. In order to make all of them understand the protection strategy and measures the three-step approach is to be applied three times during an urban development or rehabilitation project; (1) during the spatial planning phase, (2) the development and design phase and (3) at transfer to the operation and maintenance phase.
The three-step approach has been applied to the first two phases in several projects, namely Nieuwerkerk-Noord, Rijswijk-Zuid, Erasmusveld Den Haag. It has proven to be a guiding model for a collaborative design and negotiation problems. The challenge of creating a water robust urban environment is to make the appropriate decisions at the right time. This leads to a sustainable design, giving the local conditions, in the urban environment.

DD4.2-04 A PILOT APPLICATION OF THE MULTI-LEVEL CONCEPT TO FLOOD MANAGEMENT

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The European Commission stresses the need for a new approach to flood management; the EU Floods Directive lays down a step-wise approach for managing risks to human health, the environment and economic activities associated with floods. It will require EU member states to reduce flood risk for those areas where the risk is deemed significant. For these zones flood risk management plans must be prepared. These plans should include appropriate objectives that focus on either the reduction of the likelihood of flooding or on the reduction of potential adverse consequences, as well as measures for achieving the established objectives. They should address all phases of the flood risk management cycle, but focus particularly on prevention, protection and preparedness.
In line with the Directive's requirements the Netherlands is now opting for a 'multi-level safety' approach, which is laid down in the National Waterplan. This is a three-tier approach to flood management, the first of which is avoiding floods. This is and remains the cornerstone of water safety policy in the Netherlands. The second and third layers are therefore aimed at limiting the effects of flooding. The aim of the second layer is to create a sustainable spatial layout of the Netherlands and the third seeks to improve the organisational preparations for a potential flood (that is, disaster mitigation).
The Dutch multi-level safety approach requires multi-actor and area-based work. In this regard, the recently started EU's Interreg IVB project MARE will provide a relevant practical example of the application of the multi-level safety approach through collaboration of public and private stakeholders in a real life case. These activities will result in the development of a flood risk management plan aimed at creating a more resilient urban environment where the potential occurrence of a flood, even in case of an exceptional flood above design level, will result in minimal physical and social damage.

This work gives an analysis of the flood risk and of the effectiveness of possible responses with both structural and non-structural alternatives. These alternatives include, for example, robust delta dikes (i.e. non-breaching dikes), compartment dikes, and strategic urban planning. The responses were schematized in the SOBEK-Rural overland flow module to analyze to what extent management of the flood risk is possible. This information was then used as input to develop and update the flood risk management plan for the location. Besides that, the experience gained from the pilot application could contribute to the implementation process of national and European policies on flood management.

DD4.2-06 FLOOD RISK ASSESSMENT IN UNEMBANKED URBANIZED AREAS IN THE NETHERLANDS

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In many deltas, climate change is expected to increase the flood risk due to sea level rise and/or changes in river discharge. This especially holds for urban areas, where flood risk is further increased by an ongoing process of urbanization within the floodplains. Within The Netherlands, The Rijnmond-Drechtsteden area (The Netherlands) is one of the main examples where these conditions apply. While most of the urbanized areas are protected by levees, a significant part of the urbanization and industry in this region is located outside the primary flood defences. Located at a relatively high level of elevation, the region seems safeguarded against flooding. Nevertheless, the current and future flood risk for this area has only been assessed to a limited degree. Within the Knowledge for Climate program, further study is performed on flood vulnerability for current and future climate scenarios for the Rijnmond-Drechtsteden area. This research was focused on the estimation of i) flooding characteristics (water depth, flood extent, flow velocities), ii) flood damage in urbanized areas and iii) flood vulnerability in the port area.
To acknowledge the scale and differentiation within the area, the inundation depths and flood extent were determined using a high resolution digital elevation model (5 m grid). Flow velocities were derived from an existing model in combination with a literature study and flow velocities measured in the main channel. Flood damages to urbanized areas were estimated and analyzed using a broad set of attributes to provide in-depth knowledge on spatial and temporal damage distribution. For the port areas, the vulnerability was assessed by expert meetings, literature study and a comparison of external safety standards and (additional) flood risk.
The results show that the area outside the primary flood defences in the Rijnmond-Drechtsteden area is prone to substantial future flood risk. While the risk for the current conditions is limited to 'extreme events' (e.g. a 1:10.000 year flood), the shift in the probability distribution as a result of climate change moves these 'extreme events' into the realm of more frequent floods. This holds especially for the extreme 'Veerman'-scenario for the year 2100 and to a lesser extent for the G+ scenario for 2050.
The majority of expected flood damages in urban areas are located in relatively small hotspots. Minor damages are expected dispersed over a larger area. For residential areas, half of the expected damages are on the content (furnishing). Apart from increasing the expected damage levels, climate change shifts future flood risks to areas containing substantial amounts of historical buildings.

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The risk profile of the existing port is difficult to assess; individual differences between (petro-) chemical installations make a broad scale inventory intractable. Flood risk seems only a small addition to the existing risks, which have been minimized within the current safety standards.
An important aim of this study is to provide an extensive foundation for future flood management policies. Although the provided information is comprehensive and provides many leads towards future implementation of measures, a well-balanced vulnerability framework is still lacking.

DD4.2-07 ASSESSMENT OF MEASURES AGAINST FLOODING VULNERABILITY OF INFRASTRUCTURE IN DHAKA

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Due to its location in a deltaic plain, the metropolitan area of Dhaka, world's eighth largest city, is extremely prone to detrimental flooding. The city falls under the active river tidal zone and consequently its low lying areas are often engulfed by the high tide. The risks associated with these floods are expected to increase in the coming years due to global climate change impacts as well as the high urbanization rate that the city is facing. An additional causative factor for the urban flooding is the inability of the city's drainage system to cope with the runoff of excessive rainfall. The scale and condition of the drainage system has not been kept in pace with the rapid expansion of the city and there is a serious concern that future flooding will pose extensive damage to overall infrastructural system.
The lowest lying part of Dhaka, located in the Eastern fringe of the city, faces the most severe risk of flooding. This area also functions as water retention area. Due to land scarcity in the city, the population of the Eastern fringe has increased alarmingly during the last decades. Thousands of people have encroached the area in search for a place to live. The natural drainage is performing inefficiently and the area is still unprotected from flooding which causes major threats to its inhabitants. Additionally the infrastructure of the basic services sector (e.g. transport, water supply, sanitation) is at stake, as was experienced during recent inundation and flooding events (e.g.1998 and 2004). This situation increases the urgency to effectively adapt to current floods caused by climate variability and to the impacts of future climate changes. The government is planning several adaptive policies and measures to protect the infrastructure of the basic services system in the area whereas a systematic framework to analyze and assess them is lacking. The objective of the paper is to develop an integrated framework for the assessment of various adaptation measures aimed at protecting the infrastructure of basic services from flooding.
The foundation of this framework is created by assessing the vulnerability of the city's basic infrastructure system to flooding. The sectors to be assessed include the transport network, the drainage and sanitation - and the water supply system. The study firstly assesses current and future risks from flooding for the infrastructure system in the most sensitive region of the city. Subsequently, the study analyses and assesses potential adaptive initiatives and measures to address flood risks in the city based on the prioritized needs by government and relevant stakeholders. This analysis is based on in depth interviews with various stakeholders and addresses their objectives and views regarding adaptive initiatives and measures.
The assessment framework is tested in the Eastern fringe of Dhaka city. Based on the assessment and analysis, gaps and potential adaptive measures are identified to enable more effective action while taking into account different policy objectives. Based on the study and application of the assessment framework, conclusions and recommendations are drawn.

DD4.2-08 BACKCASTING FUTURE VISIONS ON ADAPTATION TO FLOODS AND DROUGHTS: A TIME TRAVEL INTO THE PAST, PRESENT AND FUTURE

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The observed impacts of floods on social-ecological systems of deltaic and coastal regions, particularly densely populated cities, are clearly questioning and challenging present-day management approaches to adapting to these human-induced events. A shift towards more adaptive management approaches is currently unfolding, though our understanding of its underlying dynamics emerging from poorly understood complex social-ecological interactions is still limited. This paper therefore aims to contributing to the apparent academic pursuit of an improved understanding of the interplay between complex flood dynamics and capacity building effort to adapt to them. It does so, by providing a framework for a multi-stakeholder participatory backcasting approach to exploring plausible development pathways of social-ecological systems towards a desirable future system state. Based on the results of a backcasting study on the Master Plan for rebuilding New Orleans, backcasting is considered a promising tool for developing a future vision on social-ecological system adaptability and constructing different pathways to achieve this vision. This paper also demonstrates that backcasting with its apparent focus on the future ironically carries potentially forgotten policy burdens of the recent or distant past, which imposes the need for bridging the past and future in environmental policy making.

PDD4.2-01 THE SAFETY PARADOX AND THE THREE POINTS APPROACH

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Problem
This paper is about climate change in urban areas and its complexity. It addresses the following three questions:
1. How can we characterise the urban climate change complexity?
2. Which theoretical method can be used to cope with this complexity?
3. What will be the impact of using this method on the practice of urban development?
To answer these questions, we make use of the (social) complexity theory and research on the significance of implicit knowledge in water management. More than seventy people have been interviewed, using the narrative method, a methodology that reveals complexity. These people work at municipalities, water boards and the national water authority. We will present results in a triptych.

Characterisation of urban climate change complexity
Discussions about climate change and flooding organise themselves around the safety paradox. On the one hand water professionals claim that due to climate change flood risks rise and people have to be aware of that. This awareness of “a real big problem”is a pre-condition for political support and for finding financial resources for improving water system’s safety. On the other hand they communicate that it is “very safe”to live in the areas close to the water front or below sea level, to stimulate companies to invest in it. This paradox characterises the climate change complexity. The data shows that water professionals and administrators have difficulties to cope with this

complexity. In fact people acting in water organisations (in the Netherlands) show a decreasing lack of consensus (order) and an increasing number of different approaches, thinking systems and opinions (chaos).
A theoretical concept to cope with this complexity
In the paper we will suggest the Three Points Approach (3PA) as a good theoretical tool to unravel discussions that are mixed and to increase consensus about the strategy to cope with the complexity. The Three Points Approach distinguishes three domains of discussions that deserve equal attention:
1. the domain of standards and technical solutions, where technical people act;
2. the domain of extreme conditions and its effects on spatial planning, where interdisciplinary professionals act; and
3. the domain of day to day values, where politicians act and interaction with citizens happens.
Currently domain 1 dominates the other two, neglecting the need for attention for social impact.
The use of the 3PA will not result in an optimised water system’s design. It will activate the mechanisms of adaptation to climate change and other processes in the water system’s context. So it helps water professionals to think in terms of adaptation instead of optimisation and it stimulates participation of stakeholders by emphasising positive values and robustness.

The practical meaning of the Three Points Approach
In the last part of the triptych we will give some practical examples about the use of the 3PA, on a local urban scale and a regional scale.

PDD4.2-02 NATIONAL COASTAL PLANNING STRATEGIES IN THE NETHERLANDS AND TAIWAN

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Coastal planning is becoming increasingly important in most nations due to issues such as climate change, habitat protection, coastal erosion and flooding. As a means of promoting inter-sectoral cooperation and consensus-building, strategic planning has an important potential role in managing coastal areas.
Coastal strategies have a long history of focusing on the protection of species (see e.g., Nystrom and Folke, 2001) and the prevention of coastal erosion. More recently, the scope of coastal strategies has broadened to include concepts like sustainable development and urban resilience, resulting in strategies for marine development in a very wide sense (e.g. wind-energy, oil and gas, shipping, nature conservation, fisheries - (Satria and Matasida, 2004), the development of coastal settlements (Gibbs, 2009, Glavovic, 2008), tourism and leisure. These strategies span, or have implications for, different levels of government (Fernandez et al., 2000).
Despite having quite different physical characteristics, coastal regions in The Netherlands and Taiwan face numbers of similar threats and pressures, such as flooding, coastal erosion, salt-water invasion and urbanisation, while coastal planning strategies for both countries reflect different policy priorities and approaches. For instance, coastline planning strategies in Taiwan are relatively inflexible and often focus on habitat protection whereas strategies in The Netherlands often focus on comprehensive land use management and arguably offer more flexibility to adapt the coming threats from climate change. This study aims to compare and contrast the national planning approaches in these two countries, both in terms of governance strategies and planning practices. The paper is structured in three main parts: (i) an assessment of the degree to which these coastline strategies are starting to reflect policy concepts like sustainable development and urban resilience; (ii) a review of governance approaches to coastal planning in The Netherlands and Taiwan; and (iii) an analysis of the benefits and limitations of these two approaches for adaptation.
Keywords: adaptation, coastal planning, climate change, resilient thinking, The Netherlands, Taiwan.

PDD4.2-03 LEGAL ASPECTS OF MULTIFUNCTIONAL FLOOD DEFENCE STRUCTURES IN URBAN AREAS

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In the coming decades the primary flood defences on seas and rivers will have to cope with higher water levels due to climate change. In many places this will require strengthening of these flood defences. Urban areas already cope with space scarcity for their own development plans and therefore this space consuming development requires an innovative approach. Combining flood defence with other functions provides a very interesting opportunity.
Inspiring examples on how to combine flood defence with other functions already exist. For example, in the city of Oostende (Belgium) a parking garage is integrated in a flood defence structure, while in the city of Hamburg (Germany) buildings provide parking and commercial facilities that also function as a flood defence. These multifunctional structures allow for an optimal use of the limited space available. Translation of these inspiring examples to the Dutch situation asks for an insight in the possibilities the existing legal and institutional framework offers.
Challenging in this field is also the combination of the (legal) requirements for design period between spatial planning and safety. Typically, flood protection structures are designed for a 100 to 200 years life, while functions typically aim at a shorter life span up to 80 years.
The present study is part of the “Knowledge for Climate-Program (hotspot Rotterdam)”and focuses on the legal consequences when realizing a multifunctional flood defence in the city of Rotterdam (the Netherlands). This study explores the challenge of defining responsibilities and liabilities between the parties owning, operating and using these multifunctional flood defence structures. Secondly, the requirements and constraints originating from the flood protection function that have to be taken into account in supplemental functions are considered. Finally, a method to manage the likely differences in design (life) relating to the flood protection function and other functions of the structure is developed.
The knowledge and experience gathered in the “Knowledge for Climate”study can also be used in other locations, in the Netherlands as well as abroad. An interesting example in the Netherlands where the information can be used well is the city of Scheveningen. Royal Haskoning is currently conducting a study in Scheveningen. In this study alternatives to protect the harbour area of Scheveningen are investigated. One of the alternatives is a multifunctional flood defence along the coast. Results from this study as well as the “Knowledge for Climate”study will be presented in the paper.

PDD4.2-04 SKINT - NORTH SEA SKILLS INTEGRATION AND NEW TECHNOLOGIES

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Speaking a mulitidisciplinary language to integrate the worlds of spatial planning and water management.
Encouraging the implementation of innovative technical and sustainable solutions which have already proved to be successful.

Problem definition
The Water Framework Directive (WFD) and Floods Directive (FD) have clear goals about improving water quality and regulating water quantity. When coupled with climate change and urbanization these create increasing pressure on water management, especially in urban areas.

Theoretical framework and methods
Many of the solutions in urban water management lie in the spatial planning process. SKINT facilitates the implementation of sustainable urban land and water management by improving the integration of water management in the spatial planning process. SKINT gathers knowledge and experience from successful initiatives and provides (communication) tools to assist water managers and spatial planners in improving their skills in integrating both quality and quantity of ground and surface water. For this SKINT will:
- facilitate the involvement of water managers and spatial planners in a multidisciplinary process by improving communication;
- create and apply an international knowledge base of excellent processes and practices of water management integrated with urban land use;
- facilitate the implementation of technical water solutions;
- provide information to professionals to convince decision makers of the need to select sustainable solutions;
- share the findings from SKINT with the future water and urban land use professionals in ways specified by those professionals;
- conduct a specially developed training programme for current and future water and urban land use professionals.

Results
Sustainability is one of the principles of SKINT. SKINT contributes to the awareness of decision makers on the environment. More often the right decisions will be made on measures to improve the water quality and to reduce the flood risk in urban areas.
Results will be used for a permanent water web-portal and a web-based face-to-face training programme for future water and urban land use professionals. The permanent portal for urban water and land use in Europe will be complementary to and interact with portals being developed by other projects. After SKINT the water portal will continue to be a dynamic user driven website for future multidisciplinary stakeholders and a source of communication about truly sustainable urban water management.
The training programme will increase the ability of professional staff in key public bodies to manage the built environment of existing urban areas so that the needs of integrated land and water planning are better met. The target group for the training will be a range of disciplines involved in water management and spatial planning / development control who as end users will be the champions of sustainability.
So SKINT will improve the implementation of the WFD and FD to contribute to the improvement of water quality in urban areas and, inter alia, the reduction of flood risk. The project runs between 01.10.2008 and 31.10.2012 and aims to provide a long lasting legacy.

PDD4.2-05 EILAND VEUR LENT: CLIMATE ADAPTATION AS THE BASIS FOR INTELLIGENT PLACE-MAKING

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A 200m wide flood relief channel for the River Waal and 1km dyke relocation at Lent, near Nijmegen, form one of the most significant Room for the River projects.
These works will have a significant effect on the existing inhabitants and local area, initiating a range of responses and conflicting interests. Numerous houses will require relocation and others will be isolated from the main land and require costly new support infrastructure. Simultaneously plans are being drawn for thousands of new homes behind the new dyke, which will transform the character of the area further. The remaining peninsula and occasional island require a new plan that provides short term measures to adapt existing properties to the heightened flood risk and long-term plans to manage use of the site for the benefit of the local towns.
These issues and conflicts create a challenge and an opportunity for designers. These can be summarised as:
- Connection between urban, biological and managed (non defensive) river environment and significant (8m) water level variation.
- Resilient construction and appropriate building typology.
- Ecological and economic issues of large infrastructure works, such as relocating large quantities of excavated soil
- Opportunity for diversity and ecology in the urban environment.
- Complexity of managing individual interests, including political short termism versus the need for long-term change.
- Added value that can be generated through an integrated approach to tackling these issues.

This paper examines proposals to combine water with river ecology, flood resilient development and sustainable infrastructure to create an energy and water self-sufficient 'eco-leisure' destination. The entire island is designed to provide 100% renewable energy, water collection and storage, taking the site off-grid. The proposals include:
- A 'hill dyke', utilizing waste excavated material (after valuable excavated soil has been sold) from the new river channel to create a landscaped feature, extending into the water.
- A 'water park', in which water becomes a uniting element and way finding mechanism, linking the land and riverside developments.
- An integrated redevelopment plan to support the existing homes, waterside tower and holiday units that extend down to the water level, to 'touch the river'.
- Pathways and connections revealed and functioning at different water levels, combining water movement and archaeology.
- A showcase of international architectural and landscape innovation.

For illustrations see website: www.climatedeltaconference.org/results

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PDD4.2-06 ZOOMING IN ON URBAN FLOOD DAMAGE ASSESSMENT: A LOW LEVEL APPROACH

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Flood risk assessment mainly focuses on floodplain delineation and risk zoning. While the concept of risk clearly includes an impact component, comprehensive flood damage assessment is often neglected or is at best based on a low level of detail. Especially since many of our urban areas are located in river deltas, the trend changes and increased residual risk expected because of climate change urge for further insights into the vulnerability of urban areas towards flood risk. Within the HSRR02 project, which is part of the knowledge for climate programme, an attempt has been made to make a detailed flood damage assessment for a relatively large urbanized area: The Rijnmond-Drechtsteden region in The Netherlands. Emphasizing on housing and infrastructure, the study provides a detailed appraisal of expected flood damages on individual building and street level. Furthermore, application of two climate change scenarios gives insight in the damage estimation for the year 2050 and 2100.
The observed results show that within current conditions, expected flood damages are low for frequent floods but rise significantly for 'extreme events'. These outcomes are shifted towards lower return periods after application of the two climate change scenarios. The associated return periods shift by a factor of almost 1000. Furthermore, the expected damages show an uneven spatial distribution; they are concentrated in relatively small areas in which the majority of damages are expected. Damages to infrastructure are somewhat more dispersed but only account of about 30% of the observed aggregate damage levels. Within the housing stock, damages to the interior comprise of almost half of the total damages expected for housing units. To some degree this is due to the absence of high flood velocities which would result in structural damages within buildings. While currently relatively unexposed, the historic building stock located in Dordrecht and Rotterdam is especially prone to flooding within the two applied climate change scenarios; for the year 2100 the majority of the flood damages is on housing built before 1900.

PDD4.2-08 CLIMATE PROOF URBAN DEVELOPMENT THROUGH LEARNING ENVIRONMENTS IN THE NETHERLANDS

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Across the world, public authorities call for more sustainable urban development and regeneration, for which more collaborative and integrated approaches are needed that integrate different sectors and technologies. However combining various sustainable policy objectives related to energy efficiency, heat stress, drought, water nuisance, flood risk and air quality, has proven to be very difficult in practice. This is especially true when using a long-term perspective, considering socio-economic and climate change scenarios.
Much research stresses the need for this integration and demonstration projects. This paper, however, provides recommendations on how research itself, via learning environments, can contribute to demonstration projects. A Dutch case study is presented where a learning environment supported the process of incorporating state-of-the-art

science into the planning of an urban regeneration project. The learning environment analyzed the neighbourhood's vulnerability to climate change, as well as its adaptive capacity defined by opportunities presented by urban dynamics. E.g. smart coupling of investment decisions (on e.g. urban drainage and sewage) and urban developments (e.g. more pervious areas or surface water) to implement vulnerability reducing measures. Also is actively sought how the implementation of spatial measures can support social cohesion.

PDD4.2-10 FLOOD PREPAREDNESS IN ZEELAND (NETHERLANDS); TRANSITION IN RESILIENCE MANAGEMENT

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Zeeland is an area identified as prone to flooding. Until recently, the Dutch have taken a technocratic approach with regard to safety. The new policies aim to increase a region's resilience to flooding by basing it on a more sustainable relationship with water, in which the demands of socio-ecological aspects are of main consideration. With the contemporary knowledge on global warming, together with the expected rise in sea level, the emphasis of the Dutch water management shifted towards a more integrated and interactive policy in which the general public is expected to participate. This is occurring alongside a trend of balancing centralized and decentralized governance.
group of undergraduate students (social science and science) investigated the susceptibility of Zeeland to flooding and combined this with a study of public awareness. Special attention was paid to the former island of Walcheren. First the risks and current flood protection policies were analyzed by considering spatial planning, man-made barriers, flood risk models, insurance policies and disaster response management. To examine public perception, a survey was conducted to assess the knowledge (safe haven availability, actual risk and residual risk) and preparedness (possession of the recommended emergency package and coping plans) of citizens. In this way, the citizen's awareness of the various transitions within the Dutch water management was evaluated. The study was further supported by individual interviews.
In conclusion, this study identified whether the transitions in approach to flood protection and governance are able to increase Zeeland's resilience to flooding. Recommendations regarding the improvement of the implementation of the actor roles and processes are given.

PDD4.2-11 AMPHIBIOUS BUILDING: A NEW STRATEGY FOR URBAN FLOOD RESILIENCE IN DELTAIC AREAS

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Current evidence of global climate change is giving rise to predictions of increases in both the frequency and severity of urban flooding in deltaic regions. It is imperative to find new approaches to urban flood mitigation that can reduce vulnerability and enhance resilience by providing sufficient protection to avoid catastrophic damage during extreme events, without disrupting the existing social and physical structures of established communities. Building on amphibious foundations is such an approach.
Amphibious foundations are a proven, cost-effective strategy appropriate for housing in areas where rising flood waters are not accompanied by high flow velocities. There is growing awareness that homeowners in established urban communities are resistant to the daily inconvenience of stairclimbing, the disruption to a neighborhood's appearance, and the lack of sufficient protection in an extreme flood event that are characteristic of permanent static elevation. Amphibious foundation systems retain a home's close proximity to the earth and relationship to the street by supporting the house at a slightly raised elevation under normal circumstances, and floating the house to as high a level as is necessary to remain safely above water when flooding occurs. Successful amphibious foundation systems are functioning in Maasbommel, Netherlands, and at Raccourci Old River, Louisiana, where they provide flood protection that is both more reliable and more convenient than can be obtained from permanent static elevation. Two amphibious houses have recently been completed in New Orleans, and a prototype amphibious house for slum dwellers has just completed construction in Dhaka, Bangladesh. The Buoyant Foundation Project for retrofitting existing traditional housing in New Orleans with amphibious foundations is currently under development.
The use of amphibious foundations is a safe, permanent, sustainable approach providing proven, low-cost, low-impact flood mitigation that can protect established communities and cultures in the face of impending environmental changes. It increases a flood-prone community's resilience by diffusing risk rather than concentrating it. Amphibious building is a strategy that encourages an attitude of accommodating, rather than fighting, water. For coastal cities to achieve long-term survival in the face of global climate change, we must learn to live in safety with water. This challenge of living WITH water is one shared by deltaic communities around the world. Why fight floodwater when you can float on it?

PDD4.2-12 USE OF SALINE WATER AS SECONDARY QUALITY WATER IN COASTAL AREAS

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Water shortage is becoming an increasingly dominant problem in many coastal cities in both low- and high-income countries (supporting about 60% of the world population). Due to rapid urbanization and climate change, traditional (like water saving, fresh water transport from far away or rainwater harvesting) and advanced solutions (sea water desalination) become insufficient, non cost-effective and/or environmentally unsustainable to matching the ever growing water demand. Direct use of seawater for toilet flushing, and other non-potable uses, is often forgotten, easily rejected and traditionally perceived as problematic due to corrosion issues and requirements for dual systems.

However, the benefits are often overlooked and, in general, not well studied and documented despite its potential and as a means towards sustainable water cycle management, opening a new paradigm towards the use of saline water as secondary quality water in urban environments. In laboratory experiments the effect of saline water use are investigated. An innovative wastewater treatment scheme, sulfate reduction autotrophic denitrification and nitrification integrated (SANI) process, is studied. The SANI process makes use of the sulfate present in saline water. Sulfate reducing micro-organisms remove COD without oxygen. The produced sulfides are used in the next step for autotrophic denitrification. Only the nitrification step needs oxygen, so overall less aeration (= energy) is needed for this new wastewater treatment concept. Growth rates of the micro-organisms involved are low, so surplus sludge production (= a big cost of activated sludge wastewater treatment systems) will be limited. Currently laboratory-scale experiments are conducted to investigate the effects of different sulfate:COD ratios and different temperatures on the sulfate reducing process. Operational parameters and the microbial community dynamics are monitored.

PDD4.2-13 CLIMATE CHANGE AND CITY DEVELOPMENT IN THE CITY OF THE HAGUE

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Climate change has a great impact on the urban habitat and how we design our urban environment. The measures taken to decrease the impact of climate change, will eventually be implemented at the local (governmental) level. Often the great ambitions fade out in this process.
The Hague is facing a threefold of effects of climate change. Firstly, heavy rainfall will increase which will cause water related problems. A second consequence is the sea level rise, which emphasizes the need to strengthen the coastal defense. A third consequence of climate change is that the number of very hot summer days will increase, which will have a large impact on the health of citizens. One of the biggest challenges for The Hague is to link the consequences of climate change with spatial goals in the city.
The scope of the paper will be as follows: the first paragraph will give a short description of The Hague, the location and the climate characteristics of the city. In the second paragraph the focus will be on the consequences of climate change and the impact on the city. In the third paragraph an overview will be given of cases in which climate challenges will be linked to spatial challenges. One of the cases will be along the coast, Scheveningen boulevard, and the next case will be in the city, the Noordpolder.
Finally this paper ends with a reflection on the adaptation strategies the city of The Hague uses in the challenges of a changing climate and city development.

PDD4.2-15 SURFACE WATER AS COOLING MEASURE IN URBAN AREAS

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Delta cities are most often megacities showing a strong Urban Heat Island effect (UHI). In the case of Rotterdam this UHI effect in combination with climate projections shows an increase in temperature, especially in summer, resulting in an increase of days that people experience heat nuisance or heat stress.

Another characteristic of Delta cities is that (fresh) surface water is highly available. The availability of this surface water provides a great potential for using surface water as a cooling measure. Surface water has two cooling effects. First, its large heat storage capacity has a cooling effect on the air temperature during the day, when air temperature is higher than the water temperature. Second, and more important, evaporation of water causes a large part of the incoming solar radiation to be converted into a latent heat flux instead of a sensible heat flux. The sensible heat flux causes a large part of the heat stress experienced by people. In our study we quantified the effect of surface water on its surroundings in urban area. We performed measurements of air temperature using the fiber optic Distributed Temperature Sensing (DTS) method. This enabled us measuring air temperature in a two dimensional grid above and near the surface water. Over larger distances a horizontal temperature profile was measured and a meteorological station was used to measure other atmospheric variables. The measurements showed a clear cooling effect of surface water on air temperature in both horizontal and vertical direction. The decrease is mainly caused by the effect of evaporation of water, thereby reducing the sensible heat flux by about 30% above the water. The effect of surface water on air temperature is significant over several tens of meters from the water.
Model results of a micro meteorological model compared well to the measurements performed.
By quantifying the effect of surface water on temperature in urban environment, better decisions can be made in urban city planning and on cooling measures; it enables quantitative comparison to other cooling measure. This study shows that surface water is an effective and sustainable measure in adaptation to climate change.

PDD4.2-16 ROOM FOR THE RIVER WAAL; COMBINING WATER SAFETY WITH SPATIAL DEVELOPMENT

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The last decades the Dutch have modified their rivers for shipping, water management and water safety. With dikes, groynes and other engineering measures the river channels were adjusted to human demands. After two river flood events in 1993 and 1995 the Room for the River program was initiated to cope with increased discharges of the rivers Rhine and Meuse. By lowering river banks and (re-) opening of side channels, the rivers get more space in order to increase water storage in the flood plains and to allow for a larger discharge. Special attention goes to the bottlenecks. These are often located in cities, where the former flood plain is embanked and densily populated. The city of Nijmegen, along the river Waal (a branch from the Rhine), is one of these major bottlenecks. The municipality of Nijmegen and a consortium lead by Royal Haskoning combined a dike relocation (setback) at this bottleneck in combination with improvement of the spatial quality in the newly formed flood plain. This effort indicates the necessity of combining flood safety with spatial development to allow for engineering measures in densely populated urban areas and regard this as a chance for enhancing spatial quality.
To allow an increased discharge through the river Waal in the future, one of the river dikes in the center of Nijmegen is relocated. With the dike relocation also a new side channel (bypass) is created to have a larger channel cross-section and allowing a larger discharge to pass through Nijmegen. This enhances the flood safety in the center of the city of Nijmegen. The extra channel has a constant 1.5% of the bankfull river discharge and captures a larger part of the total discharge during high discharges. The overall goal is a water level decrease of 27 cm, which is accomplished in the current designs.
The creation of a second channel also means the creation of a new island. This new island lays the heart of the city, directly opposite of the old city center. This unique ‘River park’ provides a new environment for living, working and recreation. The presence of water dynamics, its natural beauty and the cultural heritage, which goes back to

the Romans, has been used in the design for this unique environment. The enhanced water safety requirement is regarded an opportunity to continue most of the planned spatial development and provide extra space for recreation. All of this within the dynamic flood plain of the largest Dutch River. This effort provides the lessons in engineering and the lessons in spatial development for a large river engineering project in the heart of an urbanized area. Furthermore the applicability of the approach and spatial development strategy for other delta cities is discussed.

DD4.3-02 URBAN CLIMATE FRAMEWORK: A SYSTEM APPROACH AND KNOWLEDGE BROKERAGE INSTRUMENT

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The urgency of climate proofing urban areas is increasingly recognized, and a lot of research on climate change impacts, mitigation and adaptation is currently done. However, developing comprehensive strategies and the actual implementation of measures is still a big challenge, particularly in the dynamic and complex context of cities; urban development is already a complex process as it is. Incorporation of climate proofing requires mainstreaming of mitigation and adaptation into the broader context of urban development. It is most effective to look for relations between general (non-climate) urban issues and those related to climate change. This requires better understanding of the urban system as a whole, combining information of different nature, and cooperation between urban planners, policy makers, scientists and other actors that need to be involved. For this purpose, we developed a method and practical tool based to incorporate climate proofing in the day to day practice of city building: the Urban Climate Framework (UCF).
The UCF is based on different system approach concepts: SCENE-model, Layer Approach, DSIPR-framework and vulnerability. This combination allows identifying essential elements (stocks and flows) of a city that are directly or indirectly subjected to climate change, and how these relate to other urban issues. A four-step cyclic approach is used: 1) System analysis; current state of stocks and flows, and (potential) pressures due to climate change impacts and/or social-economic issues, 2) Problem analysis; vulnerability and (potential) impact of these pressures on the urban system and its main functions (living, working, amenities), 3) Intervention; responses (mitigation and adaptation measures), based on lowering vulnerability and possible synergies (social/physical) in the system, 4) Evaluation; effectiveness of measures and their potential influence on other stocks and flows in the system.
In the context of adaptive governance we constructed a supporting table for the UCF that facilitates interactive stakeholder participation. Cities can be considered as complex adaptive systems and require an adaptive governance approach in order to deal with issues like climate change. The extent to which people are able to understand, learn and adapt in these kinds of multi-dimensional systems depends on the degree of connectivity. The UCF contributes this connectivity by enabling to gather and combine multi-disciplinary and multi-perspective information. With the UCF we offer a method that does not only enables place-based integral assessment for effective climate strategies for cities, but also acts as a knowledge brokerage instrument that facilitates dialogue between different stakeholders. The value and usability of the UCF is tested by means of interviews and combined interactive sessions with municipal services of the city of Rotterdam. First results indicate that the framework offers a wider perspective on urban development in relation to climate change, and enables to make connections between physical and social (non) climate issues. There is a need for better communication and cooperation between the municipal services. Using the UCF table in a multi-disciplinary interactive process is seen as a powerful tool for sharing knowledge and raising awareness for the coherence between different domains.

For illustrations see website: www.climatedeltaconference.org/results

DD4.3-03 MODELLING AND MAPPING OF URBAN STORM WATER FLOODS

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Introduction
Climate change will have a considerable impact on urban areas. One of the effects of the global warming for Western Europe is the increase of storm water peak intensities during rainfall and another is likely to be an increase in the frequency of these showers. These extreme events cause the urban storm water drainage system to be overloaded, either due to the intensity of the rainfall or due to runoff from urban green areas, which normally infiltrates into the ground. When the sewer discharge capacity is exceeded, storm water will flood the streets or even buildings and homes. This situation creates a possible health risk. Other reasons for more frequent problems due to extreme rainfall in cities are the increase of paved area and the recent changes of the street profile design (e.g. shopping areas without any kerbs and without storage capacity at street level).

Problem definition
It is becoming accepted that the previously described problems need to be solved by providing more space for water at ground level. There is a growing consensus that sewer capacity is limited and that there is a need to consider all aspects of water drainage during extreme rainfall events. The main problem is how to convince other actors, concerned with urban non-water related disciplines, of the importance of (more) space for water.

Theoretical framework and methods
To display the impacts of storm water flooding, the vulnerability of urban areas, and to support the discussion between several actors and disciplines, the Dutch engineering company Tauw bv has developed a GIS-based method for mapping urban storm water flooding.
Based on an accurate digital terrain model (DTM), a land-use map and optional local precipitation data, this model generates an urban storm water flooding map that shows in detail the water flow paths during certain events (i.e. while the sewer system is temporary “out of function”), it highlights depressions in the urban landscape and it illustrates the overall extent of the problem.
To solve the inconvenient situation of flooding due to an overloaded sewer system, modifications at ground level can be implemented into the DTM to redirect water to less vulnerable areas, where it can be drained or temporarily stored. The model setup is deliberately simple in order not to raise high expectations of accuracy. It is more important to “get the feeling”and visualization of the situation and to initiate discussions, than to correctly compute the overland water flows in a complicated 3-dimensional sewer model.

Results
The model has so far been used for several Dutch municipalities. An interactive workshop with specialists of various disciplines (sewer, roads, greenery, mobility) of the municipality Apeldoorn appeared to be a great success. As a result the urban storm water flooding map improves the communication between various actors and disciplines, and is an effective and fast tool in deciding how to prevent urban storm water flooding in a cost-effective way.

For illustrations see website: www.climatedeltaconference.org/results

DD4.3-04 APPLICABILITY OF ELASTOMERIC REVETMENTS FOR COASTAL PROTECTION - A CASE STUDY

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Introduction
Waterfront redevelopments in urban areas and intensified settlement processes in coastal regions raise the economic meaning of these regions. Particularly under the consideration of the climate change the functional capability of the coastal protection of these areas has to be assured. Scenarios with higher tidal water levels and intensified wave impacts are leading to the necessity of innovative coastal protection and river embankment systems.
Within the German KLIMZUG-NORD research project, the subproject “Adaptation Need in Coastal Protection on the Elbe River”is dealing with the development of new techniques in coastline protection. Innovative and adaptive coastal protection techniques like elastomeric revetments are developed and examined in long-term in-situ tests by the Institute of River and Coastal Engineering of the Hamburg University of Technology.

Aim
Coastal revetments of gravel medium can be reinforced with the innovative Elastocoast®-System. Polyurethane bonds the gravel to a monolithic structure with high porosity. These reinforced revetments are able to resist major erosive forces more than loose gravel ripraps (Evertz et al., 2006). This innovative technique has been applied successfully in Germany at the coast of the “Holm Hamburger Hallig”and in the Netherlands as breakwater revetment in Zuidbout (Verhagen, 2009).
For this innovative technique conventional design methods are inapplicable. Earlier test runs were aimed at the investigation of the material properties only. Within the KLIMZUG-NORD research project an advanced test run on the island Sylt (Germany) is aiming to investigate the long ranging stability of an Elastocoast®-riprap. With the results of this run a design formula is to be developed.

Research methods
On the Sylt island´s beach an elastomeric revetment was build in 2009. The revetment exists of iron silicate gravel (22-45 mm) and polyurethane. The iron silicate grit is coated with polyurethane by hydraulic compulsory mixer. By heavy construction equipment this stone paste mixture is put on geotextiles to a cover of approximately 200 m² with 0.2 m of thickness.
Until the year 2014 an extensive monitoring aims the determination of wave impacts, abrasion processes and the resulting behaviour of the revetment.
Pressure sensors with a frequency of 10 Hz are installed to log the tidal water level. Additionally 1000 Hz pressure sensors are logging the wave pressure and the appearance of hydraulic shock impacts. With electromagnetic induction sensors the velocity of the wave run up is measured. Together with the data of optical backscatter sensors the abrasion impact by the water-sand-intermixture can be estimated. Periodic scans by a 3D Laser scanner will show the surface changes of the revetment.
With the interpretation of the continuous data the long-term stability of the revetment can be quantified. The knowledge of the long-term behaviour of the revetment leads to the possibility of applying the innovative coastal defence system at other locations.

References
Verhagen, H.J. (2009):
Elastomeric revetments - New method of coastal protection. Conference of Coasts,
Marine Structures and Breakwaters 2009, Edinburgh.
Evertz, T., Pasche, E., von Lieberman, N. (2006):
Elastomerical Revetments - New way of coastline protection.
Proceedings of the ICCE2006 Conference.

For illustrations see website: www.climatedeltaconference.org/results

DD4.3-05 MEASURING RAINFALL IN URBAN AREAS USING COMMERCIAL CELLULAR TELEPHONE NETWORKS

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Rainfall has a large impact on society. Extreme rainfall can lead to loss of life and property by causing land slides or flooding due to dike breach or dam failure. In urban areas flooding is often caused by short high-intensity rainfall of limited spatial extent. Rainfall also causes delays and accidents in air and road traffic. The cost to society of rainfall-related damages can be estimated to be several billions of euros per year in The Netherlands. Accurate rainfall measurements are therefore important to prevent these damages, for instance, by improving flood forecasts. Our understanding of the climate system of the earth will also become better if more accurate spatial rainfall information becomes available.
Especially for urban water management there is an urgent need for high-quality rainfall observations with high spatial and temporal resolutions. Weather radars are suited for that purpose, but often need adjustment due to remaining errors. Often only few rain gauge measurements are available to adjust the radar data in real-time. The estimation of rainfall using micro-wave links from commercial cellular telephone networks is a new development, which may provide a partial solution to this problem.
Micro-wave links are extensively used for telecommunication by transmitting electromagnetic signals from one telephone tower to another. These signals are attenuated by rainfall. By measuring the received power the attenuation can be calculated. It has already been shown that from the attenuation average rainfall intensities can be derived over the length of the link, which is typically 5 km. Besides, many commercial micro-wave links are available, especially in urban areas. Therefore, micro-wave links are potentially promising for measuring rainfall with a high temporal resolution of 15 min. Besides, commercial cellular telephone networks are typically very dense and cover most of the land surface of the earth. The data produced by the links is essentially a byproduct of the communication between mobile telephones. This data is therefore potentially valuable for developing countries, which often have few rainfall measurements, while these are, for example, important for agriculture.
A large data set is obtained from a commercial micro-wave link network containing several hundreds of links over the Netherlands. From this data set rainfall intensities are derived and extensively verified with rainfall intensities from weather radar and rain gauges. Geostatistical techniques are used to obtain link-based precipitation imagery. Special attention is given to the quality of these precipitation imagery in the largest cities of the Netherlands, such as Rotterdam. Finally, we discuss the viability of micro-wave link data from commercial cellular telephone networks for quantitative rainfall estimation.

DD4.3-06 DESIGNING CLIMATE PROOF URBAN DISTRICTS

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In order to design climate proof urban districts there is a need for a method that make stakeholders able to set clear verifiable goals.
Creating sustainable and climate proof cities is a complex process. Many different parties are in-volved in the urban planning process and each one has its own interests and priorities. Furthermore there is no single interpretation of the concept of sustainability among the stakeholders. DPL (sus-tainability profile of an urban district) is a computer programme that measures sustainability of new and existing urban districs by using three different sets of indicators for People, Planet and Profit. It helps decision makers and (urban) designers to get hold on the concept of sustainability and the effect of choices in the planning process.
IVAM research and consultancy on sustainability and engineering consultancy Witteveen+Bos are developing a climate indicator module that can be combined with IVAM's computer instrument DPL, for the Province of Limburg. The objective is to develop an indicator module that measures to what extent an urban district limits its contribution to climate change (mitigation) and to what extent a dis-trict is adapted to the most likely climate change effects (adaptation). Based on measurements, the strong and weak 'climate characteristics' of a district can be located and improvements can be made. In the developing this module, the relevant climate characteristics for urban city planning have been determined and suitable indicators have been selected. In the module the indicators are clustered in the next main themes of climate change:
- Energy and CO_2 emissions;
- Heavier rainfall in summer;
- More rainfall in winter;
- Sea level rising;
- Longer periods of draught;
- Temperature rising.

In the second step (May 2010) the concept-module will be tested in two pilot projects in Maastricht and Helden. The results of this two pilot project will be used to optimize the climate module and make it ready to use for other urban districts in the Province of Limburg. In the third step (June-October 2010) the module will be upgraded to a module that also can be used in urban districts in the rest of the Netherlands. This means that specific indicators for the lower part of the Netherlands as peat regeneration and sea flooding, will be added. The Ministry of Housing, Spatial Planning and the Envi-ronment takes part in this third step of development. The result will be an indicator module that can be used by communities and urban planning consultants in the designing of climate proof urban districts in the Netherlands.

DD4.3-07 INTEGRATED ASSESSMENT OF POSSIBILITIES FOR CLIMATE CHANGE ADAPTATION IN CITIES

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In the Netherlands a large scale research programme on climate change adaptation in cities has been established. The programme "Climate Proof Cities"is a cooperation between the technical universities, general universities and knowledge institutes, combining scientific, technical, design and social sciences expertise. "Climate Proof Cities"offers an unique opportunity to develop an integrated assessment of the issues at stake. Integrated assessments provide policy makers with the information they need for preparing strategies, evaluating alternatives and eventually taking decisions. The questions that need to be answered in this respect are:
- what is driving the climate inside Dutch cities, and what role do various factors causing the urban heat island effect and extreme precipitation play?
- how will the urban climate develop under various scenarios for the future?
- how vulnerable are Dutch cities for future climate change ?
- what will be the impacts and costs of future climate change on Dutch cities, if no measures would be taken?
- what are appropriate response actions, how much do they cost, and how can they be implemented?

Until now most of the limited research on adaptation in cities has looked at each of these questions in isolation, not being bothered by the need to compare, for instance, the effectiveness of adaptation measures. In the Netherlands the most widespread impacts of climate change in cities are expected to be related to high temperatures during heat waves and extreme precipitation events. Effects in terms of nuisance, health problems or economic losses will be experienced by various societal sectors, often different from those responsible for taking adaptation measures. For the actors that need to take adaptation measures, these need to be integrated in other decisions, whereby an evaluation of costs and benefits on the short and long term will be important. The Dutch research programme on climate change adaptation in cities will consist of in-depth research into each of the aspects mentioned above. But it will also integrate the results into policy relevant information.
An integrated approach to providing information on climate change adaptation needs a common framework for dealing with a range of impacts and a wide range of possible adaptation measures, including harmonized definitions and indicators, to be successful. This paper will describe the design of the integrated assessment framework, including the description of the dynamics of cities versus the dynamics of climate change adaptation, a typology of impacts, and linked to these of adaptation measures, and types of envisaged governance interventions. Special attention will be given to dealing with uncertainty. To systematically distinguish, and possibly quantify, the various uncertainties in the research will be of crucial importance for the final use of the information.
Also with regard to uncertainty issues, integrated assessments are generally developed in discussion with stakeholders. In the paper we will elaborate on the stakeholder involvement within "Climate Proof Cities".

DD4.4-03 ADAPTATION TIPPING POINTS AND PATHWAYS FOR ROTTERDAM ON DIFFERENT SPATIAL SCALES

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Climate change is a potential threat for people living in Delta's all over the world. Sea level rise and increased variability in river discharge and precipitation increase the risk of floods and droughts. Located at the mouth of two rivers, the densely populated Rhine and Meuse (Dutch) Delta is particularly vulnerable.
The area 'Rijnmond and Drechtsteden' where the Port of Rotterdam and the cities of Rotterdam and Dordrecht are situated, is a key area in the Netherlands. Here the effects and risks of climate change may be high because not only there is a combined effect of sea level rise, soil subsidence and increasing river peak discharges but also the economic development and spatial investments in this area are high.
The main question is how can we develop the area in such a manner that climate change uncertainty and the spatial planning goals (high quality living and working environment and healthy economy) are appropriately dealt with? How can decisions be made in present taking into account long time uncertainty.
In our paper we will show how by using the method of adaptation tipping points (ATP's) and adaptation pathways the robustness and flexibility of current and future adaptation strategies can be quantified and qualified. This includes three steps: 1) establish the urgency of adaptation - determine the tresholds beyond which climate change will limit the achievement of spatial or water management goals (ATP's). 2) describe possible adaptation strategies (ranging from more robust to more flexible) as pathways that can cope with 0-1,5 meter SLR; and 3) evaluate the strategies on other societal criteria, expressing the strategy meets other targets apart from climate proofing.
The method is applied on two spatial scales. Firstly on the regional scale including the entire "Rijnmond"region and secondly on the scale of the specific spatial development of the Rotterdam City docks (Rotterdam Stadshavens).

DD4.4-04 CIVIL PROTECTION AND CLIMATE CHANGE VULNERABILITY: A ROTTERDAM CASE STUDY

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With the end of the Cold War, the focus of civil protection in most western industrialized countries has changed from wartime to peacetime crises, with disasters caused by natural hazards as an important topic. This study is part of comparative analysis project of the impact of climate change on local civil protection institutions in four Northern European countries. It focuses on the Netherlands. Its principal research question is: What can explain changes in policy and routines within the civil protection system during the last decade regarding reducing vulnerability to extreme weather events? To address this question, a qualitative method was used, consisting of literature study and interviews with staff at the key institutions.
Nationally, we have documented significant changes in the Dutch civil protection system in the last decade. These changes can be explained from an institutional perspective and a changed reality. Institutionally, the development of safety regions is of major importance. A safety region combines the operational emergency services and the more strategic municipal tasks on safety and security. This national system was formalized after several large-scale (but non-climate-change related) disasters revealed a need for closer cooperation between the regional civil protection institutions. In the aftermath of Hurricane Katrina, a changed reality in the Netherlands consists of increasing attention for flooding risks. This resulted in a review of the national disaster management structures and a stronger position of the water boards as water management body.
Locally, we have distinguished the municipality and the water board as the most important local-level civil protection institutions. In the Rotterdam case study, however, both did not appear to have changed their civil protection practices because of climate change (except for the municipal Climate Office which carries out the Rotterdam adaptation programme). Also, the Rotterdam Safety Region does not use climate-change scenarios in its preparations as it mainly prepares for the 'prescribed' incidents and disasters which include 'regular' events such as flooding and extreme weather cases.
The case study of Rotterdam revealed a major gap in its safety system between the more strategically oriented pro-action link and the four operationally oriented ones. The proactive Climate Office, on one hand, holds a long-term vision of preparing for future climate-change impacts. This vision reaches up to 2025 and focuses on spatial planning and physical innovations. On the other hand, the operational links do not consider climate change impacts at all. Moreover, interviewees in the operational domain do not feel that their organizations need to take extra climate change measures. Thus, for the present we can only conclude to notice a 'missing link' between the existing practices and future aims in the preparedness of the Rotterdam civil protection system.

DD4.4-05 URBAN WATER SYSTEM OF ROTTERDAM; CLIMATE CHANGE IMPACT AND ADAPTATION STRATEGIES

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Problem
The city of Rotterdam is situated within a densely populated river delta system. Due to uncertainties in the consequences of climate change on urban water systems, uncertainties on climate change itself and uncertainties in autonomous developments in the urban area, a flexible framework is needed to help design and manage an adaptive and robust water system for the future.

Method
A consortium of Public Works Rotterdam, Hogeschool Rotterdam, Deltares, Delft University, Witteveen+Bos en Arcadis have investigated the consequences of climate change for the urban water system of Rotterdam, and measures and approaches to deal with them. The results are based on modeling of the urban water system, the analyses of field data, literature study, interviews with stakeholders and a workshop.

Results
If the water infrastructure does not change, there will be a significant increase in water-related financial and societal damage in Rotterdam. Calculation based on the KNMI'06/'09 scenarios confirm this. At this stage there is a lack of adequate data (time series), specific indicators are not incorporated in monitoring plans and monitoring locations

are often not suitable to determine climate change effects. Therefore, there is a great deal of uncertainty in the size and speed of the occurrence of the climate change effects. Given these uncertainties, both the water system and the spatial layout of the city need to become robust and should have a great adaptive capacity.
The effectiveness of climate change adaptation measures depend to a large extent on the added value they have for dealing with other urban problems, such as the quality of the urban living environment. Urban planning and climate adaptation therefore need to go hand in hand. The pace in which urban developments occur have proven to provide enough possibilities for the implementation of the required adaptation measures. Though the necessity for integration of climate change adaptation and urban planning is widely embraced, it is hardly implemented in practice.
Interviews reveal that stakeholders are hardly aware of the problems, let alone of their own role. Only a small group of frontrunners at authorities, companies and knowledge institutes are convinced of the necessity of climate adaptation. Housing corporations are not part of networks that deal with climate adaptation, which is remarkable since they own more than 70% of the houses.
The consortium has developed a framework that helps choosing adaptation measures and approaches. In six steps, it guides one through the characteristics of the area, the people that live and work there, problems that may be occurring in that area and the effects of climate change to come to a conclusion on the type of measures that could be successful. In new areas it is comparatively easy to include climate adaptation in the development plan. The existing urban areas will prove to be the biggest challenge. Problems and opportunities vary from one area to another. Measures in densely built neighborhoods of the city can be so costly and difficult to execute that it can be necessary to assess the choices on a larger scale.

DD4.4-06 LEARNING TOGETHER TO MANAGE URBAN FLOOD RISKS IN DORDRECHT AND SAINT LOUIS

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Delta cities around the world are facing many similar challenges that are caused by climate change and urbanization. This applies to cities in developed and developing nations. For example, similarities between the cities of Dordrecht in the Netherlands and Saint Louis in Senegal are, maybe unexpectedly, plentiful. Both cities are located in a river delta, having to deal with influence from the sea, the river, precipitation and with a high spatial pressure. Both cities have historic city centres, which feeds the public awareness that water can both be a threat to cultural heritage as well as an opportunity to make the city more attractive. Recognising these similarities has inspired the partners of the Urban Flood Management (UFM) Dordrecht learning alliance to set up a collaboration about urban flood management with the city of Saint Louis. This paper describes how this collaboration has been set up and how relatively simple scientific tools stimulate improvements in UFM.
A fact finding mission to Saint Louis was organized to identify a common basis for collaboration and subjects for mutual learning between the two cities. Qualitative interviews with key stakeholders have identified that a transition towards integration of different disciplines (e.g. spatial planning, water and ecological management) is taking place in urban development in both the Dordrecht and Saint Louis. Also, a transition is taking place in both contexts towards more bottom-up approaches that apply local knowledge and encourage public participation. These shared factors form a common basis for collaboration. In addition, opportunities for mutual learning have been identified based on structural differences. In Saint Louis robustness of systems is not as large as in the Netherlands. Instead, flood management has a reactive character to cope with and recover from floods. Planning for long term change is nonexistent in Saint Louis. However, Saint Louis has recent experience with floods in contrary to most parts of the Netherlands.
In Saint Louis, there are many ambitions to take measures and to improve planning processes. However, realisation of those plans is lagging behind. In the UFM Dordrecht project, lessons have been learnt about holistic approaches for urban flood management; institutional arrangements to better involve local knowledge and communities in planning; and process management of integration of different disciplines such as urban development, spatial planning, water management, ecology and technical services. This knowledge could help Saint Louis in a break-through towards implementation of a more sustainable and resilient urban flood management practice. In the collaboration, the Dutch partners facilitate integration and institutional processes in urban flood management based on experiences from Dordrecht. Strategies and/or plans will have to be realized by the stakeholders in Saint Louis, supported by Dutch advice where possible and desired. To illustrate this, process support tools such as flood risk maps, cross-sections of flood levels under different climate scenarios and insight in tipping points of the existing flood management system have been developed to support consensus building.

DD4.4-07 URBAN HEAT AND HEAT STRESS IN ROTTERDAM

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Heat and its health consequences are expected to be highest in urban environments. This is due to the urban heat island (UHI). Each city exhibits an UHI. Its strength depends on the size of the city, the urban structure, building density, canyon geometry, vegetation coverage, water surfaces, and heat added by human activities (antropogenic heat). The characteristics of the UHI effect have been studied extensively for many cities over the world, but not as much for cities in the Netherlands. Within the Dutch national research project “Knowledge for Climate - Heat stress in Rotterdam”, the actual and future heat stress in Rotterdam and its consequences and options to reduce heat stress are defined. In this project, the UHI of Rotterdam and its causes are measured and modelled. In addition, the effect of heat on the public health in Rotterdam is estimated.
Based on excess mortality during previous heat waves in the Netherlands, the extra deaths due to heat in Rotterdam may be estimated to be around 36 per year, a number that is expected to rise as a consequence of climate change. Furthermore, temperature was found to affect aspects of sleep in a sample of elderly inhabitants of Rotterdam.
The surface heat island of Rotterdam has been estimated from satellite imagery. Surface temperatures of 15 Landsat thermal infrared images have been investigated to identify the heat island intensity on neighbourhood scale. The results showed that the surface heat island intensity of Rotterdam can be as large as 10 °C. The results also indicated significant differences between the districts of Rotterdam. This is largely explained by the fraction of green and impervious surfaces in the city. In addition, NOAA-AVHHR satellite images were used to analyse the diurnal variation in the heat island of Rotterdam during the heat wave period of July 2006. This analysis showed that districts with a high nighttime heat island intensity differ from the districts with a high daytime heat intensity.
Antropogenic heat release could be a major contributor to the urban heat island effect, but up to now its effects are poorly understood. An inventory of antropogenic heat sources for Rotterdam indicated that the heat release of industries in Rotterdam is by far the largest compared to traffic and buildings. Except for the volume of heat introduced to the system, also the timing (season and time), location, height and medium through which the heat is

transferred is relevant. These aspects have been assessed for the antropogenic heat releases in Rotterdam, using a combination of (statistical) data sources.
From the satellite imagery analysis and the antropogenic heat releases inventory, the relevance of different heat island causes and sources in Rotterdam was estimated in order to evaluate different mitigation measures. This resulted in a set of no-regret measures to reduce the UHI in Rotterdam.

DD4.4-08 AN ASSESSMENT OF CURRENT URBAN HEAT ISLAND INTENSITY IN THE NETHERLANDS

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Until recently, the Urban Heat Island (UHI) was thought to be relatively unimportant for the Netherlands with its mild climate and its location close to the sea. This view altered after the heat waves in 2003 and 2006, which made many people realize that also Dutch cities are impacted. In addition, climate change projections indicate that also in The Netherlands heat waves are likely to become more frequent in the next decades. Thus there is now a sense of urgency to implement adaptation measures in order to cope with future climate threats on the livability in cities. However, information regarding the UHI in the Netherlands has been lacking, both from observational and model perspective. The main objective of our work is to make an up to date assessment of the magnitude of the current UHI-intensity in urban areas in the Netherlands, and to assess whether or not heat stress is or will be a critical issue. As such we base our assessment on new in-situ meteorological measure-ments in the city of Rotterdam and mesoscale model studies. In addition we utilize the recent observations of innovative mobile traverse observations in Rotterdam and Arnhem. Also the frequent observations from hobby meteorologists are taken into account. The observations are used for verification of airborne and satellite thermo graphic images. In addition, they are used to validate two mesoscale models (WRF and RAMS) for Dutch urban conditions.
Preliminary measurement results demonstrate the existence of a considerable maximum UHI in the city of Rotterdam. The difference in temperature between the city and countryside amounted to more than 7 K during nocturnal hours. Similar results for the UHI intensity of Arnhem were obtained despite its smaller city size. The observations from the hobby meteorologists indicate that maximum value for the UHI in Dutch urban areas, are comparable with those found for other European cities. To assess the effect on heat stress, wet-bulb-globe-temperature (WBGT) was estimated. In ca. 50% of the urban sites, WBGT exceeded a threshold value of 27.7 °C, for 7 days per year. Although only rough estimations could be made here, they clearly indicate that heat stress may become a critical issue in urban areas in the Netherlands. The presentation aims to give an overview of all our results.

Deltas in Depth Theme 5:

Competing claims and land use in deltas under climate change

DD5.1-02 IMPACT OF LAND USE CHANGE AND CLIMATE CHANGE ON MANGROVES OF THE WORLD'S DELTAS

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Tropical mangrove forests, distributed circumtropically in the inter-tidal region between sea and land in the tropical and sub-tropical latitudes, are among the most productive and biodiverse wetlands on Earth. These forests have a major influence on global biogeochemical cycles, climate feedbacks, and hydrology. They also provide important ecological and societal goods and services including protection from surges and tsunamis. The forests, however, are declining at an alarming rate"'perhaps even more rapidly than adjacent coral reefs and inland tropical forests. Their extent is believed to be less than half of what it once was and much of what remains is in degraded condition. The remaining mangrove forests are under immense pressure from clearcutting encroachment, hydrological alterations, chemical spill, and climate change.
Our understanding of the present status of mangrove forests and their change dynamics in world's deltas is inadequate. Earlier global land cover initiatives failed to map mangrove areas with sufficient details because coarse spatial resolution satellite data was used. The Food and Agriculture Organization of the United Nations (FAO) and The World Mangrove Atlas estimates are inconsistent across space and time because they rely on a compilation of disparate and often incompatible data sources. Moreover, there have been only few studies on the rates, causes, and consequences of mangrove forest cover change dealing with both land use change and climate change. We will present results obtained from the analysis of time-series satellite data, geo-spatial modeling, and projection of sea-level rise relative to the mangrove surface to quantify and characterize mangrove forests distribution and dynamics of the world's deltas. We will discuss how have the extent and characteristics mangrove forests changed in the last 30 years, and what is likely to happen in the next 50 years. The final part of our presentation will be to highlight causes and environmental and socio-economic consequences of mangrove forest cover change due to both land use change and climate changes.

DD5.1-03 CLIMATE CHANGE EFFECTS IN THE EBRO'S DELTA. STRATEGIES FOR ADAPTATION

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The Framework Study n1: Delta of Ebro of the "Series of Framework Studies for Later Use in Defining a Strategy for Preventing and Adapting to Climate Change in Catalonia ', is the first one of a series of studies aiming the definition of an Action Plan for climate change adaptation and prevention in Catalonia. Due to its coastal situation, geomorphological characteristics and high environmental, social and economic values, the plain of the Ebro's Delta is considered as one of the most vulnerable areas of Catalonia and the Mediterranean, regarding global warming. It's a priority area for the design and application of climate change adaptation and prevention policies.
The study describes the impacts of climate change along 320 Km2, analyzes its vulnerability, establishes the associated risks and proposes possible measures of climate change adaptation and prevention, while establishing

methodological and analytical bases to be applied in other vulnerable zones.
The vulnerability comes from an extremely low relief of delta's surface, with elevations near to sea level; the land's subsidence and the reduction of the transported sediments by the river; the presence of urbanized zones in coastal areas; the water availability to sustain rice crops; and the high natural values.
However, the Ebro's Delta can face climate change effects thanks to: the very low urbanization of its shore, with great capacity to remodel beaches that operate as barriers in front of sea level rise; the villages placed at low risk areas; and the high diversity of environments helping to adapt to climate change and conserving its natural values.
Climatic, fluvial and maritime data, jointly with historical storms and floods data documented, allow calibrating the prediction models applied.
In order to evaluate the expected impacts on the Delta it was carried out a prognosis of the trends and predictions of evolution of the:
Outer shoreline
Bays coastal zone
Presence and permanence of the salt wedge in the Ebro River
The prediction is carried out for 3 different scenarios of the IPCC:
A1B (average scenario) for 2050: 15 cm of sea level rise
A1B (average scenario) for 2100: 40 cm of sea level rise
Pessimistic scenario (long term) for 2100: 100 cm of sea level rise
Predictions conclude that the most critical phenomenon linked to climate change in the Ebro's Delta is the sea level rise in the inner zone of the bays, where there is not beach protection. That will provoke a direct flood of the adjacent terrains.
The retreat of the shoreline, associated with sea level rise, is affecting the coast as a whole, but the great availability of sand and the low occupation of the beaches, allow an important protection of the outer shore.
The designed measures of adaptation and prevention are based on the application of the precautionary principle, with the aim of improving the measure systems; obtaining data and processing information; reducing people's vulnerability and risks; protecting socioeconomic goods; promoting adaptation of economical activities; and guaranteeing protection and adaptation of endangered natural systems.

DD5.1-04 LIVING ON EMBANKMENTS, DREAMING OF COLONIES: LAND AND LOSS IN THE GANGETIC DELTA

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Coastal erosion still is a neglected field of inquiry by social scientific research on the dynamics of environmental hazards and the anthropogenic climate change. Scientific and media accounts centre on extreme events and neglect thereby continuously working hazardous processes, being the far more urgent problem to farmers and fishermen living, for instance, on the shores and banks of the western Gangetic Delta. Due to a complicated causal arrangement the islands here are since decades subject to massive soil decretion, which every year leaves farmers landless. But because accretion takes place here only on a much lesser level and outside of political boundaries, farmers find themselves permanently stripped of their most important riches, that is, land.
Another blind spot of contemporary inquiry relates to the postulate of future mass migrations, on a national or international scale, which looses individuals or groups staying back in highly vulnerable contexts even after loosing all their immovable properties out of focus. But to stay on seems to be, at least in the western Gangetic Delta, the strategy chosen by most of the newly landless and shapes patterns of rural land use, of local rehabilitations and an overall (absence of) sustainability. Building on my own ethnographic, historical and discourse analytical research this paper will therefore analyze the environmental and social history of the Indian island Sagar, situated at the western fringes of the Gangetic delta. Emphasis will be laid on perennial and, due to climate change, potentially increasing hazardous environmental events and processes (coastal erosion, salinisation, floods, cyclones). Based on this I will illustrate the social and economical processes causing and motivating to stay on as well as those institutionally regulating local micro-migrations. Concluding I will expound the gradual impoverishment on the family level, some of the ecological effects of squatting and resettlements, as well as the overall intensification of vulnerability of the local Social Ecological System (SES) related to this.
Analysing this specific local context can therefore illustrate a problem area, which will potentially apply to large coastal areas on a global scale, and which raises questions of land use from the angle of persistent loss.

DD5.1-05 CLIMATE CHANGE IMPACTS AND ADAPTATION OF AGRICULTURE IN THE NETHERLANDS

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Problem definition
Agriculture in the Netherlands evolves due to changes in policy, socio-economic and climatic conditions. Over the past 50 years, the overall number of farms decreased by 75%, while the average farm area increased from 6 to 26 ha. Climate change impact and adaptation assessments have largely focused on current farming systems and technologies, and addressed food production mainly. This is remarkable as is it likely that the dynamics in policies and the speed of technological advances are at least as important. When looking at 2050 not only the climate will have changed but also farming systems, available technologies and various contextual factors will differ from today. While some rural areas will remain production oriented, others will move to a more multifunctional character. For both types of farming there is a need to identify adaptation strategies that are effective in achieving climate-robust agricultural landscapes, contributing to social, economic and environmental objectives.

Theoretical framework and methods
A methodology is developed to assess adaptation of agriculture under climatic and socio-economic changes at multiple scales, with a first application in Flevoland. We use the SEAMLESS - Integrated Framework (www.seamlessassociation.org), which includes a cropping system model, farming system model and a market model. The market model provides the European context in terms of policies and prices, while the cropping system model simulates changes in yields. Both provide inputs to the farming system model, which assesses adoption of adaptation strategies and impacts on social, economic and environmental indicators. The modelling framework is complemented with a more applied and semi-quantitative approach, the Agro-Climatic Calendar (ACC). Based on literature review, expert knowledge and stakeholder participation, critical climate related risks are identified for major current and alternative crops. The frequencies of occurrence of these climate risks are assessed for the current situation (1990) and climate scenarios for 2040. For climate risks with changing frequencies, adaptation strategies are identified. The ACC complements the cropping system model and feeds into the farming system model.

Results and discussion
Scenario projections suggest that there will be more pressure on agriculture from other sectors, implying that the size of farms should further increase or farmers should opt for diversification of their activities. Close to nature areas, the latter should be stimulated in order to obtain cross-sectoral adaptation strategies benefiting the multifunctional landscape. In the vicinity of the still growing Amsterdam-Almere twin city, rural areas are rapidly changing. Not only because of the urban expansion but also because this new urban setting, a different role of agriculture is required, for instance providing other services like day recreation.
In the larger part of Flevoland, farmers will still be mainly production oriented. The ACC showed that most crops will be able to cope with a change in the frequencies of extreme events and the production of new crops may become feasible. However, current risks are projected to become more severe.
This contribution will present quantitative assessments of adaptation strategies for these different types of farming, also considering the European context.

DD5.1-06 CLIMATE CHANGE AND NATURE, INTEGRATION OF SPATIAL POLICIES WITH A LAND USE MODEL

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Objective of this research is to model the impact of climate change and land use pressures on the spatial configuration of nature areas, related to a series of climatic and policy scenarios. The results of the study can be used to evaluate current nature conservation policies and will be useful to future optimising and implementation of nature areas related to climate change.
Future land use is an important topic in studies related to planning and evaluation of spatial strategies. Land-use models are a well known instrument to inform spatial planners of the possible future land-use configurations, describing changes in the area of land use types related to such spatial strategies. The current available land-use change models are based on the determination and quantification of the main drivers of land use change. Results of this analysis are integrated into mathematical allocation mechanisms which redistribute the predefined areas per land-use-class based on location specific potentials.

This approach, in which socio-economic and biophysical factors are driving the rate and location of land use change, is limited applicable to the current procedure of nature planning. In the Netherlands the sometimes purely political decision for the designation of nature areas cannot be combined with the approach used for modelling the other land use classes (e.g. change within agriculture or urbanisation). As a consequence the current land use models are failing when focussing on planning of nature. In the land-use scanner this is solved by predefining and allocating a fixed area for nature, prior to the allocation of all other land use classes. However, this is disturbing the principle of a dynamic land use model, which should be able to integrate all social, economic and spatial drivers involved.
In our new approach, nature is integrated more stepwise and iterative into the land use model. First climatically and site conditions are used to calculated the probable distribution of nature types. This is done with current available state of the art models calculating effect of (the change in) site conditions (e.g. groundwater and precipitation) on nature. These potentials for nature types are the basis for further allocation and can be combined with strategies to keep or remove current designated areas.

Second step is the iterative integration with other land-use classes with probably competing claims at the same locations. Based on economical or social factors of importance, reallocation of nature areas could be considered. This decision can be made based on mathematical thresholds (e.g. maximum applicable economical cost for nature) or just based on expert judgement. Reallocation of nature can be based on the results from the first step.
The new approach was applied in a Dutch case study, focussing on the climatically robustness of the Dutch Ecological main structure related to current known land-use pressures in the Netherlands up to 2040.
We conclude that the new stepwise application of nature in the land-use scanner produces new and potentially useful information for policy makers, although the involved models and especially their climate knowledge are still under development.

DD5.1-07 EXPLORING THE POTENTIAL FOR BIOFUEL CROPS IN THE NETHERLANDS

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Bioenergy, defined as energy from biomass, has the advantage that the carbon dioxide released into the atmosphere by its combustion is compensated for through the carbon dioxide that was initially stored by the vegetation from which the energy was derived. The first-generation biofuels are, however, generally discredited because they are considered to compete with food crops and are suspected of causing as much greenhouse gas emission as they save. Much hope is therefore placed on second-generation biofuels such as cellulose-based ethanol. This requires the bulk production of biomass.
In a densely populated country such as the Netherlands one would not expect much scope for producing such a low-value crop. Yet, if it is combined with other forms of land use such as water retention, it can be economically feasible - if not under present conditions, but under a climate change scenario. Climate change can not only lead to an increased demand for land for water retention, but also to a lower profitability of alternative agricultural land use. If we add to this the likelihood of increasing energy prices, the feasibility of growing reed and/or willow for biomass production comes into view. These are plants that grow naturally in the wetter parts of the country, and can produce high yields even under waterlogged conditions.
To explore the potential location of such biomass production a combination of two different types of land-use related models at different scales is applied. The global multi-sectoral models LEITAP and IMAGE (Eickhout et al., 2007; Van Meijl et al., 2006) are used to define the demand for different types of land use, including the cultivation of biofuel crops. The models are based on scenario-based assumptions on world-wide economic drivers and policies related to the stimulation of biofuels in Europe (Perez-Soba et al., 2010). The aggregate outcomes (at the national level) are then used in the Land Use Scanner model (Koomen et al., 2008) to simulate local land-use patterns.

References
- Eickhout, B., Van Meijl, H., Tabeau, A. and Van Rheenen, T. (2007) Economic and ecological consequences of four European land use scenarios. Land Use Policy 24: 562-575.
- Koomen, E., Loonen, W. and Hilferink, M. (2008) Climate-change adaptations in land-use planning; a scenario-based approach. In: Bernard, L., Friis-Christensen, A. and Pundt, H. (eds.), The European Information Society; Taking Geoinformation Science One Step Further. Springer, Berlin, pp. 261-282.
- Perez-Soba, M., Verburg, P.H., Koomen, E., Hilferink, M., Benito, P., Lesschen, J.P., Banse, M., Woltjer, G., - -

Eickhout, B., Prins, A.-G. and Staritsky, I. (2010) Land use modelling - implementation; Preserving and enhancing the environmental benefits of 'land-use services'. Final report to the European Commission, DG Environment. Alterra Wageningen UR/ Geodan Next/ Object Vision/ BIOS/ LEI and PBL, Wageningen.
- Van Meijl, H., Van Rheenen, T., Tabeau, A. and Eickhout, B. (2006) The impact of different policy environments on agricultural land use in Europe. Agriculture, Ecosystems & Environment 114(1): 21-38

PDD5.1-01 CLIMATE CHANGE AND SUSTAINABLE LAND MANAGEMENT IN THE NIGER DELTA, NIGERIA

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The use of land for agricultural production has recently brought up the question of sustainability. Increasing population is putting a lot of pressure on the available arable land and farmers are devising strategies to ensure that they maximize output from available fast degrading land. The menace of climatic change is also posing a lot of problem to the fragile ecosystem of the Nigeria's Niger Delta. This study therefore assessed land use changes and impact of climatic change on sustainable land management. Data were obtained from 4.28 farmers from Abia, Akwa Ibom and Rivers state using the multistage random sampling. The data were analysed using descriptive statistics, principal component analysis and ordinary least square regression
Results show that Abia and Akwa Ibom States have the highest value of land use intensity with 0.2049 and 0.2010, respectively and there is no significant difference in the average values of the land use intensity across the states ($p>0.10$). Abia state and Rivers state have the highest family labour intensity and hired labour intensity respectively. However, fertilizer use intensity is highest in Rivers State with 164.0799 kg/ha, while Akwa Ibom state has the highest average amount of N158.0099 per hectare spent on organic manure. Similarly, 93.33 percent of the farmers in Niger State were burning bush, while crop rotation was used by 34.69 percent of the farmers in Abia State. Organic manure use is highest in Akwa Ibom state (53.42 percent) and 33.56 percent of the farmers were also using zero tillage. Unsustainable land use indices (ULU) analysis reveals that farmers from Akwa Ibom State have the lowest value of ULU (-0.2516) and there is significant difference in the average values of the ULU across the states. The OLS results show that parameters of fertile land scarce (-ve), affected by climate change (+ve), land conflict (+ve), market distance (-ve), marital status (+ve) and farming experience (-ve) are all statistically significant ($p<0.05$).
The study recommends that to ensure sustainable food production in the Niger Delta region, research into development of appropriate land use technologies should be strengthened. Efforts should also be strengthened to mitigate the impacts of climate change on the people of Niger Delta.

PDD5.1-02 CLIMATE CHANGE AND LAND USE OPTIONS IN THE INDIAN SUNDARBANS DELTA

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Draining an area of 1,745,400 sq kms, the Sundarbans delta, shared by Bangladesh and India, lies at the bottom of the Ganges-Brahmaputra-Meghna basin spread over six countries in Asia. The delta extends from the Sandwip channel near the Chittagong hills of Bangladesh to the Hugli-Bhagirathi channel near Calcutta in India. The largest mangrove forest in the world, the Sundarbans is located on this delta. Out of the total area of the Sundarbans of about 26,000 sq kms, 9,600 sq kms lie within India. This part of the Indian Sundarbans delta (ISD), with a population of more than 5 million, is one of the most densely populated areas in S Asia. In the backdrop of sea level rise and climate change, this paper explores future options for land use in the ISD.
The systematic deforestation of the ISD and expansion of human settlements started after the Indian Forest Act of 1878 was passed by the British rulers. The northern half of the mangrove forests was cleared by encouraging in-migration of people from surrounding areas who converted large forest lands to agriculture. The area so cleared now extends over 4216 Sq kms and belongs to 19 civil administrative units or development blocks. The remaining forest area is under the protection of the government forest department. The population depends on diverse forest products and fishing for livelihood while intensive agriculture is the main occupation of the population in general. Biomass collection by such a large population has led to degradation of forests within the protected areas and damage to the mangroves inside and outside. In addition to the provisioning services, the ISD offers important ecosystem services like protection from storm surges and potential for wilderness tourism. Continuation of business as usual would pose a serious threat to the environment of the ISD.
Global warming and climate change has affected the ISD. The Bay of Bengal has become warmer by 0.2 to 0.3 deg C/decade. The sea level at the ISD coast has risen at a rate exceeding 3 mms/yr since 1986. This is significantly more than the global average. This has led to a loss of about 250 sq kms of coastal land by erosion during 1969-2009. One important indirect land use conversion has been the growth of aquaculture. Salinity ingress has encouraged widespread conversion of land in the ISD, from mangroves and agriculture to aquaculture from 370 to 649 sq kms during 1986-2009. The cyclones in the Bay of Bengal are expected to increase in number as a result of climate change. Traditional engineering has led to the raising of more than 3000 kms earthen embankments as protection mechanisms.
The natural environment of the ISD and biodiversity are under serious pressure, from the population and changing climate. There is no clear road map for adaptive action and to sustain the ecosystem service of the ISD. The paper offers an ecological vision and a business as usual scenario for policy making and design of future steps in the ISD.

PDD5.1-03 C AND N DYNAMICS FOLLOWING DRAINAGE AND AFFORESTATION IN THE PARANA LOWER DELTA

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Natural herbaceous wetlands of the lower delta of the Parana River, Argentina, are being converted from herbaceous wetlands to tree plantations for wood production. This could have implications for carbon redistribution in the second largest delta in South America. We compared soil carbon (C) and nitrogen (N) stocks in three pairs of natural wetlands, dominated by Scirpus giganteous (Sc), and adjacent areas planted with Populus deltoides (Pd) trees 16 years ago, after levees excluding annual overbank flow and drainage ditches were built. Soils under tree plantations stored 17% more C (160 vs. 137 Mg ha^{-1}) and 11% more N (10 vs. 9 Mg ha^{-1}) than under natural wetlands. Most of this gain was attributed to higher C in Pl as aerial biomass (63 vs. 12 Mg C ha^{-1}) with C/N biomass ratios of 108 for Pd and 36 for Sc. In contrast, more C was maintained in the litter layer of the Sc than Pd (24 vs. 4 Mg C ha^{-1}, respectively) but with

less respective C/N ratios of 18 and 25. Whereas the total belowground storage was similar for each situation and element (100 Mg C ha-1 and 8 Mg N ha^{-1}), the Sc stored 4 times more C and 7 times more N in the root biomass component. Nevertheless the Pd compensated by accumulating more C (85 vs. 64 Mg C ha^{-1}) and more N (9 vs 5 Mg N ha^{-1}) between 5 and 25 cm depth. In spite of the net gain in organic matter + biomass by conversion to tree plantation, there is a large redistribution and likely significant turnover of biomass with implications beyond C and N sequestration. These include severe soil compaction and the loss of wetland ecosystem functions such as anoxic biogeochemical processes, altered decomposition rates, and the loss of complex food webs and habitats.

For illustrations see website: www.climatedeltaconference.org/results

PDD5.1-04 HOW PREDICTABLE ARE WATER AND VEGETATION BIODIVERSITY?

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Problem definition
Climate change will alter plant species composition and the diversity of plant communities through changes in temperature and in the water cycle. In turn, these alterations will affect habitat factors essential for plant growth such as salinity, soil acidity and the availability of moisture, oxygen and nutrients. As a consequence, it is questionable whether the nature targets obligatory through European law (Bird Directive, Habitat Directive and the Water Framework Directive) can still be attained in future climatic conditions. A timely response to climate change through adaptive measures in policy and nature management can eliminate potential threats, while at the same time creating opportunities for nature development. Potential measures are a different spatial planning of nature targets, the creation of hydrological buffers against desiccation, water storage during wet periods creating seasonal wetlands, or the extension of protected areas to increase the chances of successful seed dispersal for plant species.
Both hydrological and habitat distribution models play an important role in evaluating the effects of climate change and adaptive measures. In this contribution, we discuss the climate versatility of current models and to which extent policy makers can rely on their outcomes.

Results
Current models are likely inapplicable under changing climatic conditions for a number of reasons: (1) they make use of indirect relationships, based upon the climate of the twentieth century, (2) critical climate variables like temperature and CO_2 are often not considered, and (3) some important feedback processes within the system of soil, water and vegetation are usually neglected. These shortcomings have major consequences: even when accurate meteorological scenario calculations are released, still hardly anything may be predicted about the effects on hydrology and vegetation biodiversity, let alone about the effectiveness of adaptation strategies. Overall, we believe current model results should be interpreted with great caution. We present a conceptual framework that may improve current interpretations, using direct process-based relationships between environment and vegetation characteristics, so-called traits. By linking traits to their direct environmental drivers, effects of temperature and CO_2 can be accounted for. In a next phase, we also aim to incorporate feedback mechanisms. Outcomes of such improved models should be combined with sketch maps developed through expert judgments to obtain a balanced view on the potential for nature adaptation strategies.

PDD5.1-05 DILEMMAS IN THE DUTCH RIVER AREA: DO LONG-TERM CLAIMS PREVAIL?

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For a long time the Dutch have reacted on river floods by building higher and stronger dikes. Flood protection had the only priority in Dutch river management. Nowadays a more integrated approach is chosen by giving more value to inland navigation, nature development, recreation and housing. Instead of raising dikes the new policy on flood protection is increasing the flood conveyance by widening flood plains and reducing resistance to flow. This new approach is called “Room for the River”. Different programs have been set up in which local authorities are making plans for river area developments. So, regional collaboration in flood protection schemes plays an important role. However, with the climate changing higher discharges on the rivers Rhine and Meuse are expected, as well as an increased sea-level-rise. This will increase the mid and long term (2050-2100) claims on river area for flood protection. The nationwide Delta program has been set up to deal with this new situation. A short exercise shows that claims on space taken to benefit the Room for the River program, will not suffice for long term flood protection goals, especially if they are combined with regional claims and system wide ecological claims. Therefore a new long term vision will be made by the Delta-subprogram “Rivers”on how to adapt to the new conditions. Local authorities will not likely want to stop developments in the river areas until this new long term vision is available. The question now is how to deal with actual local claims on areas which might be needed for future, however uncertain, adaptations. This dilemma will be dealt with in this paper. To support the regional processes, the scenarios and demands on space should be clear. In the Netherlands a long history of hydraulic and morphologic modelling exists. To facilitate the decision-making process, new tools have to be developed to visualize the complex claims, also of ecology and navigation, in order to communicate them to the people and give awareness to the offers we might demand for the future.

PDD5.1-07 A VISION ON DEALING WITH PEAK DISCHARGE AND RISING SEA LEVELS IN THE SW DELTA

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Shortly after the catastrophe of 1953, work began on drawing up the Delta Plan. The essential aspect of the plan was to shorten the coastline through a series of dams. As a result the former dynamic system has become much less dynamic. The concern about the unused potential of the Delta as a rich and diverse natural system has only increased. Moreover, water-quality problems have severely increased in the basins with ‘stagnant’ fresh and brackish water.
The great challenge now is to implement the safety measures in such a way that the water quality problems become history and use is made of the opportunities, which the system offers. Over the past few months H+N+S Landscape Architects, in cooperation with research institute Deltares, has contributed to the discussion on this matter by means of a study, assigned by Stuurgroep Zuidwestelijke Delta.
If we think about the long-term solutions for the safety issue in the Dutch Delta, there are two extreme approaches to the solution.

Firstly, a 'closed' system of dams and floodwalls behind which, during times of heavy storms and high river discharge, the river water is temporarily stored in one or more Delta distributaries. Once the storm is over, the excess water is then released and/or pumped into the sea. This solution requires higher dikes.
Secondly, there is an open system in which the large rivers are openly connected to the sea and flow into it freely, even during storms and periods of peak river discharge. This requires climate-safe and non-submersible super-dikes.
Since the first solution requires less rigorous steps and climate change can be coped with for the time being, we will limit ourselves to a short sketch of this approach.
The proposal is to increase the storage capacity of the Delta system with a second distributary: Volkerak-Grevelingen. If this system is still functioning at the time of the peak discharges between 2050 and 2075, the dikes along the Haringvliet and the Volkerak-Grevelingen distributary will have to be greatly strengthened.
These measures in the strategy for improving safety in the Delta are included in the proposal alongside a partial repair of the estuary dynamic. The worsened water quality is combated by letting in salt water and a reintroduction of tides into the Volkerak and Grevelingen. As a result, the transition between salt water and fresh water can be partially restored.
In addition, the nutrient flow from the rivers to the Delta can be restarted, on which the shellfish and animals that live in the sea and on riverbeds can feed. The relationship between the land and the water will again become richer and more diverse, both along the basins and along the water in the urban regions. The contact zone between land and water is offering space for future development. It offers room for high-quality nature, recreation and special housing.
All this will mean that the Delta will experience a substantial increase in quality as a diverse ecological system and an attractive area for living, working and recreation.

For illustrations see website: www.climatedeltaconference.org/results

DD5.2-02 TOWARDS A TYPOLOGY OF URBANIZING DELTAS

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Introduction
Most delta-areas in the world are dealing with increasing complexity and changing dynamics, because of two reasons: first, the changes in the natural dynamics of the delta due to climate change and human interventions, and second, the changes in the dynamics of land-use, dominated by urbanization, industrialization, port-development, agriculture and leisure/tourism. Although delta-areas have similar problems, they have different morphological and functional characteristics which has to be considered in spatial planning and design. Therefore it is necessary to develop a typology of urbanizing deltas based upon these characteristics in order to understand the fundamental differences between deltas and to introduce delta-specific strategies for sustainable urban development.

Theoretical framework and method
The presented planning and design oriented approach builds upon three premises: (1) identification of different types of deltas, (2) understanding relationships between natural conditions and human responses/interventions, and (3) scale of spatial research. The theoretical innovation in this paper concerns the application of a three layer-model in analysis and comparative design research (typology) in different scales on urbanized deltas as a bases for delta specific planning and design.

The starting point is a typology which clarifies the delta as a natural system. This delta-typology derived from coastal morphology, resulted in a systematic classification of different deltas based upon the different natural conditions of the deltas in terms of sediment input, wave energy and tidal energy (Bradschaw & Weaver 1995). Knowledge of this natural conditions is crucial in understanding urbanized deltas. The natural system can alter because of climate change. Also the system of infrastructures and urban patterns have a major impact on the system as a whole and can be manipulated and adjusted. The relationship between natural conditions and manmade spatial responses and interventions can be explored by using a three-layer model in order to develop a more complex and precise typology of urbanizing deltas involving other important layers of interest. This 'layer approach' has been recognized as an important method for spatial analysis and spatial planning, design and decision-making (RPD 2001, Kerkstra & Vrijlandt 1998, McHarg 1969). It describes and understands an urbanized area as a composition of three layers: the natural landscape (bottom-layer), the system of infrastructures (middle-layer) and the system of urban patterns as the (top-layer). These layers are strongly interrelated, but are also relatively autonomous in terms of dynamics in time and are subject to spatial scale (De Jong 1992).

Result
The paper will introduce a planning and design oriented approach towards urbanized deltas using the layer approach in order to develop a urbanizing delta typology. This typology can serve as a fundamental tool in decision making on spatial interventions in specific deltas. It comprises analysis and comparative research of urbanizing deltas in three layers, three scales (river-catchment, delta-area and individual delta-city) and three periods (history, present and future). It illustrates that the dynamics of the urbanizing delta are to be found in the changing interrelationships of the layers and the impact of interventions on this process, with a crucial role for infrastructures.

DD5.2-03 MULTI-DYNAMICS AND TIME ASPECTS IN SPATIAL PLANNING AND DESIGN

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Multifunctional land-use is a standard practice in Dutch planning, but with a very strong focus on only horizontal or vertical space. Another (new and dynamic) dimension is time. Different time frames can be identified. One can consider time as dynamic changes from hours to seasons or decades or centuries. Or low dynamic land-uses can be combined with high dynamic developments. Or consider temporary use of space for specific purposes. Time can be approached from a socio-economic perspective (including politics, policy development, procedural time and project development time)g or from a spatial development perspective in which a large variety of dynamics within different land-uses can be distinguished. For instance, climate change and ecological development take much longer to be effective than recreational or urban land-use changes or infrastructural interventions.
All these short- and long-term time frame perspectives have to coincide in planning. However, most often they result in (future) conflicts. Examples are water storage and shortage issues, increased vulnerability of urban areas for climate change, or ecological or cultural-historical aspects that seriously delay developments. With a totally different time frame, climate change is already important to deal with nowadays. Current spatial developments determine our vulnerability in the future and potentially reduce our flexibility to adapt to changing conditions. However, in spatial planning practice short-term needs and interests prevail, increasing vulnerability on the longer-term. Dealing with differences in dynamics and time scales is important to adapt to the effects of climate change. This requires commitment by stakeholders, as long-term and short-term investments need to be considered in a different but coherent way.

An interactive design approach has to be put into action in a combination of different disciplines, methods and participants, brought together to provide region-specific solutions and knowledge in order to support a more time-space oriented design strategy and develop a methodology for multifunctional and multi-dynamic landscape development. Stakeholders, involved in housing, agriculture, ecology, leisure, climate change, landscape design, blue and green network development, infrastructure and cultural historical issues, have to identify claims from many different preferences in time and in space. These claims have to be met to develop a more sustainable design and development process to start a time oriented regional system innovative process. The (old) constraint theory of HÃ¤gerstrand offers opportunities to determine the influence of a 'content' related time approach, focused on the time-space development competition between a large variety of land-uses.
Two examples illustrate aspects of a more integrated time-space approach. The first case focus on biomass energy production and explores a variety of temporality options, based on possible delays during a housing site development, that can offer a broad range of temporary uses over a longer period (10 to 30 years). The second case deals with temporary housing in future water storage areas as a promising way towards sustainable development, to deal with short-term needs and conflicts and long-term effects of climate change. Both cases are examined on the consequences for planning and design and discuss the feasibility in planning practice for temporality and multi-dynamics.

DD5.2-04 SPATIAL PLANNING AND FUTURE FLOOD RISK: THE LINCOLNSHIRE COASTAL STUDY

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Ensuring a sustainable future means taking into account the potential for long-term changes in society, economy and environment. For areas of low-lying coastal and deltaic land, future changes in sea level rise associated with climate change are also significant.
This paper describes the Lincolnshire Coastal Study, an innovative project that aimed to develop options for the sustainable spatial development Lincolnshire coastal communities. Lincolnshire is located on the North Sea coast of England. Much of the land is low-lying, drained for agricultural purposes and protected from regular inundation by coastal defences. The latest UK climate change projections show that sea levels may rise by up to 90cm over the coming century. At the same time there are pressures to develop and regenerate coastal towns, which are popular for retirement and tourism.
The Lincolnshire Coastal Study took a scenario and stakeholder based approach to examining future changes, and to develop options for sustainable spatial development. Scenarios of socio-economic change were developed describing how the area may change over the century using literature review and projection techniques. These demonstrate the continued importance of agriculture and agricultural land, the opportunities for tourism, but also the potential persistence of problems associated with low wages and seasonal employment.
New flood model data which describes the present and end-of-century hazard associated with tidal flooding in 1 in 200 and 1 in 1000 year events was mapped. The modelling includes an assessment of defence overtopping and breaching, with an assumption made in producing the maps that breaching occurs during extreme events. The maps illustrate the nature of the hazard along the coast, with an extreme hazard existing immediately behind the defences, and a declining hazard stretching inland by several kilometres in low-lying areas.
Political, policy and technical stakeholders were presented with the scenarios and maps and discussion events were held to understand how sustainable spatial development could be achieved. The outcome of the workshops was a set of principles to govern spatial development, and a set of spatial development options. The principles address where and what type of development would be appropriate for the coastal flood hazard zones, balancing the need for business and employment development and housing to meeting local need, with flood risk. The principles also set out the mitigation necessary for new and existing communities, and how spatial planning could promote economic, social and environmental improvements. The spatial options describe where the required level of housing development could be located, with strategic development outside the highest hazard areas.
The Study demonstrates some of the key challenges for climate change adaptation in deltaic areas. These include the management and communication of uncertainties and the reluctance of some stakeholders to adopt the precautionary principle. Using hazard maps, which largely describe consequence, as the basis for spatial planning presents benefits in terms of information, but also challenges in terms of application and subsequent agreement regarding mitigation. The role of different stakeholder groups is also important, especially with regards to the process by which strategic plans are agreed.

DD5.2-05 MULTIFUNCTIONAL USE OF WATERSYSTEMS FOR BETTER ACCESSIBILITY OF DELTA CITIES

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Introduction
Many delta cities suffer from severe accessibility problems and heavy congestion. Expanding the road infrastructure needs space which is scarce in delta cities. Using the existing water system offers flexible possibilities to improve the accessibility of cities. In the Netherlands, water was the most important mode of transportation until the 19th century. In that period, the train became more important and many urban surface waters were removed from the city centers due to hygienic problems and water pollution. However, in many cities the main water infrastructure is still present. In addition, many Dutch cities have plans to restore the historic water systems. The main reasons are: creating more water retention, restoring connections between urban canals and improving the living quality of historic city centers. The research question in this article is: Can urban water systems contribute to better accessibility of historic city centers of delta cities in the Netherlands?

Methodology
In 8 Dutch cities the feasibility of using the urban water system for mobility was studied. The historic use of water for mobility was studied by evaluation of historic documents. Subsequently, the current use of the water system for mobility was studied by a literature survey and stakeholder interviews in all participating cities. In addition, current water retention problems and accessibility problems were studied in each cities. Future possibilities to utilize water systems for better accessibility were developed by 'research by design.' method. This included technical feasibility studies and spatial designs of several alternatives. Finally, general conclusions were made and the general applicability of the results was evaluated.

Results
This article presents the historic and current use of water systems in 8 Dutch cities for mobility. In addition future options for multifunctional use of space by using the urban water system for better accessibility are presented. Examples of innovations that are presented in this study are floating multimodal traffic hubs, floating parking lots and water based public transport. The main conclusion of the study is that water offers possibilities to improve the accessibility of all participating cities.

DD5.2-06 BUILDING ADAPTIVE CAPACITY FOR WETLANDS WHEN COMPETITION FOR LAND IS HIGH

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Problem definition

Adaptation to climate change is about making decisions for possible future outcomes with a considerable amount of uncertainty. Anticipatory adaptation strategies are extremely difficult to implement, because of the partly unpredictable outcome of climate change and its long term consequences and the low immediate salience to stakeholders. It is expected that support for adaptation measures for natural systems will increase considerably, when benefits for society as a whole are clearly communicated. Therefore adaptation of the natural system should not be regarded in isolation of the social-economic system but needs to be integrated to be successful.
In this respect the recently published EU White paper on climate adaptation is helpful. As it is being recognized that ecosystems form an important part of adaptation to climate change as they perform services for society such as climate regulation, carbon sequestration, protection against flooding and avoidance of soil erosion. To fulfill these services resilient ecosystems are needed, that are able to cope with the effects of climate change.
Adaptation of land use patterns, intended to both diminish the impacts of climate change and to improve opportunities for natural and social-economic systems to respond, are essential to build on the future adaptive capacity of the landscape. Also adaptation strategies needs to be flexible and adjustable in future when new impacts and new knowledge might ask for further adjustments.
In this paper we present an adaptation strategy to improve the adaptive capacity of ecosystems to cope with climate change. We present an on-the-ground application of the strategy for wetland ecosystems. Finally we give examples how to find synergy with other functions by integrating adaptation measures on a regional level.

Theoretical framework and methods

We developed an adaptation strategy that is flexible and adjustable in future when new impacts and knowledge might ask for adjustments. The adaptation strategy has four components: 1) Increase (international) connectivity and ecosystem network size; 2) Increase heterogeneity of habitats; 3) Enhance natural landscape ecological processes; 4) Reduce existing pressures on habitat quality.

Results

We propose to concentrate adaptation measures in a so called ‘climate corridor’, as a cost-effective strategy to enhance the adaptive capacity of wetland ecosystems to cope with climate change.
For the implementation of the climate corridor an integrated planning approach is required finding common objectives between for instance water management, agriculture and biodiversity adaptation measures. There are several possibilities to forge links between nature policy, river- and coastal management and water storage policy. Examples are given how adaptation measures for wetland restoration can be combined with water safety and water management goals.

DD5.2-07 MULTIFUNCTIONAL LAND USE; INNOVATIVE SOLUTIONS FOR ADAPTATION STRATEGIES

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The Brabant countryside – although still retaining a rural character – is a densely populated and regulated area in the south of the Netherlands. Urban and rural land use functions are closely connected. Demands for available space are many and often conflicting. Land prices are high. Adaptive measures to cope with climate change impacts (e.g. rainstorms, floods, droughts, heat waves) can be space consuming, adding even more pressure on available land. One of the solutions may be multifunctional land use, increasing land use efficiency and generating added value for welfare (economy) and wellbeing (society).
This research project is aimed at exploring the possibilities of multifunctional land use as an instrument for adaptation strategies in sandy rural regions, especially in the province of Noord-Brabant. The ambition is to bring innovative but sometimes abstract concepts to the concrete level of business plans in a participatory planning setting. The project has an integrated beta-gamma research approach as the implementation of the concept poses challenges to both content (planning and design) and process (governance). Combining for example agriculture, preservation of biodiversity and recreation has to work in a technical sense but also requires cooperation between stakeholders. Starting with ‘classical’ combinations like nature and agriculture (e.g. green-blue services and overflow areas) the project aims at broadening the scope of multifunctional land use, especially in the rural-urban interface (e.g. green roofs, water parks or ‘high tech’ ecological corridors). New combinations also require new coalitions of stakeholders, supported by new financial, legal or policy instruments. Proven options- best practices - and promising concepts from the Netherlands and abroad will be tailored to the regional setting of Brabant.
To do so, the project will select two pilot areas in which we research the feasibility and effectiveness of a number of multifunctional land use types. Selection criteria for the multifunctional land use types are (1) their effectiveness in climate change and/or future proofing the landscape and (2) their innovative character. Important selection criteria for the pilot areas are the (magnitude of) challenges that these areas face in water management, the preservation of biodiversity and adaptation in the urban-rural interface (e.g. water retention and cooling facilities). Also the attitude of local and regional stakeholders towards exploring and adopting innovative ideas will be considered in the pilot areas.
Key deliverables are:
- an inventor – or catalogue – of available multifunctional land use options in the Netherlands and abroad, and evaluation of their applicability in Noord Brabant;,
- a ‘suitability map’ of the province of Noord-Brabant for a selection of multifunctional land use types and identification of focus areas for pilots with stakeholders;
- business plans for selected pilot areas.

The business plans mark the end of the research activities and the beginning of regional planning (follow up activity).

DD5.2-08 HOW NEW DEVELOPMENT CAN HELP TACKLE MULTIPLE PRESSURES FROM CLIMATE CHANGE

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UK policy is encourages non-defensive approaches to flood-risk management by 'making space for water'. This impacts upon all land use in three ways, space for bio-retention of surface water run-off, sacrificial land to cope with increased river flows or pressures from sea level rise and coastal erosion. In deltas these three pressures converge. Much of our existing infrastructure and development exists in delta or riverside locations; therefore these locations are often considered the most economic and sustainable for redevelopment. Shortage of available land, competing land use interests and rising spatial demands of infrastructure and development add further pressure on the limited resources.
These multiple pressures call for an integrated approach to planning that identifies stakeholder (actor) interests and collectively aligns interests to identify the best solutions. New development is a major source of revenue and therefore can be a key actor in identifying short and long-term solutions for delta sites.
Based on the work of the Defra funded and award winning Long-term Initiatives for Flood-risk Environments (LifE) project a range of bespoke tools and an integrated development approach is being used to identify economic and adaptable solutions for challenging sites around the UK. This paper examines the specific interests and pressures on redevelopment of a managed estuarine location on the south coast of England, and the application of these tools to find a solution. These tools include:

- Bespoke design and planning tools
- Quantitive brief development
- Coalescence and valuation of interest groups
- Opportunity and asset creation, to achieve wider improvements such as environmental gain or renewable energy generation
- Joint funding and partnering (collaborative working)
- Visioning and profit engineering

This approach has created an economically and technically feasible solution for a significant resilient redevelopment, linked with the generation of adjacent multi-functional land use. As the existing farmland becomes unsustainable due to rising salinity the new use seeks to maximize the alternative benefits. Therefore the land will be transformed into an extensive inter-tidal wetland, providing combined flood storage, habitat generation, non-biomass 'zero carbon' renewable energy generation, ecological and recreational leisure enhancement.
The scale of development provides the critical mass to pay for flood management improvements to existing properties and provide a sustainable regeneration arm to the struggling town. The vision for the site is to establish a 'mirador' of coastal wetlands, beach frontage and leisure facilities, making this an exemplar of sustainable design, climate change adaptation and a destination on the south coast.

For illustrations see website: www.climatedeltaconference.org/results

Deltas in Depth Theme 5: Competing claims and land use in deltas under climate change
Session DD 5.2: Generating and evaluating potential solutions **ORALS**

DD5.2-09 RESPONSIBLE INVESTMENTS IN TIMES OF CLIMATE CHANGE

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Problem definition
Fertile regions are scarce, so is fresh and clean water. Due to climate change, fertile regions need adjustments to stay productive. Specially in delta regions there is a high pressure on land because of high competition for space due to urban development - globally seen most people live in delta regions - while also agriculture is most productive in these regions. So while the cities are expanding, the pressure to produce more food per hectare in the region where urbanization is taken place, is increasing. Phrases like "Battle for acres"and "Producing more crop per drop"are more and more heard. The Von ThÃ¼nen model with respect to the use of land for agriculture has become relevant again. Besides agriculture also nature, transport infrastructure, utility and energy networks claim increasingly larger space. Metropolitan agriculture can provide a solution to develop a region in such a way that all above mentioned factors are included in one region: combining (more) sustainable agriculture with urban development.
To realize this multifunctional use of the delta regions cooperation is needed between governments, universities, entrepreneurs; and all these developments need financial input. Specially a project like metropolitan agriculture needs to be developed at one moment to make the closed loop work. Financing these developments should be done without disturbing market competition. Therefore it's interesting to look at a practical level how these developments can be realized.
The derived research question is:
Which (financial) institution is able to contribute to realizing the investments necessary for adjusting the delta regions to increase agricultural production in a sustainable way in an increasingly urbanized region?

Theoretical framework and methods
Theories from Von Thunen with respect to land use, and theories on sustainable agriculture, also using the term metropolitan agriculture, will be applied to sketch the pressure on the land to meet the future needs of the urbanized delta regions, while rural resources are depleting.
With respect to the (financial) institutions who can contribute in financing these developments, the focus will be on pension funds.
Methods used are desk research, interviews and field experience.

Results
Pension funds involve themselves in the role of financing (long term) projects. Field research has proven that institutional investors (via fund managers) are interested in partnerships with entrepreneurs, receiving annual dividend, derived from the results from the entrepreneur in return. Institutional investors are able to commit their money for a long term to a project, receiving a performance fee while selling the project after a few (e.g. 10) year. This performance fee will be higher when value adding investments have been done, so the investors are interested in scientific developments. These kind of long term commitments are necessary for projects like metropolitan, more sustainable, agriculture. Projects with more sustainable agriculture close to urbanized regions become more and more important to meet the needs of the (future) people.

PDD5.2-02 BORTH - THE MARZIPAN CAPITAL OF THE WORLD?

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Borth is a small town on the mid-welsh coastline in the UK. It lies on a shingle ridge, fronted by a wide sandy beach, which has formed across the majority of the wide entrance or delta area of the Dyfi Esturary. The shingle ridge separates the sea from a wide area of low-lying land now containing a designated fresh water peat bog. Borth is understandably a town that is dominated by tourism with many visitors arriving for the summer to enjoy the beauty of the area.
The existing defences are now at the end of their useful life and over a number of years a strategy as been developed by Ceredigion Council in consultation with the local community. At one of the visioning events the community were asked what they wanted for the future of their town, a reply was the marzipan capital of the world. This suggestion encompassed a range of concepts discussed at the meeting, these include:
- continuing viability of the town
- development of tourism
- improvement of amenity use of the beach
- conservation of the designated sites
- local impact on present facilities and property

The scheme is currently in the process of detailed design and this paper will explain the development of the coastal defence strategy at Borth, the opportunity of constructing a multipurpose reef to hold a wider nourished beach and improving the surfing; in addition to rock groynes and fishtail structures. Funding is sought from the Welsh Assembly Government and European Regional Development Fund for the coastal defence work. How the strategy of the next 50 years is complementary to the wider shoreline management plans. The shoreline management plan covers for the whole of the west of Wales coast, and considers the possibility of a 2m sea level rise scenario. And finally how it meets the aspirations of the local community.

For illustrations see website: www.climatedeltaconference.org/results

PDD5.2-04 DEVELOPING ADAPTATION STRATEGIES FOR AGRICULTURE IN THE NORTHERN NETHERLANDS

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Agriculture in the Netherlands has been and is changing rapidly. Primary production is concentrating in regions with larger specialized farms while other regions move towards a multi-functional agriculture. Important drivers for these changes are policies, societal demands, globalization of consumer and producer markets. Climate change is becoming an additional factor prompting for changes in regional and local planning and practices. With limited space and changing environmental and societal conditions competition for land between various functions in the strongly urbanizing Netherlands is increasing.
Although the number of farms is declining the area in agricultural use is relatively stable, indicating a trend towards larger farms. Primary production is sensitive to climate change. These changes are expected to affect agriculture in different ways. As farming systems differ in resources, strategies and management, adaptation strategies will vary for the different farms. Where some farmers will see opportunities and feel confident that changes in society, market and climate can be addressed by changes in farm size, management or diversification. Others may have to opt out of agriculture or move to other regions.
A study on the impacts of gradual climate and market changes on agriculture in the northern provinces indicates that potato and milk production in the region are competitive in a globalizing and liberalizing world. Although this relative good starting position gives ground to be confident for the future it does not mean that inaction is warranted. Remaining competitive requires action at different levels.
Extreme events have the potential to destroy entire harvest. The impacts of extreme events are presented using the Agro-Climate-Calendar. In the ACC impacts of extreme weather events on arable farming in the northern region of the Netherlands are documented for the 2040 period. The overall picture is that most extreme events only show a minor increase or decrease. A few extreme events e.g. high intensity rainfall, pest and diseases related to warm and wet periods are high risk events that may have large consequences for the yield quantity and quality. The information from the ACC is used in interactive workshops with stakeholders, so called adaptation ateliers, for validation and serve as a basis for discussion on possible adaptation strategies.
The adaptation ateliers helped in raising awareness about climate change and get insight in perceptions of farmers. Most farmers indicated that they are confident about the future and see ample opportunities to adapt. Operational management options to avoid risks related to extreme events such as improving soil structure to cope with drought and extreme rainfall, monitoring pest and diseases to allow timely responses are part of their portfolio. Longer term solutions related to improved or the introduction of new crop varieties are more in the arena of science and policy. Farmers also indicate that adequate water management is a key factor in achieving high quality and quantity agricultural production.
To be able to formulate coherent regional adaptation strategies addressing the different responsibilities between farmers, local and regional government, water boards, the agro-sector and science requires a close interaction between these stakeholders.

PDD5.2-05 THE DELTA- CITY PERSPECTIVE OF THE PEARL RIVER DELTA

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Urbanized Deltas are one of the most impotent coastal areas facing the challenge of Climate Change because of their high vulnerability in both social-economic and nature process. As the earliest settlement of cites established around 214 B.C., the Pearl River Delta is one of the most density and rich deltas for dwelling. The economic boom and fast urban expansion has been fiercely changed the relationship between the cities and the delta since 1980's.
First the study Investigates the Pearl River Delta region by a 3 layers x 3 periods framework to present the delta-cities dynamic in the past thirty years: the layer of natural landscape transformation from morphology and land use, infrastructures and human settlements; the layer of spatial pattern evolution among major cities from population density, and the layer of infrastructure development from transport map in 3 periods -1980's, 1990's, and 2000's.The paper then explains how the existing delta-cities dynamic will lead to high risk not only in ecology process but also in urban development.

The paper argues that two possible solutions would be: learn from the neighborhoods and learn from the history: Delta cities need further understanding towards their neighborhoods' characters within the region. Delta cities should also learn from the past pattern which functions well for thousands years. With these communication and understanding could the delta region effectively unite and solve the regional issues like flood, storm, fresh water supply, species extinction, sea level rise, and development. It also argues that the Delta-City perspective should applied to the regional planning cooperation within other delta regions under the challenge of Climate Change.

PDD5.2-06 CONTRIBUTION OF MULTIFUNCTIONAL FARMLANDS TO A CLIMATE PROOF ECOLOGICAL NETWORK

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Problem definition
In 1990 the Dutch government has designed a National Ecological Network. In this network existing nature reserves were connected and areas were appointed where small reserves could be enlarged and new ones created. However, the realization of this nationwide network is going slowly. Climate change puts extra pressure on biodiversity in the highly fragmented landscapes of the Netherlands. In response to increasing temperatures some species will need to migrate to find new suitable habitats. For other species, with limited possibilities to migrate and low reproduction capacity, their habitat should be enlarged and made more diverse to create better survival opportunities in case of more extreme weather events (e.g. droughts and extreme rainfall).

Theoretical framework and methods
The hypothesis is that multifunctional land use can contribute to the proofing of the ecological network against climate change. In two regions, Winterswijk (sandy soils) and De Venen (wet peat soils), we explored how land use practices can be adapted to make these areas more resilient against the impact of climate change such as the related variations of ground- and surface water levels and nutrient conditions. The impact of adapted land use on migration characteristics of a selected number of plant-, bird- and butterfly species were evaluated as well as the creation of migration corridors to new habitats. Next to that we studied the impact of adaptation options at the farm level and combined these options into integrated packages of adaptation measures at a regional level.

Results
We distinguish between three groups of measures:
1. Green-blue veins
   These measures increase the green/blue veins between fields (like ditches, hedgerows, wooded banks, verges along roads, railways and canals, field margins) and their connection to existing nature reserves. Alternative management of these landscape elements support the requirements of flora and fauna for feeding, breeding, shelter and hibernation. Most of these measures fit relative easily into common farm practices.
2. Adaptations at field level
   Such measures aim to improve habitats by adapting grassland management or growing other types of crops. For example, the first cut of grass can be delayed until mid summer to allow the vegetation to flower and produce mature seeds, or long grass can be kept standing during winter time to offer insects suitable habitat during hibernation. These adapted fields act as stepping stones for several species and fit well into agri-environmental schemes.
3. Buffering of nature reserves in an ecological network.
   Two types of buffering that give positive results are presented: 1) maintaining higher water levels in ditches and groundwater to buffer nature against dehydratation and 2) increasing water quality by minimising nutrient losses from agriculture to surrounding nature.

For each group of measures a number of relevant issues are presented, including the impact on flora and fauna, farm management and the region as a whole.

PDD5.2-07 METHODOLOGIES FOR SETTING UP ADAPTATION STRATEGIES IN PEAT AREAS

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Problem definition
The use of land is in the Netherlands closely related to the way we organize our water systems. Climate change will effect our water systems and therefore the way we use our land. The impact of climate change on peat areas located mostly in the western part of the Netherlands will be significant. To keep economically and socially vibrant areas we need to adapt to the effects of the changing climate. This will lead to a situation where we can try to maintain the present situation or create a new situation adapting to the climate change. The first strategy is about taking measures to counter the impacts of climate change as where the second one offers possibilities and opportunities to benefit from. For example new economic activities could be the production of regional organic food, sustainable energy production or recreational purposes for the people living in urban heat islands.
Different methods are available for setting up an adaptation strategy for spatial planning and the water system on a regional scale. It is unknown if different methods will result in different strategies, social and economic prospects and costs.

Study area
This study focuses on the Hof van Delfland. This rural area within the metropool of Rotterdam, Delft and The Hague in the western part of the Netherlands has a unique original landscape as a result of the reclamation of the peat areas. The area is a dairy farming area that will undergo a huge economic changeover because of the declining economic possibilities for this sector. The main question for this area is how to adapt to the climate change within this transition within the next decennia.

Theoretical framework and methods
Forecasting and Backcasting
Two methods for setting up a climate change adaptation strategy are forecasting and backcasting. Forecasting focuses on the present values of land use. It defines the adaptation effort which is needed to keep these values as long as they are socially, financially or physically acceptable.
Backcasting starts with the definition of a climate proof image for the future defining a land use that suits the future physical conditions and builds on an autonomous development. The next step within the backcasting is to determine the proper timing of implementing measures which will finally result in a transition from the current situation to the composed image.
For the described region in the Netherlands these two methods will be worked out and put into practice. The different results of both methods are determined.

Results
This research project has started at the beginning of 2010 and will end in early 2011. Initial results will be available in the summer of 2010.
Finally, this project will result in:
- The development, application and comparison of two methodologies for adaptation strategies on a regional scale (including definition of design guidelines)
- An inspiration book with climate adaptation opportunities for peat areas
- The contours of an adaptation strategy for the Hof van Delfland including an implementation plan

DD5.3-02 'SKETCHING AND MATCHING CLIMATE ADAPTATION' WHERE SCIENCE MEETS SPATIAL DESIGN

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Problem definition
When climate adapatation comes down to the stage of policies carried out into plans and implementation, a mono disciplinairy approach, along the lines of ministerial responsabilities then seems common practice. This in spite of statements and intentions for an integral spatial approach. In the case of climate adaptation, water safety and flood protection, controlled by the Ministry of Transport, Public Works and Water Management, dominates the implementation of policy into practice. The key problem we want to address here is that there is hardly an integrated spatial approach between science, policy and practiniors when applying climate adaptation solutions.

Theoretical framework and method
"Design knowledge is inextricably linked with theoretical knowledge and practical wisdom".
Jannemarie de Jonge, 'Landschapsplanning en ontwerp in de netwerkmaatschappij (Landscape planning and design in the network society)', in: De Blauwe Kamer, February 2009.
The method we use is one of research-by-design. The place where this happens is in a so called atelier, bringing together scientists, designers and stakeholders.
The power of this atelier (in the US called 'charette', in the Netherlands 'sketch and match' or design atelier) is the combination of scientific knowledge, social involvement , and 'the art of creation'.
It is a multi-disciplinary approach in which the 'climate adatation' task is brought down from a natioanal level to the regional or local level and connected to issues like nature, infrastrucure, urban development or agriculture. Social involvement in this setting means that knowlegde on a local and regional level (like cultural-, heritage-, history-) is brought in by regional or local experts (not necessarily scientific). This being a crucial component of a participatory proces. The 'art of creation' is the responsibility of the designer, architect or landscape architect. It is their task to connect different spatial solutions into an integrated and supported result.

Results
We present a selection of 1 or 2 out of 5 case ateliers which were held in 2009-2010 in Bergen op Zoom, Rivierenland, Maasdijk , Noordoostpolder and Helmond.
These cases show the succes of elaborating climate adaptive measures incorporated in local and regional developments.

DD5.3-03 FIRST WE CHANGE THE RIVERS, THEN THEY CHANGE US

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Deregulating and diverting of rivers
Recent programs for the deregulation of rivers in Holland (room for the river) or the restructuring of the Mississippi with additional spillways (Davis, etc) in the southern Louisiana delta compensate for earlier maladaptation at a regional or national scale. The neglecting of large spatial contexts such as the hydrological regime or autopoietic geomorphological processes results in consequences at precisely these scales. We become aware of the neglected interactions of micro and macro interventions facing conditions of natural dynamics as they manifest in costly and partially dramatic ways. First we change rivers, then rivers change us.

Threefold critique of Modernism
Examples will point out the necessity of reflecting on immanent characteristics of landscapes. Three conflicts within the concept of nature and landscape in Modernist thought are identified. The paper will critique and suggest a reassertion of measures of modernity.
A) Functional separation: "hybrid" versus mono-functional
B) Mechanical time: "cyclic" versus linear
C) Rational Objectification: "producing" versus produced
Hybrid, cyclical, and producing are the defining terms for a contemporary landscape concept which is aimed towards rehabilitating the utilization of "producing"nature as natural infrastructure. Since we can no longer afford outdated infrastructure with low adaptive capacity in the future, neither in economic nor ecological terms, we require new strategies to reconfigure static and centralistically organized systems in a decentralized, redundant, and flexible manner. Mono-functional infrastructure projects are eroded by the cyclical and producing character of nature. They resemble discontinued models of an outdated product line within a society that is becoming aware of the limitations of this aspect of the project of Modernity.
The paper argues that Landscape architecture as one of the few remaining generalist disciplines has the capacity to design adaptive strategies aimed towards stability in the context of an environment, which continues to change in a dynamic way. Processes of urban growth and shrinkage can be guided along a natural infrastructure of landscape-related conditions and potentials. The landscape of River Deltas are exemplary for this approach due to their illustrative and narrative capacity. In order to adhere to this task, an adjustment of how we conceptualize landscape is necessary. In this regard, J.B. Jackson's "prototypical" landscape definition is helpful: "A landscape is a space deliberately created to speed up or slow down the process of nature." (1)
It is decisive that future adaptations occur as conscious, reflexive actions in order to avoid even larger accidental, yet predictable maladaptations. In the future, as alternative to investing billions in further flood barrier projects with limited half-life, strategies of landscape architecture are needed that evoke "alliance techniques collaborating with a befriendable nature."(2) Recognizing and utilizing the co-productivity of a "producing"nature is the basis for organizing space along the dimension of time when conceiving future infrastructure systems. A renewed appreciation of landscape is thus not a project of formal aesthetics but represents the choreography of natural processes.
(1) Jackson, J.B. Discovering the vernacular landscape. New Haven 1984, S. 8
(2) Bloch, Ernst: Das Prinzip Hoffnung. Frankfurt/M. 1977

For illustrations see website: www.climatedeltaconference.org/results

DD5.3-04 WATERFRONT POTENTIALS OF 'RHINE ESTUARY CLOSEABLE BUT OPEN' CONCEPT

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The Rotterdam region (Rijmond) is part of the northwestern Rhine-Maas estuary and the South wing of the economic core region Randstad-Holland. It has always been vulnerable for the effects of the global climate changes: flooding. However, it has become economically, demographically and henceforth politically vulnerable as our new Dutch export product 'Wilders' shows. These developments interact and sound strategies are needed to cope with the negative effects. All hands on deck!
The project 'Rhine estuary 'closeable but open' – a multidisciplinary exploration' explores a copying strategy.
As mainly a civil-engineering concept it aims to protect the Rotterdam region from flooding. Instead of dike reinforcements all along the rivers, various upstream (Rhine, Maas) flexible surge barriers - similar to the well-known Maeslant Storm Surge barrier – are advocated. If this innovative concept works a 'closeable but open' Rotterdam region emerges. This Dutch polder 2.0 might be more cost-effective then dike reinforcements. According to many policy-makers and planners 'closeable but open' might have an extra benefit. It might trigger waterfront developments especially in the old inland harbors. These former economic core locations are outdated and abandoned, but may be attractive for housing and new firms (creative industry). Do waterfront development create the context to change the economic and demographic base?
In this contribution we focus on waterfront development for housing in the 'hot spots of Rotterdam City'. The key factor that determines success: 'is there demand?' In this contribution we use economic and demographic scenarios to estimate which locations are most attractive for waterfront development. We use an economic Null scenario (1 % GNP growth and 0% income growth) in combination with two levels of household growth. The household growth '+10,000' assumes a turning point: less out-migration of higher educated households (24 years and older) then the past two decades showed. Finally, the scenarios assume that municipalities in the Rotterdam region do not compete with each other, but join their efforts to boost the region as whole. To estimate demand and supply between 2010 and 2030 we use the well-known demographic and housing market simulation models Primos/Socrates. For specific potentials for waterfront developments we rely on research by Kauko, Goetgeluk & Priemus published in the special issue of Built Environment 'Flood and Cities' (2009).

DD5.3-05 SHORELINE MANAGEMENT PLAN FOR THE WASH: AGRICULTURE AND HABITATS IN THE BALANCE

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In England, the Environment Agency and the local authorities are responsible for flood and erosion risk management. They use Shoreline Management Plans (SMPs) to set their long-term vision. SMPs look a hundred years into the future and are reviewed every five to ten years. The SMPs determine the preferred high-level approach to managing the shoreline. The shoreline management authorities work with all relevant partner organisations to determine an integrated vision how the coastal zone should function. This is then translated into an intent of management in the short, medium and long term. The end result of the SMP consists of shoreline management policies for these three timescales, using the following policy labels: No Active Intervention, Hold the Line, Advance the Line and Managed Realignment.

The Wash is an embayment in the East of England. It is surrounded by a large area of drained low-lying land called the Fens, from 20 to over 50km in width. The Fens were largely drained in the 17th century by Dutch engineers; land reclamation occurred until the 1970s. The Fens contain about 50% of 'grade 1 land' in England, which is the land with the highest agricultural potential. Four main rivers discharge into the Wash: Witham, Welland, Nene and Great Ouse. All this land, including towns such as Boston, Spalding and King's Lynn, and regionally important infrastructure, is protected by seabanks. The intertidal area consists of a wide expanse of saltmarsh and mudflats in front of the seabanks. This area is protected by all relevant European and national habitat designations, and it also plays and essential role in reducing wave attack.
The intertidal area has accreted since the last ice age, but it is uncertain how long this will continue. If climate change leads to a reversal to saltmarsh erosion, then this will put pressure on the flood defences and threaten the integrity of the habitats.
The SMP is being developed against this background. The legal framework asks for a precautionary approach to habitat loss. At the same time, there is a strong political driver to keep protecting all the good quality agricultural land to safeguard the role of the Fens for national food security, which may come under threat in the future. If the future turns out to be 'erosional', then a different approach may be needed: a landward realignment of the seabanks would re-create a buffer zone for wave attack and could create replacement habitat for the saltmarsh lost through coastal squeeze. However, a precautionary approach to habitat replacement could be 'high regret' from the point of view of food security.
The SMP has succeeded in developing an acceptable approach for both sides of the argument. This required creativity and flexibility in using the SMP guidance, setting policies that are conditional on future developments, to be ascertained by focused monitoring. This has brought together the regional politicians and other stakeholders for a plan that has succeeded in raising the big decisions and setting in motion a plan to deal with future coastal change.

DD5.3-06 ADAPTATION FOR NATURE IN DUTCH FEN MEADOWS; REFLECTIONS FROM STAKEHOLDERS

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Problem definition
After fragmentation due to intensification of land use and urbanisation, the biodiversity of the fen meadow landscape in the Groene Hart region of the Netherlands now faces an additional threat: climate change. Since 1990 a National Ecological Network (NEN) is designed to prevent further habitat fragmentation. This NEN connects existing nature reserves and expands at key locations by: 1) acquiring new nature areas, and 2) adaptation of farmland management through agri-environmental schemes. However, further expansion of this network stalls because; 1) many land owners do not want to sell their property for the purpose of nature, and 2) the adoption of agri-environmental schemes is not sufficient to construct coherent networks.

Theoretical framework and methods
In the fen meadow landscape dominated by grasslands we explored alternative options to connect habitat for species that are vulnerable to climate change. By connecting existing landscape elements (e.g. field margins and ditches and their banks) fragments of the landscape become more coherent and result in green-blue veining of the landscape. These green-blue veins can be used by species that are vulnerable to climate change for migration to other areas and as extended habitat.

Based on literature, information from experts and our own agronomic and ecological knowledge we designed a green-blue coherent network for farmland in the polders between existing nature reserves. Individual consultations of local experts and focus group discussions with local stakeholders provided feedback on practical implications, costs and benefits of green-blue veining options and the willingness to implement them.

Results
In focus group discussions most farmers, ecologists and policy makers agree that they have to cooperate to make the fen meadow landscape more resilient to climate change. Furthermore, the current agri-environmental schemes do not fit well in modern farming practices and they do not stimulate connectivity of the landscape sufficiently. The explored alternative options, especially green-blue veining, have been rated positive in the focus group discussions because they fit better into modern farming practices according to farmers and are thought to be more effective according to ecologists and policy makers. For species under pressure of climate change it is essential that habitats are connected and diverse. The connectivity of such networks is therefore a key issue and this will need more attention in the future design and implementation of agri-environmental schemes.

DD5.3-07 DEALING WITH FLOOD THREAT THROUGH APPROPRIATE BUILDING DESIGN

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Climate change involves several complex disruptions in the global balance, and the first thing that - especially in the Netherlands - springs to mind, is the problem of rising sea levels and flooding. Rather than resisting by continuously improving traditional water defences (dikes, seawalls, locks), this problem could also be dealt with adaptively, through building design. Instead of pushing the water aside (and thereby exacerbating the problem for surrounding areas), it is possible in many areas to accept these occasional floods, and turn something traditionally perceived as a threat into a positive – and even interesting – phenomenon.
This paper investigates how new housing can be designed to withstand rising flood waters, without loss of function or the need to evacuate. We identify several typologies of housing capable of dealing with this challenge, and show how they can offer attractive lifestyles in a polder under threat of flooding. A selection of these typologies has been studied with respect to the special considerations required, as well as alternative solutions to solve issues such as access, foundations/ anchoring, waterproofing, technical utilities, health & safety and quality of living.
We show that it is possible to design dwellings with minor negative consequences in case of flooding, providing unique added qualities while at the same time allowing ample space for emergency water catchment and storage. Finally, a plan for an entire area is proposed combining the various typologies, as a showcase for possible future delta habitation.

Deltas in Depth Theme 6:

Governance and economics of climate adaptation

DD6.1-02 MIGRATION AS AN ADAPTATION STRATEGY TO CLIMATE CHANGE IN DELTAS

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Massive population displacements are now regularly forecasted as one of the most dramatic possible consequences of climate change. Recent empirical studies have shown that environmental factors were increasingly important drivers of migration movements, both forced and voluntary. These studies have also highlighted how migration was not necessarily the result of failure of adaptation strategies, but could be one of possible options for populations to cope with the impacts of environmental changes, and global warming in particular. As a result of this, migration has increasingly acknowledged as a possible adaptation strategy in the international climate negotiations.
The proposed paper is based on a research conducted in the framework of the EACH-FOR project, a European-funded research project that examined how populations responded to environmental changes in 23 case-studies across the world (www.each-for.eu). Several of case-studies were conducted in deltaic regions, including the Nile delta, the Mekong delta and the Ganges delta. The paper presents these case-studies in a comparative way.
The paper examines the factors that make migration a possible adaptation strategy for populations confronted with environmental changes. Such factors include environmental elements, but also socio-economic conditions, public policies, as well as discourses and representations on migration. The research reflects in particular on two key observations from the EACH-FOR project: the first one is that the most vulnerable populations are often unable to migrate when they face environmental changes; the second observation is that public discourses portraying the migrants as victims of environmental changes hinder their ability to adapt. Building on these observations, the paper examines the specific challenges that deltas are faced with, and suggests some policy developments for a better governance of climate-induced migration in these regions.

DD6.1-03 ADAPTATION TO CLIMATE VARIABILITY: THE ROLE OF PAST EXPERIENCE AND INSTITUTIONS

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Currently, climate change adaptation receives a lot of attention. It is, however, sometimes forgotten that people all over the world have been coping with the impact of climate variability on their ecosystems already for decades. Their experiences can be helpful in designing appropriate policies for climate change.
This paper presents the results of a World Bank study on costing adaptation through local institutions in Mali and Ethiopia. The study raises two questions. First, which adaptation strategies were adopted in the past by rural households to deal with the impacts of climate variability? Secondly, to what extent do institutions provide assistance to adopt adaptation strategies?
Based on household surveys, focus group discussions and institutional stakeholder interviews, first, the components of vulnerability, exposure, sensitivity and adaptation capacity, were analysed. Sensitivity refers to the extent to which people are susceptible to exposure to climate change. In general, high levels of exposure and sensitivity and low levels of adaptation capacity result in high levels of vulnerability. High exposure, however, not necessarily results

in high vulnerability e.g. if the adaptation capacity is high. Based on these components of vulnerability, clusters of households were formulated. Secondly, reasons for differences in households' choice of adaptation strategies were analysed. Thirdly, the role of institutional assistance in adopting adaptation strategies was investigated.
The results show remarkable differences in adaptation strategies used. In Mali, less adaptation strategies were adopted than in Ethiopia. Almost all households in both countries use adaptation strategies such as improved seeds and changed planting dates, to make yields less susceptible to climate variability. In both countries, adaptation options chosen differ between types of households. In Ethiopia, wealthier households participated more in communal strategies, like soil erosion, communal irrigation or reforestation, for which outside help is necessary. Also pastoralists adopted communal water harvesting and rangeland management strategies to reduce exposure, which cannot be financed by them individually. In Mali, the only communal strategy chosen is irrigation, which is adopted by only a few, wealthier households. Income diversification techniques outside of agriculture were chosen only by a few households. A problem here is that rural areas lack an enabling environment in which non-agricultural trade activities can sustain. Finally, migration as income diversification strategy was chosen more often in Mali than in Ethiopia. In both countries, especially the wealthier households migrated to urban areas.
In Ethiopia, the network of public extension agencies is well developed. Most Ethiopian households received assistance from them, especially in terms of training. In Mali, extension agencies are almost absent and their assistance focuses on providing inputs for irrigation and home-garden agriculture. The role of NGO's, cooperatives, micro-finance institutes and religious communities was small in both countries. Finally, wealthier households had more access to assistance.
In both countries, people living in rural areas are exposed and sensitive to climate variability. Various strategies are adopted and wealth levels are important for applying adaptation strategies. Differences in coverage of institutional assistance and type of assistance provided, however, were substantial, in this way affecting prospects for future development.

DD6.1-04 CLIMATE CHANGE RELATED CHALLENGES OF THE PEARL RIVER DELTA, CHINA

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The 2200km long Pearl River is one of Chinas three largest rivers, and its watershed, comprising 409480 km², covers large parts of the Chinese Southwest. The Pearl River Delta, PRD, is a vast delta landscape including the cities of Guangzhou, Jiangmen, Huizhou, and Shenzhen, affecting also the shoreline regions of Macau and Hong Kong. The PRD is therefore one of the largest metropolitan areas worldwide and belongs to the heaviest populated river deltas globally. Population density with 1800 persons /km² even exceeds the one of the Nile Delta. Challenges of the PRD include a projected population growth of 77% until 2015 (especially increasing since the establishment of special economic zones), imposing conflicting demands for land from the sectors of urban development, industrial growth, agriculture, flood retention and ecosystem preservation.
The conference contribution will present the resulting problems especially from the fields of land and water shortage, as well as pollution and contamination and resulting migration of vulnerable parts of the PRD population, all in the context of expected climate change related trends. Predicted sea level rise, and the climate change related occurrence of extreme events (storms, typhoons, floods, droughts etc.) at higher frequency will clearly aggravate the afore mentioned, already existing challenges. A conservative minimum scenario predicts a 30cm sea level rise for the PRD by 2030. Hence, there is a strong need to set up efficient and coordinated climate change adaptation plans. This

is hindered by partially overlapping and partially uncovered responsibilities in delta- and coastal zone management, complex governance of the delta and its special industrial zones, agreement deficits among decision makers, and an overall lack of preventive policies. For such a complex environment large transdisciplinary research- and application projects are needed, which include research and consultation from the natural sciences side (sea level rise scenarios, hydrologic modelling, streamflow investigation, water quantity and quality evaluation, sedimentation patterns, landcover and landuse change, ecosystems and biodiversity etc.) as well as the social sciences side (institutional analyses, power structure analyses, information flow analyses, analyses of the legal frameworks, knoweldege management approaches etc.), addressing all involved parties from the local level up to the ministerial decision makers and channelling their results via different media, such as online available Information Systems, customized IT solutions supporting planning and decision making, as well as via 'soft' bottom up participatory approaches, strengthening awareness rising among the population. Especially the latter is a very powerful tool in a country where decision making of local governments often follows subliminal public pressure, especially when social unrest is at risk.

DD6.1-05 DRR GOVERNANCE: A CRUCIAL INTERPLAY BETWEEN ADAPTATION AND DEVELOPMENT

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In this paper, we focus on Disaster Risk Reduction(DRR) in developing countries to assess the importance of governance for achieving a "climate resilient"development. To do so, we draw more specifically on the example of Bangladesh and of its delta. Indeed Bangladesh has been foremost in DRR planning among developing countries.
First, we posit DRR as a keystone to successfully understand and tackle some issues in adaptation to climate change in developing countries. DRR holds a clear link to development in avoiding direct and indirect costs to the economy. Thus, this challenges the notion of adaptation to climate change policies being only constraints to development. With due respect to the adverse effects of climate change, the increase in consideration of risk leading to better DRR policies increases overall resilience of the population and of the economy. DRR is also a way of binding in common policies a strong preference for the present normally exhibited in development policies and a long term perspective needed in adaptation to climate change (i.e a non regret strategy). Hence, the time loophole differing the consequences of an action from its decision-making process is closed. We will assess the debate on this issue in the literature.
Second, we consider the role of governance in DRR (with regard to adaptation to climate change). It means drawing lessons from developed economies to improve the way we perceive and propose DRR in developing countries while understanding key differences due to the state of development. This leads to detail particularly two elements (i)what are the main features for a 'good governance' in DRR seen through success and pitfalls from developed economies, (ii) questioning to which extent DRR is a necessary bias towards development with regard to longer term perspective (climate change).
Third, we tend to address the cutting-edge issue of indirect benefits of DRR. Governance is often seen as a crucial element for the success or failure of DRR (or adaptation strategies). Usually, DRR policies are often assessed through their budgetary cost and their benefits in avoiding direct and indirect costs from the risk. We propose to reverse this perspective in addressing the indirect benefits of DRR strategies to development. To start with this idea in DRR context, we consider governance as the main channel to which DRR may positively interplay with economic development. To this regard, we will consider DRR role in (i) the general improvement of institution and legal framework, (ii) peculiar role in property rights enforcement, (iii) infrastructure planning, (iv)financial risk and investors

environment, (v) allowing social network to play their positive role in development and (vi) accountability issue. DRR takes part in the construction of a singular core mission of the State, which holds strong elements of legitimacy and accountability, while interplaying with economic performances.
To conclude with, this paper proposes to assess governance in DRR as a key link between development and adaptation strategies. It may play a role in the two directions with a potential virtuous and vicious circles.

DD6.1-06 FLOOD PROTECTION AND ADAPTATION TO CLIMATE CHANGE IN NORTH-WEST GERMANY

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Flood protection in North-West Germany is practised in the river basin of the Weser and along the German North Sea Coast. Both, river basins and the coast, have witnessed far reaching policy change which incorporates issues of climate change. With regard to the Weser river basin, the future challenge consists of coping with more frequent and more intense flood events, mainly due to heavier rainfall in the catchment area. Here, the so-called 'Flood Control Act' which has been enacted in the aftermath of the severe floods in Germany in 2002 is the key document. It gives guidance for spatial planning and flood communication issues on the local and regional level. For example, the German Länder are obliged to designate more areas as 'flood plains' than before. In addition, the Länder shall integrate the concerned public into the process of decision-making. In general, the focus is on risk rather than on safety; possible failure of dams is explicitly taken into account. Concerning flood protection along the coast line, the recently enacted 'Master Plan of Coastal Protection' ('Generalplan Kästenschutz') includes the elevation of dykes by 0.5m, half of which has been justified with expected sea level rise and climate change effects. In contrast to the first case, the aim is to ensure the same degree of safety all along the coastline.
Our paper describes these policy changes in terms that are held to be relevant for recent tendencies in many European countries, that is, changing perceptions of nature (from a 'struggle against water' towards efforts to better adapt to 'natural' developments), re-scaling of decisions (re-scaling of decision powers both in the direction of centralisation and decentralisation), and inclusion of stakeholders (changes in the number and variety of actors).

DD6.1-07 ADAPTATION AND POLICY INSTRUMENTS: THE CASE OF DELTA ZAMBEZI, MOZAMBIQUE

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Climate Change impacts are threatening lives, livelihoods and development efforts worldwide. It is indeed in developing countries, especially in sub-Saharan countries such as Mozambique, that climate change impacts are felt the most. The 2000 flooding in Mozambique claimed more than 700 lives and squeezed the GDP from expected 10 percent growth to just 2 percent. To withstand these impacts, mitigation and adaptation measures have been widely recommended as part of policy planning and intervention practices. Over the past years, climate change policies on mitigation and adaptation have been being promoted worldwide but their results remains to be seen. Of particular relevance it remains to be seen how policy instruments designed by state agents enters the lifeworlds of the local population and how do local people perceive and act upon them in their everyday life.

This article takes a constructivist perspective, which sees policy as an outcome of social negotiation rather than a 'thing'. Climate change is the concern of many different actors and institutions that can be seen to constitute an arena where this social negotiation (by all different means) takes place. The positioning of these parties towards the issue is not a translation of a shared concern with the urgency of climate change adaptation. It is also not a direct function of their political-economic interests. Interests are usually not clear nor consistent, and even rights are often contradictory and subject to interpretation. Adaptation policy can thus be seen as the result of a pattern of interaction between the different participants, which try to shape the process in ways that fit their own perspectives of the problem and goals. This means that we have to step away from the notion of the policy cycle model that views human action as instrumental rationality, in which policy is the systematic pursuit of goals and the end result of a purposive course of action. Instead, we have to follow empirically how policy evolves and gets transformed during the process of implementation.
The article is based on 18 months fieldwork on the delta Zambezi in Mozambique as part of an on-going doctoral dissertation on disaster response and climate change adaptation in Mozambique. It used ethnographic research methods which involved participant observation, interviews, group discussions, survey and secondary data analysis. The results of the research show that climate change adaptation policies along the delta Zambezi are based on evacuation and resettlement. This tends indeed to collide with local perspectives and practices which advocate the 'living with floods' approach. Local people have historically developed adaptation measures which are embedded on the local social, economic and cultural repertoire. As this is the case adaptation policies and measures advocated by the state agents become, from a local perspective, a problem rather than a solution and, contestations and disobedience follows. Emerging from this, I claim that adaptation polices needs to take a participatory approach and be grounded on people's everyday practices.

PDD6.1-01 ROLE OF MNCS IN DELTAIC COUNTRIES REGARDING CLIMATE ADAPTATION: BANGLADESH CASE

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The debates around climate change or environmental concerns against business strategy and competitiveness establish that climate change has opened a new window for exploring new businesses around issues related with climate change. However, those businesses are not yet comprehensively in operation and the business strategies are not yet adequately analyzed through research considering different vulnerable countries with dissimilar geographic features around the world. Most of the academic literatures widely concentrate on different aspects of well-known but general business issues around climate changes like emission trading, clean development mechanism, trade of clean technology and multilateral negotiation on environmental goods and services. However little concentration has been given on the opportunity climate change has created for Multi-National Corporations (MNCs) in international business to be re-oriented in a vulnerable country with specific geographic feature like that of a deltaic country. This paper highlights the case of Bangladesh as such a deltaic vulnerable country where under the climate change adaptation framework, MNCs would potentially have a leading role in promoting climate change adaptation in Bangladesh in different business sectors.

PDD6.1-02 CLIMATE GREENING ROTTERDAM, LONDON AND TORONTO

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This paper addresses the question what the key barriers and opportunities are with respect to the governance capacity of the spatial planning policy field to “climate green cities”, that is to adapt cities to climate change by means of green space. The use of green space is a no-regret adaptation strategy, since it not only absorbs rainfall and moderates temperature, but it simultaneously contributes to the sustainable development of urban areas through its many co-benefits. However, green space competes with other short-term socio-economic interests that require space. As a cross-divisional policy field spatial planning can mediate among these competing demands for land use and as such offers potential for the governance of adaptation. Through their effect on land use and spatial configurations in cities, spatial planning policies can affect resilience to the impacts of climate change. Nevertheless, climate change considerations have not yet had much impact on urban planning. Through an in-depth comparative case study of three frontrunner cities in adaptation planning, Rotterdam, London and Toronto, the governance capacity is analysed for each city. A framework of analysis was developed to analyse the governance capacity, broken down into five sub-capacities: legal, managerial, political, resource and learning capacity. The content analysis of key policy and strategy documents of each city has provided a top-down perspective, while in-depth semi-structured interviews with key actors and stakeholders in each city have provided the bottom-up perspective. This was complemented with a horizontal perspective by comparing the cities in order to distinguish patterns. The overall conclusion is that the legal capacity of spatial planning appears to be most important for climate greening cities, while the managerial capacity is seriously hampered by the complexity of urban governance structures, leading to compartmentalisation and institutional fragmentation as the two key barriers to the capacity for climate greening cities. The biggest opportunity seems to be the establishment of strong links between adaptation and other important societal governance themes, the most obvious one being climate change mitigation. Ultimately some first insights are generated with respect to the necessary institutional conditions for climate greening cities.

PDD6.1-04 VULNERABILITY TO TRANSBOUNDARY RIVERFLOODS: THE NETHERLANDS AND MOZAMBIQUE

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Flood management is difficult enough in national river basins controlled by a single, national authority, but becomes even more challenging when dealing with transboundary floods. Nonetheless, vulnerability and adaptation to shared floods is poorly understood. This study acknowledges the significance of shared flood events and examines the differences or similarities in vulnerability to transboundary floods: what have been the responses, measures taken, and institutions created of a developed downstream country prone to flooding (the Netherlands) and a lesser developed yet relative equally exposed country (Mozambique) - what are the lessons learned?
History shows that, in order to decrease the likelihood for conflict, existing institutions should be able to absorb and manage any change - which includes shared flood events - that occurs in the basin’s physical setting. This requires that sound, comprehensive institutions to deal with these events are in place, but also that these institutions and organizations should be flexible enough to adapt to uncertainty. Although the ecological, economical and physical interconnectedness of river basins naturally calls for collaboration between countries, flood management at root will be a national endeavor. However, since local or national flood protection measures can have negative affects both downstream and upstream, national flood protection measures should always take into account their possible impact on the other riparian states.
In the Netherlands, past investments in flood control structures proved to be sensible, but many structural and non-structural strategies have failed to be sufficiently effective. So recently, the emphasis in flood management shifted from controlling floods to living more in harmony with them. Mozambique’s flood management approach mostly still resembles the old Dutch approach of fighting against water and trying to prevent floods with massive flood-containment and landscape altering constructions. Changing climate conditions and population growth rates are likely to demand a less rigid water management strategy. Therefore, the choice for future flood management in Mozambique should be for the most flexible strategy, a more resilient pathway of living with floods. Compared to the Netherlands, very little needs to be undone in order to implement this alternative strategy, not only because there is still more faith and reliance on traditional flood risk warnings and indigenous approaches than the traditional engineering structures, already very compatible to the holistic approach of flood management, but also because very little needs to be undone in order to adhere to this alternative strategy. Hence, Mozambique can even end up leading the way and setting an example for developed countries for postmodern flood management.

PDD6.1-05 ADAPTIVE WATER LEGISLATION. WHAT CAN THE DUTCH LEARN FROM THE UNITED KINGDOM?

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Problem definition
In the Netherlands the Flood Directive has been implemented in the Water Act, the Water Decision and a Ministerial Order with regard to Provincial Risk Maps. The Dutch Water Act came into force on 22 December 2009. In the United Kingdom a Flood and Water Management Bill (FWM Bill) is prepared at the moment. It seems that English Water legislation gives more attention to the role of private actors.
To prevent flooding and to mitigate the negative effects of floods its necessary private actors (civilians, businesses) take their own responsibilities. A flood becomes a bigger disaster when people and businesses don’t know how to anticipate and don’t take preventive measures to mitigate the negative effects of flooding.
The questions we will try to answer in this paper are:
- How do Water Legislation in the Netherlands and the UK address the possible contribution of private actors (civilians and businesses) to flood prevention and mitigating the negative effects of flooding?
- What elements of the Water Act and the Flood and Water Management Bill (FWM Bill) are possibly useful in stimulating or even obliging private actors to adapt to climate change?
- What can the Dutch in this context learn from the FWM Bill?

Theoretical framework and methods
This paper applies the Adaptive Capacity Wheel (ACW) - developed in Climate Changes Spatial Planning Research (IC12) - to assess the ‘adaptive capacity’ of water legislation. In order for institutions to be able to react to climate change there must be room for a variety of perspectives, actors and solutions. Institutions must enable social actors to continuously learn and improve their institutions; institutions must also be able to allow and motivate social actors to adjust their behavior. The Adaptive Capacity Wheel (ACW) will be used to analyze legal documents, and to answer the research questions. The methods that will be used are: legal analysis and policy analysis.

Results
The paper aims to provide insight into the potential influence of legislation on the adaptive capacity related to climate change and demonstrates the use of the Adaptive Capacity Wheel in a legal context. The paper also provides some insight into the differences in implementation of the Flood Directive in the Netherlands and the United Kingdom.

PDD6.1-06 F:ACTS! - FORMS FOR: ADAPTING TO CLIMATE CHANGE THROUGH TERRITORIAL STRATEGIES!

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Climate change and its predictable effects in terms of natural hazards offer a big challenge for policy makers at regional and local level that deal with integrated territorial approaches. The big gap between the increasing body of scientific research and the concrete and necessary preparation at regional and local level is the main rationale for the Interreg IVC project F:ACTS! It brings together a partnership of 14 organisations, many of them experienced and committed to interregional learning and developing.
F:ACTS! focuses on risk prone areas that lack resilience to respond to and recover from extreme weather. Prevention of hazards often has a spatial dimension touching functions and land use structures. Examples are; creating room to prevent flooding, improving access, zoning and managing of forests to reduce risks of wild fires, creating climate buffers around vulnerable natural areas to mitigate effects of extreme weather on valuable ecosystems. Regional and local governments are not well prepared to use integrated territorial strategies for adapting to climate change.
Such strategies aim to make room for new land use functions, to rearrange ownership and use and to convert areas into these new functions.
Territorial strategies are sometimes misunderstood to be the same as spatial planning. Territorial strategies in F:ACTS! context is a pro-active implementation oriented package of interventions in which governments and private parties work together in active stakeholder approaches.
F:ACTS! is a partnership of regions across Europe. It contains a mix of organisations dealing with policy making, implementation and innovation at relevant government levels. Via review, study visits, thematic workshops and identification of good practice, the stage is set for concrete work in pilot areas. The pilots - in tune with a well-planned dissemination approach - will deliver important outcome for policy makers and practitioners and it will facilitate active transfer of approaches. F:ACTS! will deliver useful accessible documents, a handbook and recommendations for policy makers. All of this will strengthen the implementation capacity, it will lead to increased awareness among experts and policy makers to act and it will deliver more effective territorial development approaches at regional and local level. The project runs from January 2010 until December 2012. By September 2010 the FACTS project will have completed an overview of learning wishes for all five pilot areas in Bulgaria, Flanders (Belgium), Galicia (Spain), Greece, and Portugal, a workshop report on Governance and Institutional arrangements, a review study on the state of the art of climate adaptation measures in territorial strategies (relevant knowledge and good practices for each of the pilot areas).

PDD6.1-08 A NEW FRAME FOR MULTI-ACTOR ANALYSIS AND GOVERNANCE DESIGN IN DELTA MANAGEMENT

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High population densities in many of the world's deltas tend to pose significant demands on the water system. These demands will most probably increase due to autonomous developments and climate change. New technical capabilities in delta infrastructure are considered crucial in making development more sustainable. The question is: how are we going to organize these capabilities vis-à -vis the social environment? Government interventions, stakeholder participation and business initiatives are required to effectively apply the appropriate technologies for improving water management and promoting sustainable development. But who needs to do what, when and with whom? In this paper we introduce a new frame for multi-actor analysis and design of governance in delta management. This frame starts from the hypothesis that institutional arrangements significantly differ within a delta when it concerns resource use, spatial planning and water infrastructure. When this incongruence of arrangements between the different management tasks is made visible, new opportunities for improved governance in delta management can be designed with more success. We use an adapted version of the 4-tier model for institutional analysis from 2009 Nobel laureate Williamson to analyse why implementation of delta technology and planning is often frustrated by the existing institutional arrangements. Should the 'rules of the game' be changed? And if so, does the cultural setting (embedded traditions, norms, religion) make this possible or not? Are the actors able to play the new game? By combining this layer model with a 3-layer approach for physical planning that distinguishes a base-, network and occupation layer, a matrix model emerges that provides insight in the issues in which some of the actors are locked in, either by deep cultural values or by formal institutional regulation. We use the matrix model to reframe the historical perspective of institutional development in deltas. This provides knowledge that can be used to design climate adaptation measures, as for instance described in the paper of Hommes et al. for this Conference.

PDD6.1-09 DORDRECHT: MOST CRITICAL, MOST ADAPTIVE? INVOLVEMENT OF PRIVATE ACTORS.

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Problem definition
In this paper we focus on the role of private actors in the proces of climate change adaption. We focus on the Dutch city of Dordrecht, but also look at other cases. In the recently published State of the Climate 2009, the Dordrecht region is labeled as the "most critical"(p. 30) area in the Netherlands in terms of vulnerability to climate change impacts. The report states that far reaching measures will be necessary to protect the Dordrecht region from flooding. The questions we will try to answer in this paper are: to what extent do institutions in Dordrecht allow for private actor involvement in tackling vulnerability to future climatic changes, and how does this affect the adaptive capacity in the Dordrecht region?
The rationale behind this research matter lies in the raised attention for shared responsibilities in water management as part of adaptation. For years, national governments have been the main actors responsible for water management.

However, over the last decade roles of nongovernmental actors in water management are increasingly stressed. For example, according to the White Paper of the European Union (April 2009, p. 14) in any adaptation framework public-private partnerships should be encouraged with a view to "the sharing of investment, risk, reward and responsibilities between the public and private sector in the delivery of adaptation action."Additionally, the first Delta Programme Commissioner of the Netherlands, Wim Kuijken, recently stated that social participation at all levels is of paramount importance. Involving private parties in adaptation activities is seen as an important strategy to enhance the adaptive capacity of society.

Theoretical framework and methods

The paper adopts an institutional approach. Institutions are rules, procedures and customaries, both formal and informal, and both produced by governmental as well as by non-governmental actors. Institutions can enhance the adaptive capacity of society, but they can also hamper an adaptive society.
As an analytical framework, the paper applies the Adaptive Capacity Wheel (ACW), developed in Climate Changes Spatial Planning Research to assess the adaptive capacity of Dutch institutions (IC12). In order for institutions to be able to react to climate change there must be room for a variety of perspectives, actors and solutions. Institutions must enable social actors to continuously learn and improve their institutions; also institutions must be able to allow and motivate social actors to adjust their behavior.
The Adaptive Capacity Wheel (ACW) will be used to analyze popular, scientific, policy and legal documents, and to answer the research question.

Results

The paper aims to provide insight into the institutional shift towards multiple responsibilities in water management, deliver a few good examples of how private initiatives can be used to enhance the adaptive capacity of society, and demonstrate the use of the Adaptive Capacity Wheel in a local context.

PDD6.1-11 INSTITUTIONAL ANSWERS TO UNCERTAINTY: FLOOD RISK MANAGEMENT IN THE 'LOW LANDS'

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Flood management is an issue in both the Netherlands and Flanders. Recently experienced flooding, obligations stemming from the EU flood directive and expectations towards climate change have led to a surge of flood management plans being developed in the Netherlands and Flanders. The design process of such plans is characterized by a high degree of uncertainty and complexity. Different approaches to deal with this uncertainty and complexity can be observed in the Netherlands and Flanders. In this paper two cases are compared: A dike relocation plan in the Nijmegen area in the Netherlands and flood management plans in the Demer catchment in Flanders. The following questions are analyzed in this paper:
How do various actors in these projects, such as scientists, government, interest groups, citizens and businesses, deal with aspects of uncertainty and complexity? How are plans developed despite this uncertainty and complexity? How does the manner in which is dealt with uncertainty and complexity influence the public support for these plans?
The cases show that Flanders and the Netherlands deal in different ways with uncertainty and complexity caused by climate change. An example of an important difference in the dealing with uncertainty is:
In the Netherlands local interest groups and citizens are increasingly involved in the plan development. These interest groups and citizens each have their own interpretation of the problems, the uncertainties and the relevant scientific knowledge. In Flanders public participation is relatively limited and as a consequence scientific studies play a more central role in the developments of plans. These differences between Flanders and the Netherlands have consequences for the development of public support. Uncertainty and complexity play a more pronounced role in the development of public support in the Netherlands than in the development of public support in Flanders. This analysis of two region specific cases will contribute to a better understanding of the differences and congruencies in the political context of the 'Low Lands' and their consequences for the development of climate change adaptation plans.

PDD6.1-12 "CLIMATEGATE": A CONTROVERSY BETWEEN "DENIERS" AND "ALARMISTS"?

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The controversy about climate science that became known as "Climategate" erupted with the hacked e-mails from the Climate Research Unit at the University of East Anglia. How did this climate controversy build up? What was the role of traditional and new media? What is the structure of the debate as reflected in the frames used by the proponents? What are the implications for climate policy? In this paper try to get a grip on a few key dimensions of the recent climate controversy, using theories on we will use theories on framing, agenda setting and network governance.
The controversy has a long history and over the last years has taken the form of rivaling websites or blogs on the internet. They have been arguing over issues like the so-called hockey-stick graph, open access to data, the urban heat island effect, the soundness of the peer review process in climate science, the functioning of the IPCC, and the presumed hidden agendas and/or reprehensible intentions of their opponents. The hacked CRU e-mails have been used to stir up these discussions and to get attention of mainstream media. The discussion goes about crucial aspects of climate science: about historical temperatures, the role of greenhouse gasses, scientific process and the science-policy interface.
It's very difficult to take a neutral position in this controversy, as is apparent in the use of quotes in our title. 'Climategate' as a label for the controversy suggests a won battle by those who those who question climate science, since it refers back to all kinds of scandals. The polarization is also reflected in the names that the sides use for each other and themselves. 'Alarmists' call their opponents 'deniers' and accuse them of links with the oil industry. 'Deniers' call their opponents 'alarmists' and accuse them of being environmental activists. Both sides call themselves 'realists'. The label 'skeptics' is often used as a more neutral term for 'deniers', also by themselves, and is sometimes used by people calling themselves 'lukewarmers'. The latter take a rare third position in the debate, by acknowledging the role of greenhouse gasses, but emphasizing the importance of other factors influencing climate (e.g. land use change). This third position is visible on a few active blogs, but is hardly visible in the mainstream media.
The implications of this controversy are hard to asses at this point - that debate is still going on. Implications can be sought in a variety of directions, since the core issues in 'climategate' have been variously considered to be: the IPCC as a scientific body; the scientific peer review process; the clash between progressive and conservative ideologies; open access to information in science and policy; escalation in the blogosphere; the hijacking of science by interest groups on both sides; the creation of doubt for political purposes; the entire foundation of climate policy; or the nature of science itself. At the very least, the controversy will have to be addressed one way or another by climate policy makers.

PDD6.1-13 TOWARDS A COMPARATIVE ASSESSMENT FOR A CLIMATE PROOF DELTA

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Problem definition:
The present study deals with the development of a Comparative Assessment (CA) decision making framework for adaptation measures which may be used by the national and provincial level of government. A CA relates to the question which adaptation measures are most cost effective and yield most socially desired benefits. This CA may be used to compare the contribution of different options for climate proofing in rural and urban development and planning and the outcomes of the accompanying investment plans.

Theoretical framework and methods:
In a multidisciplinary study the practice of spatial planning is combined with theories on policy making and governance. Spatial development is market-based and developers search for opportunities. Administration processes and decision making on spatial planning search for reduction of uncertainties. A conceptual framework is developed for the assessment of multilevel policymaking, dealing with the multiple issues on climate change, defined by the following four themes: security, economics, nature/biodiversity and the quality of the living environment, and the analysis of risks, chances, costs and benefits. In Dutch case studies on national, regional and local level, we have checked the usefulness of the concept. A comparison is made with the Vietnamese practice and policymaking for the Mekong Delta.

Results:
CA proofs to be a good instrument to include climate proofing in the decision making process for spatial planning and water resources developments. Adaptation measures are most successful if they are an integral part of planning and implementation at all levels of administration. The CA framework provides the decision makers a structured approach with a stepwise plan for screening of options by climate proof indicators and to express this in a quantitative score. A checklist helps to determine whether there is sufficient information on the effects of climate change, whether the decision making framework is sufficient, and whether a clear picture has been made of possible solutions and risks. The developed framework has been tested at the provincial, regional and urban level. It appears to be very usable at the provincial and municipal level. The Rotterdam case study reveals a substantial number of recommendations for climate proof development of an urban flood prone area. The urban planners take into account the results of the CA to draw the urban development plan.
At the provincial level the CA appears to be helpful in making the Provincial Spatial Development Plan climate proof. The Relation Array, a part of the CA, visualizes the relation between climate tasks and the spatial choices for a variety of issues on the provincial agenda.
From the case studies it is clear that climate adaptation is rarely a goal in itself, primarily because of the limitations of funds. Most promising adaptation measures have demonstrable positive benefits at the short term time horizon, i.e. within a period of five years. Punitive measures are not very effective, adaptation is a matter of stimulation and persuasion. Show cases and best practices are excellent ways to demonstrate perspectives to act.

PDD6.1-14 ASSESSING ADAPTIVE CAPACITY OF INSTITUTIONS TO CLIMATE CHANGE A COMPARATIVE CASE STUDY OF THE DUTCH WADDEN SEA AND THE VENICE LAGOON

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Climate change is expected to have a broad range of impacts on several sectors of society. The effect of sea level rise on human safety is often high on the political agenda, but climate change will also influence the development of natural habitats, maintenance of cultural heritage, economic possibilities of harbours and so on. An important question that arises is if human society will be able to cope with these challenges. In this study we compare the adaptive capacity of the human institutions in two complex systems, the Dutch Wadden Sea and the Venice Lagoon. A new tool called the Adaptive Capacity Wheel is used to diagnose where the strengths and weaknesses are in the institutional systems in these two areas.

The Adaptive Capacity Wheel identifies six dimensions that are relevant for the adaptive capacity of a society, according to the literatures on climate adaptation and governance. They are variety, learning capacity, room for autonomous change, leadership, availability of resources and fair governance. These dimensions are developed further into 22 criteria. The method can help social actors to assess if their institutions stimulate the adaptive capacity of a society to respond to climate change.

DD6.2-02 FRAMING RISK PERCEPTIONS IN TRANSITIONS TO DROUGHT AND FLOOD RESILIENT CITIES

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The growing awareness of vulnerability to extreme events like droughts and floods is rousing societies to reflect on how urban water systems in Australia, the Netherlands and many other nations are being managed. In this respect, reorganization of traditional infrastructure and management of urban water systems is considered to offer a more resilient alternative. For example, disconnection of stormwater sewers, flood-proofing of buildings and local water harvesting and reuse are decentralized alternatives to combined sewage systems, regional flood defense systems and bulk drinking water supply systems, respectively. However, there is still a long way to go for the widespread implementation of such technologies in policy and practice. In this transition towards more decentralized urban water management, stakeholder risk perceptions play a crucial role because they form the basis of decisions to invest in innovative urban water systems. However, so far there is limited scientific knowledge about these stakeholder risk perceptions and the role that they play in the innovation of urban water management, in contrast to other disciplines such as the oil and mining industry and nuclear energy. In light of these limitations, the aim of this paper is to provide a conceptual framework that explains stakeholder risk perceptions and their roles and consequences for transitioning towards more drought and flood resilient urban water management.
A literature review has revealed different meanings of risk in different disciplines, such as engineering, ecology, finance and others. This is fundamental to different perceptions of risk and different methods of risk management

in the various disciplines. Also, risk perceptions depend on situational variables, such as the expected outcome or previous outcome history. They can be different for different people under identical conditions. Many scholars make a distinction between expert judgment and laypeople's judgment of risk. Expert assessment of risk is performed in the absence of completely objective knowledge, while public perception of risk is developed with subjectivity and intuition. This difference is critical at the science-policy interface, where science and policy-making interact and influence each other. Because of such interaction and for other reasons, individuals and organizations can develop in their knowledge of risks and in assessing and managing them. For example, Sharp et al (2002) describe that organizations can progress from 'learner organizations' with ad hoc approaches to risk to 'adaptive organizations' that employ adaptive, responsive and proactive techniques.
Based on the literature review, a conceptual framework will be presented on which stakeholder risk perceptions of innovations in urban water management can be mapped. This is tested in three major cities in Australia, where decentralized water services are being considered to increase resilience to drought. Some preliminary results of this research will be presented in this paper. The next step will be to test the conceptual framework also in the Netherlands, in order to compare risk perception under drought and flood prone conditions.

DD6.2-03 FRAMEWORK FOR LEGITIMATE, EFFECTIVE AND RESILIENT GOVERNANCE ARRANGEMENTS

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Adaptation to climate change raises important governance issues. This paper argues that it does not suffice to apply existing insights from governance literature to the issue of climate adaptation in an instrumental way only. The specific complexities of the governance of adaptation call for development of new advanced governance knowledge. The question is what kind of governance arrangements can be developed and how these arrangements can be evaluated? This paper presents a theoretical framework to study the governance of adaption. It comprises of an analysis of the specific complexities, a normative framework and key concepts for assessing and developing governance arrangements.
Three complexities will be elaborated:
First, important changes in local, national and European governance systems are unfolding. Governance today includes a variety of actors at different scale levels. This multi-actor, multi-sector and multi-level governance world forms the inescapable context for climate adaptation.
Second, climate adaptation lacks a well-structured policy domain and practice. Adaptation is an emerging policy field with, at least for the time being, only weakly-defined ambitions, responsibilities, procedures, routines and solutions. As a result, a series of basic dilemmas have to be (re)addressed in developing the governance of adaptation.
Third, decision-making in relation to climate change is knowledge-intensive and important uncertainties about the nature and scale of risks and the effectiveness of solutions will persist. In addition, the many actors involved bring with them a variety of perceptions leading to fundamental controversies. In spite of these inherent uncertainties, decisions about adaptation strategies need to be taken or prepared now.
Normative principles for adaptation are needed for assessing and developing governance arrangements. Good governance of adaptation should be (a) legitimate, i.e. ensuring transparency, accountability, fairness and equity (b) effective, i.e. address the adaptation task decisively and efficiently through the right mix of norms, instruments, strategies and processes; and (c) resilient, i.e. both enabling autonomous adaptation and building long term adaptive capacity.
We outline three key concepts that can guide the (re)search for effective, legitimate and resilient governance arrangements for climate adaptation:
1. Organizing connectivity refers to bringing actors, issues, sectors and scale levels together to realize creative climate adaptation options. This means taking the challenge of tailoring responses to the problems at hand, within the fragmented governance structures. This requires knowledge of designing process trajectories, organizing collaborations and partnerships, linking with related policy problems, multi-level governance and developing entrepreneurial leadership strategies.
2. (Re)allocating responsibilities and risks refers to changing the existing governance structures by changing the allocation of responsibilities and risks between a variety of actors, in order to enable climate adaptation. It requires knowledge about clarifying responsibilities, allocating costs and benefits or creating new systems of economic incentives.
3. Dealing with controversies concerns coping with the inherent uncertainties and varied knowledge frames, especially concerning the spatial and temporal scales at which to address climate adaptation. The challenge is to act without ignoring this variety and without paralyzing decision-making processes. It requires knowledge of methods of dialogue, learning, negotiation and co-production of knowledge.

DD6.2-04 LINKING WATER MANAGEMENT AND URBAN RENEWAL,THE CASE STUDY OF ROTTERDAM

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Introduction
The focus of this article is the integration of water retention infrastructures, such as stormwater ponds, canals, infiltration facilities and green roofs, into urban development and urban redevelopment projects. The objective of this article is to identify factors that contribute to including urban water management innovations in urban planning.
There are different perspectives possible with regard to urban water infrastructure transformations to adapt to climate change. One perspective promotes improving the current urban water system by developing technological innovations that improve the functioning of the existing system. Others argue that alternatives should be developed that completely replace the current water management and sanitation systems because these systems are inherently unsustainable. The third perspective argues that the urban water infrastructure should gradually transform by integrating water infrastructure investments with urban revitalisation programs. This is called the transformative perspective in this article. This perspective requires a form of integrated urban water management. Integrated water management encompasses the whole urban water cycle, including groundwater and surface water, transportation and treatment of water, wastewater and storm water.
Multilevel analyses of historic urban water management transitions point to the importance of the niche-regime interaction in transition processes, but they provide limited insight on how this may change current and future water infrastructure. The aim of this study was to study how niche developments may influence the urban water

management regime. More specifically the aim was to find out how niche developments can be taken up into mainstream urban water management and urban planning. This research focused on the city of Rotterdam.

Methodology
In this case study, a multi-level analysis was used to reconstruct the urban water management cascade - that is, the turns in thinking made by the Rotterdam water professionals leading to this new approach over the past 15 years. In particular the role of the climate adaptation envisioning process Rotterdam Water City 2035 in this cascade was investigated. To this end, local water policy documents, urban planning documents, internet resources and project plans were analyzed. In addition, the authors participated in two field trips, an interdisciplinary design workshop and carried out 16 oral interviews with key-individuals, affiliated with water boards, social housing corporations, consultancy firms or several departments of the municipality at medior or senior level positions (executives, project leaders, or senior advisors).

Results
The article first presents the regime developments in urban water management from 1989 to present. Secondly, the article describes how a small policy niche (Rotterdam Watercity 2035) emerged that promoted to transform water infrastructure by utilizing the windows of opportunity in urban planning programs. Thirdly, this article elaborates how this policy niche successfully influenced the water management and urban planning regime. In the discussion, this article presents general key factors that contributed to the inclusion of urban water management innovations in urban planning.

DD6.2-05 ARE DUTCH INSTITUTIONS BE ABLE TO ADAPT TO CLIMATE CHANGE?

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This paper addresses the question: Do institutions in the Netherlands enhance the capacity of society to adapt to climate change? Institutions are defined as: “systems of rules, decision- making procedures, and programs that give rise to social practices, assign roles to the participants in these practices, and guide interactions among the occupants of the relevant roles”. The rules and roles can be formal and informal, visible and latent, and conscious and unconscious. Institutions provide a source of stability to interactions of actors, without which every form of collective behaviour would be impossible. Many of the current governance institutions are the product of times in which the climate issue was hardly of any importance.
Climate change calls for institutions that promote the adaptive capacity of society and allow society to modify its institutions at a rate commensurate with the rapid rate of environmental change. Climate change potentially brings continuous and unpredictable changes to local weather patterns, water supplies and sea levels. Institutions, traditionally conservative and reactive, will now have to be designed in a way that they support social actors to proactively respond through planned processes and deliberate steps but also through cherishing and encouraging spontaneous and autonomous change that is rapid enough to deal with the impacts, as well as allow for institutional redesign.
Drawing on an extensive literature review, we have developed an assessment tool, the ‘adaptive capacity wheel’, which distinguishes between three dimensions integral to adaptive capacity: variety, learning capacity, and room for autonomous change, and three factor conducive to adaptive capacity: leadership, resources and fair governance (see figure 1).

Subsequently, we have applied this tool to both formal documents and to practices of climate adaptation in the fields of spatial planning, water management and nature conservation as they are unfolding in the Netherlands now. It follows from the assessment that nature institutions are the less adaptive. Using the theoretical framework, five general institutional weaknesses have been identified which can cause tensions on the long term: 1) the lack of openness of the political system towards learning and variety; 2) the strong one-sided reliance on scientific experts; 3) the tension between top down policy development and bottom-up implementation; 4) the institutionalized mistrust in the problem solving capacity of civil society and 5) the wickedness of reserving funding for the long term.

For illustrations see website: www.climatedeltaconference.org/results

DD6.2-06 CLIMATE ADAPTATION NAVIGATOR: DESIGN AND ANALYSIS OF ADAPTATION STRATEGIES

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Awareness of climate change has increased and, as a result, mitigation and adaptation strategies are being developed and implemented. Climate adaptation takes place in a multi-actor setting, i.e. a complex social interaction process and should be studied as such. In this paper, we present a ‘Climate Adaptation Navigator’ (CAN). This navigator assists in analyzing and designing climate adaptation strategies. The CAN is based on a 3x4-matrix, which is a combination of two layer approaches: a) 3-layer (base, networks and occupation) approach for spatial development; and b) 4-layer (embeddedness, formal institutional, governance, actors and games) approach for institutional analysis, by Nobel prize winner (2009) Williamson. The CAN describes the institutional structure for the base layer, the networks layer and the occupation layer of the physical planning approach. Therefore, it has the potential to bridge the gap between physical planning and the societal and institutional environment. The essence of the layer approaches, and thus the navigator, is the difference in temporal dynamics and public-private involvement. We interpret embeddedness, which is the least dynamic layer from Williamson’s model, as the deepest, fundamental motive to act. These motives or ‘drivers’ can be individual as well as collective. The physical planning layers enable or constrain activities on another layer. Safeguarding the large adaptive capacities of natural systems (the base layer) is the main responsibility of the government. The role and influence of the government on the networks and occupation layer is more restricted and the influences of private parties and citizen’s interests are more dominant. The navigator can be instrumental in the design of strategies for adaptation to climate change. It shows the possible ‘routes’ through the layer-matrix, based on the enabling and constraining conditions from the physical layers and the steering influence from the (collective and individual) drivers. In this paper, we will apply the navigator to the case study of climate robust fresh water supply in the Dutch southwestern Delta. Using the navigator we will show the possible implementation routes for the ideas from the National Water Plan. The Climate Adaptation Navigator is applicable to other deltas/countries as well. It provides a comprehensive way to describe, compare and analyze the differences in governance structure for the delta considered. Furthermore, it is a tool to design adaptation strategies.

DD6.2-07 THE POLICY CONTEXT OF ADAPTATION DECISION-MAKING IN THE NETHERLANDS DELTA REGION

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Global average warming is likely to reach 2°C, if not more, by the end of the 21st century. Societies will have to adapt to changes in local and regional climate conditions. Decisions taken in the next 20 years will be important not only because some climate impacts are already felt, but because tackling slow-onset impacts need the appropriate decisions taken now and in the near future. Yet, there is a lack of tools, methods, and experience to deal with the risk and uncertainty evoked by climate change. Furthermore, there is no comprehensive review of who decides on adaptation options, using what methods and tools, and on what information basis.
As part of the research undertaken for the European research project MEDIATION on adaptation to climate change, we examine the Netherlands, particularly the Delta Program, as a case study for adaptation policy-making. Adaptation problems are seen as action situations in which climate change is a key influencing factor. Two distinct but related questions are addressed: First, what type of adaptation problems do decision-makers perceive? What policy issues emerge and who identifies what types of issues, policies and decisions are to be addressed in the next 20 years? Second, what tools and support is required in adaptation decision-making? Answering these questions also entails exploring the context within which decisions are made: How is adaptation policy being made - is it mainstreamed, or still separate from other policy processes? What institutions shape policy in the delta region? Who sets the agenda and frames the key uncertainties? How are institutions and individuals linked?
The overall objective of the Delta Program is to warrant water safety in the Netherlands in the light of climate change and capitalise on opportunities that water offers. This overall objective is explored in a series of regional and topical subprograms. Most subprograms focus on a particular long-term strategic decision that is considered relevant for warranting long-term water safety. The subprograms operate relatively independent and have their own project organisation. All subprograms are fed with the same climate scenarios from the national program secretariat. To streamline decision-making, three base values (solidarity, sustainability, flexibility) and three starting points (integral, coherent, transparent) have been defined for the Delta Program. The nesting of the subprograms and their relative independence make the Delta Program a convenient case to study the relationship between project team actors, policy-science interaction and the framing of the uncertainties, policy objectives and options.
The study will build on a series of actor interviews and a review of policy documents. In particular the implementation plans of the different subprograms will be analysed that are currently being prepared. The results of this study will provide a better understanding of what is driving adaptation decisions, who is taking them, and what is needed to support adaptation outcomes. By identifying who takes decisions and what issues motivate these decision makers, steps are made to delivering truly useful analysis and tools for adaptation decision support.

DD6.2-08 RESILIENT URBAN GOVERNANCE SYSTEMS

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For every public authority climate adaptation is a major challenge. However, due to the many competing spatial claims which have to be accommodated, for cities climate adaptation is an exceptional challenge. In this paper we argue that cities deal rather differently with the way they adapt to climate change. This relates to their resilience. A resilient city is able to keep its identity and at the same time to adapt to significant changes. There are several factors which contribute to enhancing the resilience of urban governance systems. An important factor concerns its self-organizing capacity. We believe that the resilience of urban governance systems exists in finding dynamic balance between conservative and dissipative self-organizing behavior. We use complexity theory, for example the concept of ‘bounded instability’ (Merry, 1999) and self-organization (Heylighen, 2002) to elaborate this line of thought.
Urban systems which show more conservative self-organization frame and resolve climate adaptation quite differently from urban systems which are more dissipative self-organizing. Conservative urban systems frame climate change in terms of a threat and a complication in relation to their own agenda. Within these systems adaptation policies are organized in a different way compared to dissipative urban systems. Dissipative systems conversely frame climate adaptation as an opportunity to reflect upon their possible futures and the way they can realize existing and new agendas. From the way climate change is perceived, we thus can say something about the extent to which an urban system is resilient.
Based upon a cross case comparison of different cities dealing with the challenge to realize more water retention capacity, we analyze the way conservative and dissipative urban systems frame their adaptation challenge, what that mean for their concrete adaptation strategies and what constitutes urban resilience.

PDD6.2-01 POLICY PERSPECTIVES ON BARRIERS AND OPPORTUNITIES TO CLIMATE ADAPTATION

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Background
Contemporary research on the impacts of climate change by several frontrunner countries has pushed the policy discussions on the need for adaptation to the background. The current discussions focus on the question how the amorphous concept of climate adaptation can be integrated and mainstreamed in climate sensitive policy domains. An abundance of innovative concepts, methods, techniques, options and measures are suggested and discussed to manage the unavoidable impacts of climate change. These discussions take place in a new policy arena on adaptation where actors from different sectors, levels and organisations meet - each with their own objectives, strategies and motives to participate.
Climate adaptation as well as policy administration literature shows that there are numerous potential barriers and opportunities to efficient and effective climate change adaptation, which are key-factors in the development and implementation of adaptation strategies. These include uncertainty, fragmentation, institutional void, short-termism, and motives and willingness to act (Biesbroek et al., 2009). There is little understanding how these institutional factors influence the decision making process on climate change adaptation. Some of these factors are present in any

complex policy issue while others stem from the inherent characteristics of climate change adaptation. In addition, the factors are not experienced similarly by actors - what one perceives to be a barrier could be an opportunity for others. Questions that have emerged include; are some barriers or opportunities perceived to be more present than others? Is there a difference in terms of experienced barriers and opportunities between policy development and implementation? Are there differences between the barriers and opportunities in different countries? Is there a correlation between the characteristics of actors and the barriers and opportunities they perceive? And to what extent do the barriers and opportunities found in the literature match those found in policy practices?

Method

In order to answer these questions a comparative internet based survey (n=>1000) is implemented where policy makers from different sectors, levels and functions were asked what they perceived to be barriers and opportunities for climate adaptation. An earlier study that addresses barriers in climate change adaptation has been used to construct the survey (Biesbroek, et al., 2009). In addition, several semi-structured elite interviews with policy makers in the Netherlands and the UK were conducted (n=13). These cognitive interviews were used to supplement the barriers and opportunities found in literature and to shape the questions in ways that will enable respondents to understand what is wanted and ensuring they are able to respond to them. The experiences of policy makers from the Netherlands and UK – as frontrunners in climate adaptation – are compared.

Results

The paper contributes to emerging discussions on barriers to climate change adaptation. The paper discusses the main barriers and opportunities to climate adaptation and will plea for a critical examination of their role in the policy processes.

Reference

Biesbroek, G. R., et al. (2009). Institutional governance barriers for the development and implementation of climate adaptation strategies. Paper for the International Human Development Programme (IHDP) conference, 2-4 December 2009

PDD6.2-02 INSTITUTIONAL ANALYSIS OF LOCAL ADAPTIVE CAPACITY IN DUTCH STORMWATER MANAGEMENT

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In 2003, the Dutch water authorities agreed upon new norms for stormwater management in response to flooding incidents, urbanization and climate change. The local water authorities are responsible for implementation of these plans. Many efforts concern adaptations of the technical system and operations. This includes the creation of water retainment areas, the building of water storage facilities and increasing drainage capacity by enlarging pumping facilities. The adaptive capacity of the technical system turns out to be large; even in highly urbanized areas the water authorities do find many alternative ways to enlarge the storage and drainage capacity of the stormwater systems. On the other hand, costs are much larger than anticipated and the rate of implementation falls behind schedule. Apparently, the adaptive capacity of the stormwater management system is not only bounded by technical but by institutional aspects as well. Is it possible to indicate the institutions that either enable or constrain the implementation of adaptations? What institutions contribute to the adaptive capacity of stormwater management systems? Answers to these questions could be helpful in understanding the adaptive capacity of physical infrastructures in general. The stormwater management system of the highly urbanized district of Delfland, located between The Hague and Rotterdam, is a good case for studying adaptation. Flooding occurred in 1998 and 1999 when stormwater management failed to store and drain a once in 100-300 year precipitation event. A plan for adaptation of the stormwater management system was drawn, making use of a thorough technical systems analysis. Implementation started in 2001 and to be completed in 2015. In this paper, I present an institutional analysis of the stormwater management system before 2001 and in the period up to 2009. The 4-layer institutional framework of Williamson is applied to each of the four tasks assigned to Dutch water authorities (operations, design, financing and building of water works). An overview is given of all institutions involved using a 4x4 matrix.The analysis shows that many formal and informal institutions were changed or added in order to facilitate the implementation of the adaptation plan. Changes that enabled adaptation included the preferences held by the electorate with regard to cost-allocation, zoning of land and water functions, and system design principles. Institutions belonging to one task cross-influenced the effectiveness of institutions related to other tasks. Constraints posed by institutions were lifted as needed, having positive effects on coping ability and adaptability of system operations.The formal institutional environment enabled adaptation but the revision of the Water Board Act in 2010 has changed an enabling institution into a constraint of adaptive capacity. Another institution related to financing, namely the ability to take out loans, first enabled adaptation and then turned into a constraint on adaptive capacity as the loan carrying capacity reached its limit.The results of this institutional analysis underpin the need for continuing assessment during adaptation of infrastructures rather than focusing on ex-ante assessment. Such assessments must address all aspects of adaptive capacity: operations, design, financing and building of infrastructure.

PDD6.2-03 TABOOS FOR CLIMATE ADAPTATION IN THE NETHERLANDS

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The climate is changing. In the Netherlands in winter it will rain more often and it will pour more. In summer however, it will rain less, but there will be more showers. River discharge will decrease in summer and increase in winter. But above all it will be warmer. Will climate change be an accident waiting to happen, or will our small country be a much more pleasant country to life in?

Climate change brings chances. The Netherlands will be much nicer! People will go out, terraces and beaches will be crowded. New friendships will be made and old ones will be revived. The shore, lakes, ponds and canals will be an important asset as tourist attraction. A good water quality and internationally known national parks contribute to an attractive settling climate and an excellent standard of life. Fertile land, river water of good quality and more hours of sunshine cause a healthy position in the farmers market.

The current strategies for climate adaptation arise from problem thinking en are therefore mostly defensive. Chances are under exposed. Chances don't built policies. The new Delta Commissioner focuses on the Maeslantkering instead of a more attractive Markermeer. The Dutch still fight water, while we should move along with it by using natural processes and making our designs so they have low impact and little maintenance.

Do we have the courage to take the chances climate change offers? Or will our own polder model hold us back? Do we dare to make risky investments or will we take measures of which we know for certain that they are 'no regret'.

There is a relation between the way we are used to solve problems and the type of measures we develop. Where are the Netherlands in international perspective? What can we learn from the entrepreneurial skills of the Asian and Anglo-Saxon model without losing our own values and strengths?

There are certain taboos that exist amongst the policy makers in the Netherlands. Taboos that hold us back in fully taking advantage of the chances climate change brings. In a scenario session with a group of climate experts we will sketch

what will happen when climate adaptation will be carried out along three scenario's: the Asian, the Anglo-Saxon and the European-continental model. In what way can the scenario be followed and which taboos will be dissolved?
In a Round Table Conference with leading (inter)national experts from the business sector, science and government we will further elaborate on the chances and the way to break with taboos in the Netherlands. Result of this conference will be a book with a vision on the development of our country and ways to reach this vision. The intention is to present the book for the first time during the international conference 'Deltas in times of climate change'!

PDD6.2-05 TOWARDS A SUPPORTED AND CLIMATE PROOF PLAN FOR THE IJSSELDELTA

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Problem definition
Climate change and spatial challenges in the IJsseldelta
The IJsseldelta is a low-lying area that is threatened by floods from both the river IJssel (a branch of the river Rhine) and from the Lake IJsselmeer. Although the delta and its major cities Zwolle and Kampen are protected from flooding by levees, the safety standards cannot be guaranteed in the near future because of the effects of climate change. Predictions of climate models indicate that the extreme high water levels of the river IJssel will rise with up to 40 cm. in 2015 and up to 1 m. in the long term (2050-2100).
Meanwhile several major spatial developments are planned in the IJsseldelta by various stakeholders, including the construction of some 4000 houses, a new railway line (the Hanzelijn) and the reconstruction of two highways (N50 and N23). Furthermore, a river bypass is foreseen as measures to increase safety against flooding along the river Rhine system. All these potentially conflicting spatial developments are coordinated in Project IJsseldelta.
Sustainable development planning
In 2005 the Province of Overijssel initiated the process of developing an integrated and sustainable spatial plan for the IJsseldelta area, with a strong focus on climate adaptation. Although the Province has a key role in the project as a director of the planning process, it highly depends upon others. Plan development occurred in close cooperation with other actors such as the national government, municipalities, neighbour provinces, water boards and many nongovernmental organizations in the region.
THE MAIN QUESTION WE WOULD LIKE TO ADDRESS IN THIS PAPER IS WHAT KIND OF GOVERNANCE APPROACH COULD GUIDE THE PLAN DEVELOPMENT OF A SUPPORTED AND CLIMATE PROOF PLAN AND WAS PROJECT IJSSELDELTA SUCCESFUL IN DEVELOPING SUCH A PLAN?

Theoretical framework and methods
To answer this question, first a strategic plan development approach will be described for integrated area development projects that involve many actors and include challenges in multi-sectors, at multi-levels and at multi-scales, such as climate adaptation. This strategic plan development approach is based on literature study and an in-depth case study of project IJsseldelta during the period March 2007 and March 2008.
Subsequently, it will be analysed whether the IJsseldelta plan sufficiently anticipates on climate change on the one hand and is supported by the actors involved on the other hand. This second part will be answered by an analysis (desk research) of the research documents and reports that have been drawn during the plan development of IJsseldelta, covering a period between 2004 and 2010. Besides, interviews were held with the most important actors to identify the success of the planning process.

Results
One of the key conclusions of the research is that the current plan for the IJsseldelta is both sufficiently climate proof and supported by its actors.

PDD6.2-06 THE ROLE OF PILOT PROJECTS IN INNOVATION PROCESSES IN DELTAS

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Innovation is conditional for adaptation of societies to climate change. Due to uncertain consequences of climate change for social-ecological systems in combination with increasing social and economic pressure on deltas, societies will face new challenges. Contemporary methods and solutions are no longer satisfactory for these challenges. Consequently, new or adapted approaches and supporting technologies need to be developed. Next to challenges, changing environments also create new opportunities for the development of innovations. A major step in the process from idea to implementation is to understand the functioning of the innovation in practice. Computer models and laboratory settings cannot give answers to specific practical and societal questions implications of an innovation. Full implementation of the innovation is often no option for users, because risks and uncertainties are regarded too high. An intermediate step is to apply the innovations first in pilot projects to learn more about the functioning of the innovation in practice. However, a common complaint is that pilot projects assort very little effectiveness in terms of feedback of the knowledge into policy-making and management. Consequently, few pilots result in full implementation.
In this paper, we explore the instrument pilot projects more in-depth to learn more about its nature and functioning in innovation processes. Four pilot projects (Ecobeach, C-Energy, INSIDE and HoogWater Vrije Weg - high water free road) that aim to contribute to flood protection, energy from water and evacuation strategies in the Netherlands form the basis of the research. Data is collected through semi-open interviews with diverse project participants on their experience with and insights in the project. This is followed by a questionnaire with propositions on their motivations to participate and their perception on the use of the pilot as a whole. The research questions studied are:
- Which motivations different actors have to initiate or participate in a pilot?
- Which contributions the pilot projects make to the innovation process?
- Which factors contribute to the enhancement of the role of pilot projects in innovation processes?
The paper provides examples of innovation possibilities in deltas, and contributes to the innovation debate and particularly to the governance of changing delta environments by creating insights in the complexity of pilot projects in which multiple types of actors with diverse interests and interrelationships participate. The studied projects show how pilot projects can be used as a research, management or political-entrepreneurial instrument, how they make a contribution to the innovation process and which barriers exist for to do so. The paper finishes with recommendations for pilot project initiators on how to strengthen the function of the pilot project in their innovation process.

PDD6.2-07 CAN LOCAL GOVERNMENTS IN ASIA PLAY A ROLE IN CLIMATE CHANGE ADAPTATION?

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Climate Change adaptation can no longer be ignored as a political priority. Global level discussions are on-going on how to reduce Green House Gas emission and on national level many governments in Asia have started to discuss the different scenarios for increased flooding and extreme weather events that will occur in the next 50-100 years. Meanwhile Local Governments (LGs) and their inhabitants are already experiencing more and more extreme weather events, increased flooding and rising sea levels, affecting the lives of many people on a daily basis, especially in the low lying and vulnerable areas. It is indeed on the local level that authorities are trying to cope with the implications of climate change in a pragmatic way.

Each geographic locality will face its own particular range of risks and vulnerabilities and hence there is the need to develop an area specific understanding of the impacts of climate change. These are needed now for all localities so that they progressively build into their infrastructure, and wider development plans, resilience to climate change impacts. Analysis starts at the local level. It is the Local Governments that will need to play a key role in analyzing the threats and identifying stakeholders capable of building resilience. LGs should translate central level policy into local action and act as coordinators and facilitators and bring together the differing agendas and actors.

Informed differential analysis of local threats and vulnerabilities, local resources and capacities, and local trends, will prepare LGs to make strategic climate proofing investments. While Climate Change will necessitate changes in planning and policy to prepare for the future, it will also require innovative investments in climate resilient infrastructure to protect existing areas and continue vital economic flows.

Climate Change adaptation is best conducted by testing and evaluating approaches at the local level to understand how they fit into the local dynamics of planning and governance. LG's are the facilitators and coordinators between those on the ground, affected by the problem, those who possess the knowledge and those who take the decisions and provide resources. Climate change requires a multi sectoral-integrated approach involving all levels of government, the private and the public sector.

Immediate action that local authorities, the private sector and local communities /groups can take are, amongst others:

- Enable local authorities to think about how climate change will exacerbate current vulnerabilities and create new opportunities and challenges.
- Engage vulnerable populations/community organizations as stakeholders in urban climate resilience planning.
- Build capacity to analyze the direct and indirect impacts of climate change.
- Develop locally appropriate resilience strategies.

LGs will thus need to take a pro active and businesslike approach in evaluating their climate change adaptation and mitigation strategies and create new and innovative partnerships to better adapt to CC and at the same time reduce emission. Considering the present situation and looking at the potential problems ahead, it is time to consider the direct and indirect impacts of climate change as an opportunity to start planning in a different way.

PDD6.2-08 CLIMATE PROOFING AN INTENSIVELY USED POLDER: SEASONAL STORAGE IN THE WESTFLANK

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Polder Haarlemmermeer

The polder Haarlemmermeer is one of the deepest reclaimed lands in the Netherlands. As is common in the Randstad, the polder is intensively used. Its land use is dominated by the airport Schiphol that, besides the space needed for buildings, airstrips and parking space, also indirectly claims land due to required safety contours. Further, some 150.000 people live in the various villages of the Haarlemmermeer. The government currently works on a plan for the Westflank of the Haarlemmermeer to develop 10.000 new homes in the area, including space for water, environment and recreation.

Climate issues in the polder Haarlemmermeer

For good water management, an enormous supply of fresh water from the river Hollandse IJssel is needed; up to 100 million m3/year in an extreme dry year (normal 40-60 million m3/year). In dry periods, which will occur more often due to climate changes, there is not enough water of good quality at the intake in Gouda to provide the full water demand. This problem would not be solved if the Westflank would no longer demand fresh river water, but it is obvious that there is a strong need to develop areas that are more robust and depend less on the supply of fresh water. The spatial developments in the Westflank provide the opportunity to combine the planned interventions with the development of a more-or-less self-providing water system; the combined construction of new residential and recreational green areas and the development of surface water offers attracting views and additional recreation possibilities, but also opportunities to optimise investments.

'Seasonal storage'

The joint aim of the involved actors -municipality, province, water board and national government- in the project Westflank is to develop a climate proof area. This will be realised through developing a so-called 'seasonal storage' that retains fresh rain water in the winter in order to use it during the dry summer. Since the water level in the new lake and in the ditches will be flexible, the area could usually provide its own water demand. Only in very dry years a supplement of water from outside the polder will be needed. Space is scarce in the Westflank and since the seasonal storage claims hundreds of acres of space to provide for millions of cubic metres fresh water, the same area should also be used for other spatial functions like housing and recreation.

This paper will describe how an intensively used polder, as is the Westflank of the Haarlemmermeer, will be made climate proof by developing seasonal storage, covering both the technical system and the governance challenges. Insight will be given in the choices that still need to be made in the plan development of the 'seasonal storage' and how the actors could take a next step. A shift in governance should be made from the current 'thinking in certainties' towards 'dealing with uncertainties', while at the same time the actors involved should operate with a more integrated approach in order to be able to deal with such complex development processes.

PDD6.2-10 TOWARDS A RISK BASED SPATIAL PLANNING POLICY FOR FLOOD PRONE AREAS

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Problem definition
Currently, there is a debate in the Netherlands regarding flood risk management. Fuelled by the discussion on the effects of climate change and the recent floods in France, it became evident that there will always be a residual risk for floods. This applies to areas outside the dykes as well as inside the protected areas. The main question is to what extent the citizens are able to bear this risk? When are restrictions and conditions needed? What should be their nature and content? In the Netherlands existing laws and regulations on flood risk management are connected to the physical water defense system. Therefore the juridical system for maintaining the safety standards is related to the organizations that are responsible for the construction and maintenance of the dykes.

Theoretical framework and methods
Recently a shift in attitude towards flooding and the residual risk of flooding emerged. In a flood risk approach the following general assumption is made:
(Flood) risk = Chance on flood times the impact on the area and/or activities.
In order to maintain the same risk level one may reduce the change on floods or lower the impact by means of spatial planning (risk zoning), flood proof building, awareness raising of inhabitants, evacuation route planning etc. For the three low lying Provinces in the Netherlands this principle is used to set and define the safety standards (in 5 classes) for regional water defense systems or polder dykes. Besides the chance on flood the classes also take the (possible) flood damage in the polder into account. A similar approach is necessary for areas in the (tidal) flood plains outside the protection of the main dykes in South Holland. For those areas no regulations for flood risk exist. Land use in those areas is 'at own risk'. Policy makers can only regulate land use planning by defining special conditions.

Results
The Province of South Holland took the initiative to develop policy on spatial planning in tidal flood plain areas. They developed a qualitative assessment method for local authorities to estimate the possible risk and impact of flooding. The method is based on the vulnerability of land use against flooding. Vulnerability of land use functions is related to a set of main criteria:
- Casualties
- Damage to goods and business
- Disruption of the society

This approach is also used as guiding principle for planning of a new built up area for 4500 houses in the municipality of Rijswijk near The Hague. In stead of reinforcing the polder dykes the local authorities (Municipality of Rijswijk and the Waterboard of Delfland) are exploiting alternative options for flood proof building. The spatial plan ('bestemmingsplan') which has a juridical status on responsibilities and liabilities regarding safety is also prepared in this manner.

PDD6.2-11 ADAPTIVE WATER GOVERNANCE: CERTAINTY OR FLEXIBILITY? THAT'S THE QUESTION

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Not only the coastal delta region is faced with climate change, also the water systems on the fringe of high and lowlands are faced with its wickedness.
This paper states that the linear textbook approach of policy implementation contributes partly to the hampering of implementation of water and adaptation policies. The complex properties of the system mismatch with the rational prescribed properties of the implementation process. In the early stages of the process there is a lot of fixing decisions that can result in resistance in later stages. In complex integrated water projects, project managers are faced with the dilemma of fixing agreements or keeping it open and flexible for other opportunities to emerge. Unforeseen properties emerge from the interactions between the stakeholders, the process and the context. Complex adaptive systems have unpredictable emergent properties and to keep an open process is dealing with emergence.
The paper presents the case of the integrated water project "Vaassense beken"(EN: Vaassen water channels). Here flexibility is combined with certainty in an implementation strategy based on the concept of Interactive Implementation. The village Vaassen is situated on the eastern slope of the Hoge Veluwe massif just western of the IJssel valley. It is characterized by a manmade water system created in the 17th century to distribute water from the massif to the mills downstream for power and production (copper smithies, paper mills, wash houses). In Dutch perspective it is a "highland"area and in wet periods it is confronted with problems in water storage and drainage. The project combines water quantity goals with quality, ecological and cultural historic preservation goals. The paper tells how certainty was created by early agreement on certain boundary issues and flexibility by keeping others open for discussion. The case shows that it is possible to combine certainty with flexibility. This approach made it possible for the water authority to start construction within a year after the first negotiations on starting the project. It even included the construction of an unplanned fish migration cascade. A pace never met in other projects of water authority Veluwe.
A lot of (interactive) plans have been and will be created to make the Dutch landscape climate change proof. These are combined with different policies in even more innovative plans at the regional scale of the water authorities. It is this level where most plans need to be implemented. However, a lot of innovative interactive plans are not implemented. It is a challenge for both the community of practice and science to think about implementation (instead of creating plans). New strategies obviously come with new complexities. An increase in complexity already characterizes current water management in the Netherlands, because more processes influence the implementation of integrated water projects. It is important to bundle the capacities of the stakeholders.
Keeping an open process creates flexibility, but also extra uncertainties. Decision making creates feelings of certainty. It gives direction and orientation to the project. The case shows that it is possible to combine certainty and flexibility.

DD6.3-01 CLIMATE-INDUCED RISKS IN COASTAL AREAS: GOVERNING PUBLIC AND PRIVATE ADAPTATION

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Climate change affects economic development and policies around the world. In coastal zones, which are home for a great part of world population, economic activities are threatened by sea level rise and growing probabilities of storm surges. Increasing climate-induced coastal risks require spatial adaptations. Economics of climate change differentiates between public (planned) and private (autonomous) adaptation [1]. This reflects the complexity of the socio-economic system [2]: governmental policies at macro-level provide an economic and spatial policy framework for microeconomic agents to interact and to give rise to emergent macro phenomena that serve as criteria for adaptive management. In the Netherlands risk management policy focuses on public adaptation using state-funded engineering defense measures. Private adaptation measures and promotion of behavioral adjustments at microeconomic level are largely neglected. The question is whether public infrastructural adjustments are sufficient to reduce risks imposed by climate change.

This paper uses concepts from urban economics to model land market dynamics in a coastal town exposed to increasing risks. Land patterns and property prices (and consequently risk of flooding or erosion) are the emergent outcomes of many economic interactions in a land market. The basic monocentric urban model of a coastal town [3] is extended to account for spatial heterogeneity, i.e. flood or erosion probabilities. In addition, we analyze the implications of homogeneous vs. heterogeneous but unbiased flood risk perceptions on land market dynamics.

We employ agent-based computational economics as a method to model this complex system [2, 4]. The purpose of the model is to explore: a) what aggregated outcomes emerge from various microeconomic behaviors exposed to increasing risks; b) implications of public adaptation and prospects for creating private incentives for climate-resilient spatial developments. The model produces 2D rent gradients and a set of welfare and spatial metrics. First, we demonstrate what land patterns and property prices emerge under various assumptions about individual risk perceptions in the case when only public adaptation measures such as engineering defenses are employed. Next, spatial distribution of developments and property prices in a coastal town with increased hazard probabilities are presented. Using survey data and spatially-explicit economic modeling we show that if individual adaptation to increasing climate-induced risks in coastal areas is not promoted then individual risk awareness is very low and there are no incentives for individuals to make climate-resilient choices in a land market. Thus, public adaptation alone may lead to unexpected results that reward microeconomic choices contributing to increasing flood and erosions risks in coastal zones. Some implications for the recommendations of Deltacomissie 2008 and developments in the outside-dikes areas in the Netherlands are discussed.

1.Stern, N.H. 2007. The Economics of Climate Change: The Stern Review. Cambridge University Press. 692 pp.
2.Arthur, W.B., Complexity and the economy. Science, 1999. 284 (5411): 107-109.
3.Wu, J., 2001. Environmental amenities and the spatial pattern of urban sprawl. American Journal of Agricultural Economics 83(3), 691-697
4.Tesfatsion, L. and K.L.Judd,2006. Handbook of Computational Economics Volume II. Elsevier

DD6.3-02 CLIMATE ADAPTATION, URBAN MANAGEMENT AND ECONOMIC EFFECTS IN DELTA CITIES

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Climate change affects the development of the world's cities, industries and societies: global warming reduces the planet's ecological diversity and agricultural production; rising sea levels threaten the densely populated coastal areas across the globe; and impoverished air quality seriously impacts the healthiness of people and living conditions within cities. In order to deal with these challenges we need to alter our ways of production, reconsider the management and planning of urban development and change our consumption patterns. Cities have in this context an important responsibility in promoting sustainable development and reducing emissions. Cities only take up 2% of the world's surface but are responsible for almost 75% of the greenhouse gasses released into the world's atmosphere. Furthermore, cities are the engines of the world economy but are mostly located in coastal areas that are threatened by rising sea levels. Port cities act as specific a case, exactly because of their location along the coast and their industrial profile. Therefore climate change provides enormous challenges for (port) cities and industries to reduce emissions in the decades ahead. But, these challenges also provide opportunities for (port) cities to create new jobs, to innovate and renew industries and communities.

Within regional studies and economic geography it often argued that the competitive advantage of firms and regions in this global age is dependent on the local capacity of actors to absorb new knowledge, learn and innovate (BOSCHMA & LAMBOOY, 1999). As argued by NOOTEBOOM (2000, p71), the 'absorptive capacity' of actors to learn from interaction is determined by their environment and past experience. This implies that regional and local industrial legacies both help to shape new avenues of exploration, while at the same time they can act as constraints by excluding novelties that not correspond well with the existing knowledge base, industrial legacies and vested interests (HALL & JACOBS, forthcoming). Therefore, innovation in port cities is crucial if they want to adapt to climate change and upgrade their economic profiles. However, port cities' existing industrial structure and legacy can at the same time act as barrier to those radical innovations necessary to break with their existing development path. Recent policy initiatives in the port city of Rotterdam will serve as an illustration.

Problem statement

What means climate change for sustainable economic development, attractiveness and the innovative capacity of delta cities in general and the urban region of Rotterdam in particular?

DD6.3-03 INFRASTRUCTURE & ECOSYSTEMS - PART OF THE SAME TOOLKIT FOR CLIMATE ADAPTATION?

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Climate change will magnify the risks of living in delta areas. Frequency and magnitude of storms, flooding and sea-level rise related inundations are likely to increase. This demands that risk management adapts by enhancing protection measures at an affordable cost. A broad range of responses to the challenges of living in delta areas already exist. They include traditional 'hard-infrastructure' measures such as the construction of dykes and reservoirs, but also innovative 'soft' ecosystem-based approaches that ensure maintenance and restoration of environmental services such as flood and storm protection and prevention or reduction of saltwater intrusion. The latter, either alone

or in combination with hard measures (the 'hybrid engineering' approach) are an important and often highly cost-effective solution. However their application, especially in developing countries is rare and is largely driven by weak insight on the relative costs and benefits of these approaches.
Planners and decision makers often fail to take into account that large-scale infrastructural developments could undermine the provisioning of important live-sustaining ecosystem services. For example constructed sea defences, whilst having an undisputable economic benefit in terms of the protection they provide, can also contribute to the loss of wetland ecosystems and the valuable services they provide such as biodiversity, recreation, fish stocks, carbon storage and coastal protection. A good example is the loss of mangrove forests in Southeast Asia due to sea defences built as a reaction to the Asian tsunami. . There is an increasing body of evidence that failure to take account of the impact of infrastructure development on natural functioning in strategic environmental assessments or cost-benefit analyses leads to ill-informed decision making and may ultimately result in maladaptation. Ecosystem-based approaches to adaptation, such as establishment of protective mangrove belts, restoration of floodplain areas, rehabilitation of shellfish reefs and restoration of coastal peatlands are increasingly piloted at a small scale as so-called 'no-regret measures'. However, it remains unclear to what extent these measures can provide cost-effective protection from climate hazards when scaled up and / or combined in hybrid engineering approaches.
This session will explore the current state of knowledge around the costs and benefits of various hard, soft and hybrid approaches to adaptation in delta regions. It will draw upon experiences from both developed and developing countries provided by consultants, government agencies and non-governmental organisations. Case studies from around the world will introduce the issue. The following dialogue will explore how improved insights could best inform decision making and drive the design of innovative climate adaptation approaches.

DD6.3-04 CLIMATE CHANGE EFFECTS ON INLAND WATERWAY TRANSPORT: A LITERATURE SURVEY

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The paper presents a survey of the literature on the effects of climate change on inland waterway transport. As a result of climate change it is expected that the navigability of rivers and lakes will deteriorate. For the river Rhine in North West Europe for example, it is expected that in winter precipitation will increase and higher temperatures will cause a smaller proportion of precipitation to be stored in the form of snow in the Alps mountain range. As a result, in winter more precipitation directly enters rivers, average and peak water levels will be higher. In summer, besides a reduction in melt water contribution, there will be less precipitation and more evaporation due to higher temperatures. As a consequence, inland waterway vessels on the Rhine will experience lower water levels as well as an increase in the number of days with low water levels in summer and autumn. High water levels may result in a temporal stop of inland waterway transport because of safety reasons. Low water levels imply restrictions on the load factor of inland ships. This suggests that the capacity of the inland waterway transport fleet is (severely) reduced in periods with low water levels.
For some sea ports in the world, inland waterway transport is essential for further inland transportation. For example, in 2002, for the port of Rotterdam, the inland waterway transport mode share (road, rail, pipeline, inland waterways) for transportation of cargo to the hinterland was 52%. Insight into the potential effects of high and low water levels on inland waterway transport is therefore of major importance for the competitive position of inland waterway dependent sea ports.
The paper focuses on the effects of high and low water levels on inland waterway transport prices, its modal share and the reliability of inland waterway transport. Estimations for changes in transport costs per tonne for inland waterway transport due to climate change vary from -44% to +54%. Only few studies have focused on the effect on modal share but those who did find a decrease in quantity transported by inland waterways of about 5%. Finally, not any study was found that explicitly dealt with the effect of climate change on the reliability of inland waterway transport. Therefore, the current study focuses on the value of reliability (VOR) for shippers that make use of inland waterway transport. The studies that were evaluated did not agree on the importance of reliability (relative to other determinants of mode choice such as travel time and costs) for inland waterway dependent shippers.

DD6.3-05 CLIMATE CHANGE AS A CATALYST? THE GOVERNANCE CHANGE OF THE SHATT AL-ARAB

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Iran and Iraq have regularly been fighting over the water, land and natural resources of the Shatt-al-Arab River and its delta for the last five centuries. Despite these regular periods of conflict and continuous tension, the freshwaters from the Shatt al-Arab delta have always played an indispensable role to the Arabian/Persian Gulf marine ecosystems where the River discharges, and are indispensable to its continuous supply of seafood, (desalinated) water and other ecosystem services. They are beneficial to the populations of the Gulf's 8 riparian States, which totalize an estimated 150+ million-strong population.
Despite having faced a variety of trans-boundary environmental issues, the Shatt-al-Arab and its delta have almost always been addressed on a local or national scale. The Shatt al-Arab is currently experiencing a grave period of pollution and decline of freshwater flows due to increased uses for human activities. This leads to an unprecedented salinization of the waters and soils along the River and especially in the delta, due to the increased penetration of the Gulf seawaters. The issue of climate change seems likely to either exacerbate - if no significant political and economic investments in the water infrastructures are made - or challenge this situation and pattern.
The author argues that it is significantly more cost-effective for the wealthy Gulf Cooperation Council (1) neighboring countries to secure their (indirect) water supplies - which are heavily and increasingly relying on the Gulf waters for desalination because of depleted local aquifers and declining raining forecasts - by investing into a more efficient and sustainable use of the waters of the Shatt al-Arab upstream in order to both improve the quality and increase the freshwater influx going into the Persian Gulf. This would reverse the ongoing shrinking and degradation of the freshwater flow to the Gulf waters that could otherwise seriously affect the whole Gulf desalination industry.
The author also proposes some key initiatives and concrete projects for a more sustainable governance of the Shatt al-Arab River and its delta by the regional stake-holders, emphasizing the need to increase the wastewater collection and treatment capacities in both Iraqi and Iranian sides of the River, to improve agriculture efficiency and further the regional energy integration to free some of the water resources allocated to electricity generation. Finally, the author calls for a private sector role in this new regime of regional environmental governance of the Shatt al-Arab to be defined along the Gulf region's best practices for other natural resources like oil or natural gas, to circumvent the local fears of foreign (primarily Western) interference and unfair exploitation of the local resources.
(1) The Gulf Cooperation Council is a regional political and economic organization, created in 1981, that gathers the monarchies of Kuwait, Saudi Arabia, Bahrain, Qatar, the United Arab Emirates and the Sultanate of Oman.

DD6.3-06 REVITALIZATION OF TAIWAN COASTAL SUBSIDED AREA UNDER CLIMATE CHANGE THREAT

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Along Chiayi 20 kilometers coast of southwestern Taiwan, there are about 100000 inhabitants on the area which have been specified as the severe land subsidence region, which means land subsided more than 2 meters within recent twenty years. It has been measured out that nearly 2250 hectares of this region were already below the sea level and 7350 ha below the daily average tidal level currently. This kind of low land has faced rapidly increasing climate change threat due to continuous land subsidence and sea level rise effect. Therefore, master planning of regional land use and landscape reformation was introduced for this region.

In the process of decision supporting system was conducted for understanding of effects in regional revitalization practices. First of all, index of flood relief was established as the reduction of inundation area. Then recovery of water harvest for fishery was established. Natural treatment capacity assessment for domestic wastewater was also included. Land price raise was at last calculated. Three scenarios were compared as No Change, As Usual and Live with Nature. Comparison among scenarios was conducted in four different situations: current condition, low impact condition (symbolized as Year 2013), medium impact condition (as Year 2019) and high impact condition (as Year 2032).

After simulations, the suggestions for master planning were concluded into four categories: flood control measures, village and road, environmental friendly practice, and land use reformation. Total duration of implementation was estimated for twelve years up to Year 2019. Gross budget of suggestion project was close to 560 million US dollars. In order to explain whole process of this environmental restoration and sustainable revitalization planning, three pilot sites have been appointed for demonstration. Public participation was emphasized since the beginning stage of conceptual plan. Direct dialogue, small group workshops, professional debating seminars, and several conferences were conducted within stakeholders. Discussions of flood control facilities, local livelihood and production, landscape reformation, and land use adjustment have been all practiced and reviewed in these pilot sites. Final suggestions for pilot sites were concluded as follows,

- About 18000 inhabitants living in 2000 ha area will be immediately affected.
- The protection level of inundation for living area will be improved from currently less than 2-year storm event up to at least 50-year in the pilot sites.
- Water utilization of 758 ha fish farming can be switched from groundwater extraction to retention storage.
- 5400 m^3/day of domestic wastewater may be treated in 18 ha constructed wetland for natural water purification.
- 95 ha of embankment will be piled for potential village reallocation to adapt unpreventable inundation.

Overall investment of three pilot sites was 192 million US dollars. Benefit over cost analysis for their contents ranged from 0.59 to 1.53. Among them, Dongshi site has the most priority of implementation in terms of B/C analysis, average investment per capital, transferable groundwater usage and public common consensus.

For illustrations see website: www.climatedeltaconference.org/results

Deltas in Depth Theme 7:

Decision support instruments for climate adaptation policy

DD7.1-02 USING WATER SYSTEM AND SOCIETY INTERACTION TO PREPARE FOR AN UNCERTAIN FUTURE

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Sustainable water management is able to cope with uncertainties in the natural and social environment. Ideally, a strategy is robust under different climate change scenarios, socio-economic developments and societal perspectives, or the strategy is flexible enough to adapt. Uncertainties inherent to these developments lead to different potential pathways of water management into the future. Our hypothesis is that in order to achieve sustainable management under an uncertain future the interaction between the water system and society needs to be taken into account.
We, therefore, follow a transdisciplinairy approach of social and natural sciences. We developed a multi-actor, interactive game to develop storylines for river management which describe these interactions. Players of the game get the assignment to manage the water system of the study area. In each interactive run, the users, who have the role of a river manager, will be confronted with a year-by-year evolvement of river runoff, related impacts on safety, damage, shipping and ecology and societal changes and events. In response they may accordingly undertake management measures.
The Pressure State Impact Response (PSIR) concept is used to describe the interaction between water (PSI) and social system (R). The PSI part exists of a Rapid Assessment model that is able to calculate effect of different scenarios and measures. The response part is elaborated with a policy arena and a public support model. In the policy arena, players have to negotiate water management measures. At every point in time the players can evaluate strategies and their effects on the system state, and may accordingly change or adapt their strategy. However, they may be constrained by a lack of public support for their strategies. In the public support system society responds to events and developments occurring within and outside the water management system (e.g. a flood, or economic crisis). Societal perspectives influence decisions made in the policy arena. Depending on the public support individual players and coalitions receive, they will be able to implement a strategy or not.
A story line completes when the user has managed the river for 100 year. The model records the inputs provided to the user, the measures taken by the user in the course of a run, i.e. the PSIR cycles, the evaluation of strategies and their effects, and the evolvement of the pubic perspective and support.
With the game it is possible to experience how important interactions between water system and society are. It can help to get insight in possible responses under different circumstances and to develop ideas on how to include this in the development of water management strategies. We use the game to get a better understanding of these interactions and improve our method to develop pathways for sustainable water management.

DD7.1-03 HIGH-PERFORMANCE COMPUTATIONS AND 3D-VISUALIZATION

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Problem definition
Decision support systems for climate change policy depend on a proper assessment of the impact of climate change. This assessment is based on model simulations for expected floods due to dike breaches and extreme rainfall. In densely populated areas, like most deltas, it is far more difficult to assess the impact of climate change, taking into account the influence of the sewer system, street flow, metro-system and underground storage, like cellars and parking lots. The traditional flood inundation software does not cope well with these influences.
This article deals with solutions to improve the level of detail of the type of simulation used for decision support systems. Typically flood models have a spatial resolution of 100x100 m2, whereas a spatial resolution of 1x1 meter would be more appropriate. It is expected that higher resolution simulations in urban areas will lead to a far better understanding of the impact of climate change and therefore to improved 'tailor made' measures in both spatial planning and calamity management.

Theoretical framework and methods
In order to make more detailed simulations, two factors are of vital importance: 1) detailed terrain data should be available and 2) the computation speed should be increased with factor 100. The terrain data is recently made available in the Netherlands by Flimap. This is a laser metric system with a resolution of 15 to 60 points (3d-coordinates) per square meter. Remains the problem of the computation speed of the simulations. The calculation speed can be improved in two ways: by an improvement in hardware, using the graphical processor unit (GPU) instead of the Central Processor Unit (CPU) and by one in software, using sub grids in the numerical computation. Both techniques have been tested in a prototype study and have given promising results.
Detailed calculations such as these produce an enormous amount of data. This both asks for and enables better visualization. At the TU-Delft a 3d-visualisation tool has been developed that allows the spectator to "fly"through the inundated areas and view the impact of flooding in a realistic way. This creates a far better understanding for policy makers and civilians alike.

Results
The results of the study when using the sub grids method show an acceleration of the computation speed with factor 35. The method of processing the algorithm computations on a GPU has to developed further in the upcoming year, yet comparative results in the GPU-programming area show an acceleration of factor 30 in process time. Detailed flood calculations have been carried out for a case polder in Delfland. The results show both a far clearer picture of the impact of flood and an increase of the accuracy in time (difference of hours) and inundation depth (difference up to 0.30 m).

Deltas in Depth Theme 7: Decision support instruments for climate adaptation policy
Session DD 7.1: DSS – improving their communicative power **ORALS**

DD7.1-04 TESTING OF AN IWRM DSS FOR ASSESSING CLIMATE ADAPTATION OPTIONS IN BANGLADESH

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Currently, the Institute of Water Modelling (IWM) hosts a suite of hydrodynamic models that can estimate river stages and discharge; water levels for floods, groundwater and the Bay of Bengal; and water quality parameters for most regions of Bangladesh. In the past 10 years, there has been a growing capacity and capability of numerical modelling in IWM and other organizations in the country. However, there is pressing need to translate the outputs of these models into meaningful information for decision makers. Decision support instruments are required to address questions such as: "What is the effect on Aman rice production from an increase in upstream water levels due to a new embankment on the Jamuna River?" "What is the cost of infrastructure damage due to Climate Change induced sea level rise in Chittagong port area?"To address this knowledge gap, researchers at IWM have developed a water resources Decision Support System (DSS) that can use outputs from the numerical models to predict likely impacts on key sectors, such as agriculture, infrastructure, environment, fisheries, navigation, etc. It is envisaged that this DSS will assist policy makers and planners by providing information about likely impacts of water-related projects in Bangladesh. The DSS has also been designed to be a communication and educational tool for non-technical users and key project stakeholders.
In this paper, results from DSS testing and consultations with stakeholders for a climate change related project in southwest of Bangladesh are presented. The DSS is GIS-based and primarily data driven. However, it also has features of a model-driven DSS. At the heart of the DSS impact estimates are sector response functions, which consist of quantitative and qualitative relationships that describe how changes in the state of water resources will affect key sectors. For example, for the agriculture sector, response functions include empirical equations that estimate losses in rice yield depending on rice type, growth stage, water level, duration of inundation and salinity levels. The impacts are presented in terms of yield loss in tonnes and also in monetary units, where relevant price data is available. The testing of the DSS with stakeholders show that with growing comfort with computer technology, the DSS can empower local people and also enable decision makers to effectively assess climate adaptation policies. The next major development step for this IWRM DSS is to make the package available online to give local people, researchers and practitioners the opportunity to use it for more projects.
The development of DSSs is a key feature in IWM's long-term plan. This involves meeting the growing demand from integrated modelling software to hydroinformatic objects, such as DSSs. This evolution should assist resource managers and decision makers to adapt better to Climate Change and chronic water-related challenges, such as arsenic contamination in groundwater.

DD7.1-05 EVALUATING LANDSCAPE IMPACTS OF CLIMATE MITIGATION USING LAND-USE SIMULATION

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Bioenergy production can help mitigate climate change and is therefore part of various stimulation programs (e.g. EC, 2009). This climate control option is, however, causing concern for issues such as food security, food prices and major landscape impacts such as the loss of traditional agricultural open space. The latter is the focus of this study. Although open space preservation has been a major spatial planning issue in many developed, densely populated countries for decades, the amount and quality of open space are diminishing rapidly, affecting both quality of life and viability of ecosystems. For the design of more successful spatial policies we need to anticipate the landscape effects of different future land-use configurations under different social economic and climate change scenarios. This paper presents a new method to analyse the landscape impacts on open space that are associated with the large-scale production of second generation energy crops such as reeds and willow. An essential component in the proposed method is the application of a land-use model to simulate future land-use patterns that will be evaluated for spatial effects with the help of a group of specifically designed indicators.
Apart from the challenging task of developing plausible land-use scenarios this methodology faces the difficulty of determining indirect spatial effects of land-use configurations using spatial data of common land use models of very limited quality in terms of spatial and attribute resolution. The latter problem offers a relatively unexplored research area as most landscape related research on openness is focussed on the spatial effects of current land use. To overcome the data quality issue we examine the use of additional data layers that relate e.g. to landscape typology and cultural heritage. Furthermore, scenario dependent decision rules are used to value specific land-use changes in certain areas. Indicators are operationalised in a geographic information system using common spatial analysis techniques such as patch and neighbourhood analysis. To validate the results, derived indicator values for current land use are compared with the results of state of the art indicators for specific study areas. The assessment focuses especially on the areas that are likely to be used for the cultivation of biofuel crops and builds on a previous study into the potential of such crops in the Netherlands (Kuhlman et al., 2010).

References

EC (2009) Renewable Energy Directive. Directive 2009/28/EC. European Commission, Brussels.
Kuhlman, T., Verburg, R., van Dijk, J.J. and Phan-Drost, N. (2010) Biomass on peat soils? Feasibility of bioenergy production under a climate change scenario. Chapter 6 in: Borsboom-van Beurden, J. and Koomen, E. (eds.) The LUMOS approach; land-use modelling in the Dutch planning practice, Planbureau voor de Leefomgeving, Bilthoven (in press).

DD7.2-01 ADAPTATION TO TANGIBLE AND INTANGIBLE FLOOD RISK: A DETAILED DSS

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Both recent flood events and climate change projections have resulted in the promulgation of the European Flood Directive, encouraging the development of flood risk management plans by all member states in 2015. A large range of source-oriented, effect-oriented and curative measures can be considered to limit human flood risks. Decision support tools are in development to assist policymakers in their selection of cost-effective flood measures. Two limitations of currently available decision support tools are the limited focus on material impacts and the absence of climate change projections.
Beside material impacts, flood victims face intangible impacts as well, like stress, health impacts, financial disruption, etc. Several studies have demonstrated that flood victims may experience these intangible impacts as more severe than material impacts. The intangible impacts, however, are often not considered due to their complexity as well as the difficulty with monetizing these impacts. The unilateral focus on material impacts is likely to preferentially safeguard wealthy people to the detriment of the people that are more vulnerable to intangible flood impacts. Secondly, in order to select flood measures, the consideration of climate change in flood forecasts is requested in order to implement the sustainability principle. Decisions based on information that does not account for climate change are likely to result in suboptimal decision making as the actual flood risk may be either an over or underestimated.
The decision support tool described in this paper elaborates a methodology for quantifying the intangible impacts to individuals as well as a method for accounting for the effects of climate change. The methods put forward assessing the flood risk at the level of the individual household. Both technical flood protections measures as well as complementary non-technical measures can be assessed as well as packages combining and technical flood measures.
The methodology is illustrated by the case study of the river Dender in Belgium. One of the conclusions is that climate change scenarios still have high uncertainties. Depending on the climate change scenario considered the socio-economic flood risk may vary a lot. The relative impact of climate change can be quite different for various locations. Integrating not readily comparable effects, some expressed in monetary terms and others not, adds to the overall uncertainty. Dealing with these uncertainties is a challenging aspect of the decision making process. The paper concludes with an overview of research needs to increase the accuracy of the estimations and the practical application of the tool by water managers.

DD7.2-02 AN INFORMATION SYSTEM FOR THE SUSTAINABLE DEVELOPMENT OF THE MEKONG DELTA

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The Mekong Delta – one of the larges Delta areas in the world – is on of the hot spot areas for climate change adaptation- and mitigation research, as numerous challenges lie spread out for the next decades. A strong population pressure and economic growth lead to conflicting land demand for agri- and aquaculture, space for urban sprawl and infrastructure. Drinking water availability – especially in rural areas – is very limited. Changed discharge patterns of the Mekong and deteriorating water quality through untreated discharge and high nutrient- and pesticide levels affect the population. With predicted climate change related sea level rise large parts of the Delta will get flooded. Salinization of water resources, soils and accompanying shifts in agricultural practises are key topics to be addressed for the next years. The administrative and management landscape to tackle these complex challenges is characterized by strongly dispersed data sources in the field of geoinformation, a lack of data- and information sharing, overlaps or gaps in insitutional responsibility, new and extremely complex legal frameworks lacking law enforcement, as well as a need to local awareness rising on the issue of climate change.
Within the WISDOM project (Water related Information System for the Sustainable Management of the Mekong Delta) about 60 Vietnamese and German scientists and 14 PhD students from 18 different institutes undertake research in these fields as well as Integrated Water Resources Management, aiming at the support of such for the Mekong River Delta in Vietnam.
It is the goal of this conference contribution to present a broad overview of the project's research results to a broad audience, focusing on the Mekong Delta Information System (IS), which is developed within the project. The IS contains information from the fields of earth observation and GIS (flooding, land cover, land use, urbanization, change detection), hydrology (modelling of water levels, sediment transport, flood scenarios, water pollution from pesticides, endocrine disruptors, sewage etc) sociology, demography (population density, vulnerability, coping capacity of the local inhabitants, education levels), knowledge management (hierarchies and networks in the water sector in Vietnam) and information technology. The System can thus support decision making and planning at institutes and ministries of relevance for the water sector in Vietnam. It furthermore grants that research results generated will not only exist in paper form, and could thus be easily lost after a projects end. The System also allows access to all project's results simultaneously, and most important, enables the end-user to perform analyses, and to query the extensive database, e.g. to demand: "show me all the settlement areas that are located along heavily polluted river branches, where coping capacity of the population with floods is low".
The topics mentioned above will be addressed at three scales: a) at the trans-boundary Mekong Basin scale, b) at the Delta scale comprising mainly the area in southern Vietnam and parts of southern Cambodia and c) at Province scale, where detailed in-situ measurements within the WISDOM project are undertaken.
For further project details please visit: wwww.wisdom.caf.dlr.de

Deltas in Depth Theme 7: Decision support instruments for climate adaptation policy
Session DD 7.2: DSS – enhancing decision making **ORALS**

DD7.2-03 SEA-LEVEL RISE AND RISK ASSESSMENT

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Engineers, planners and policymakers traditionally consider the statistics of current environmental extremes when performing a risk assessment for present or future infrastructure. For example, coastal planners take into account the present return periods of storm surges when designing coastal structures. Under conditions of climate change, a worst-case scenario is often used to modify the existing exceedance statistics. However, the uncertainty in climate projections is as large as the variability in the present weather and climate. Therefore, combining conventional exceedance statistics with single or worst-case climate projections only includes part of the future uncertainty; what is required is a consistent combination of the uncertainties of present variability with the uncertainties of how we think the world will change in the future.
A technique is described which combines the exceedance statistics of present tides and surges (from both observations and model simulations) with projections of future sea-level rise. The method provides the user with the estimated sea-level exceedance probability (i.e. the likelihood of one or more flooding events), for a given location, period of time during the 21st century and emission scenario.
The method has been implemented as a decision-support tool for the Australian coastline but could be readily extended to other regional or global applications. Future developments of this tool will be discussed.
Further information is available at sealevelrise.info.

DD7.2-04 DEVELOPING A CLIMATE CHANGE ADAPTED PSS FOR THE DUTCH RANDSTAD REGION

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Due to its location below sea level and high level of urbanization the Randstad is expected to face serious consequences of climate change more than other Dutch regions. Increased city temperatures and precipitation variability are some of the potential effects. These developments pose serious challenges for urban and regional planning for the Dutch Randstad region. As a part of the Climate and Environmental change and Sustainable Accessibility of the Randstad (CESAR) research programme (University of Amsterdam, Radbout University Nijmegen, TNO, Utrecht University and Wageningen University), this project experiments with the application of different process models, policies and designs of planning support systems, in order to develop strategies for improving accessibility within the Randstad in the context of climate change.
The main focus of this research is the transitory development of Planning Support Systems to address climate change by means of incorporation of a so-called 'climate change – land-use change – behaviour' module. Inspired by insights from the CESAR programme in urban climates and the influence of climate change on mobility behaviour an inventory of needs and description of specifications will be made for a climate adapted Planning Support System.
The main question of this paper is: In what way(s) can scientific knowledge concerning the relationship climate change - land-use change - behavioural adaptation be incorporated in an existing Planning Support System? The paper will explore the state of academic thinking about this question and try to classify approaches in research.
By means of literature research an overview of best practices of climate change adapted Planning Support Systems is gathered. This is expected to provide insights in the key factors that make climate adapted Planning Support Systems

effective. Based on these experiences, needs and specifications will be formulated for a climate adapted Planning Support System for the Dutch Randstad area. The projected results for this research are an overview of best practices in Planning Support Systems that are adapted to climate change and functional requirements and specifications for a Planning Support System to address the challenges that climate change poses for the Dutch Randstad area.

PDD7.2-01 DECISION SUPPORT SYSTEM FOR OPERATIONAL MANAGEMENT IN A REGIONAL WATER SYSTEM

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Even today operational management of regional water systems is complex, mainly due to the large number of different water users and functions that need to be served. The daily management of the water systems in Western Brabant (The Netherlands) does not differ from this image and is dealt with by Waterboard Brabantse Delta. The service area of Waterboard Brabantse Delta comprises both low lying clay polders in the northwest as well as elevated sandy areas with free flowing brooks in the south.
In the future, water management in the low lying polders as well as the elevated sandy areas will become more complex due to the salinization of the Volkerak-Zoom Lake and climate change and increasing variability. Nowadays the lake is used as a fresh water source during dry periods. Most probably, alternative fresh water sources are not able to meet the peak demands in the area under dry circumstances in the near future. Hence, daily water management will become more complex, putting both the infrastructure as well as the water managers to the test. Besides the increasing complexity of daily water management, the number of water quantity calamities will increase. Anticipating on, especially water shortage, will become more eminent. In the case of Waterboard Brabantse Delta, this requires:
- a shift in mind-set (from ‘abundance’ to ‘shortage’ thinking);
- an improved and more accurate operational management (no water leaks or spillage), and
- the development of a decision support system (DSS) to improve daily operational water management as well as the capacity to anticipate and deal with (impeding) calamities (water shortage and floods).

The DSS described in this paper is not yet implemented, but rather a description of required functionalities and capabilities needed in the changing environment of important fresh water resources due to of climate change and salinization.
Although it is said that decision support for climate adaptation policies concerns three main elements: i) assessment of climate change impacts and ways to deal with uncertainties; ii) adaptation options with multiple stake-holders; and iii) evaluation of climate adaptation alternatives, we argue in this paper that a DSS itself can be seen as an adaptation measure to climate change and an increasing variability of daily weather patterns.
The envisaged DSS of Waterboard Brabantse Delta will:
- assess the impacts of climate change, or rather climate variability, on (potential) water shortages and floodings;
- help to cope with uncertainties of weather predictions;
- analyze impacts of adaptation strategies on various stakeholders; and
- be used to evaluate climate adaptation strategies.

The DSS will improve the operational decision making process of water distribution and flood management, give a better insight into the water system behavior to researchers, policy-makers and managers, and serves as a communication and presentation tool to decision-makers.

PDD7.2-02 FLOOD CONTROL 2015 IN JAKARTA

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Problem definition
Every year floods occur in Jakarta, Indonesia. Widespread flooding occurred in 1996, 2002 and 2007, inundating up to 40% of the city. Increasing population pressure and subsidence (10 cm/year or more) of areas already under MSL lead to an autonomous increase of flood risk. In addition, Jakarta is one of the mega cities, situated in a delta, in the world that will be affected by climate change: sea level rise as well as intensive rainfall will cause more frequent and worse flooding.
Since the major flood in 2007, considerable progress was made in improving the instruments available for modeling and analyzing the floods in Jakarta and a thorough examination of the institutional aspects related to flood management was drawn up. Some major conclusions from previous studies are:
- Using internet, GPS techniques, and updating the flood forecast system it becomes possible to obtain an overview of the actual and forecasted situation.
- Attention for upgrading the flood warning system and dissemination of information must increase.
- There is a certain kind of hesitance between government agencies to enhance collaboration.

Theoretical Framework and methods
The program Flood Control 2015 aims to develop new techniques and to integrate these, resulting in advanced forecasting- and decision-supporting systems. Flood management practices therefore become more transparent, quicker and, simply, better. And while this increases our safety, the cost of managing water systems falls markedly at the same time. Also, a major research theme in the FC2015 program is to reduce uncertainty in flood information and at the same time, recognize that information will always be uncertain and decisions always need to be taken based on uncertain information..
FC2015 is currently working to implement the innovations developed in the Netherlands, in South East Asia region, with at the heart of it: increased accuracy of flood information, solutions to anticipate with uncertainty in decision making, improved dissemination and conclusively total transparency for improved collaboration.

Results
One of the results of this project is the concept of a “Dashboard Water safety”to be visualized on Smartphone or through the web. The Dashboard Water Safety provides users a (near)real-time overview of the current and forecasted water safety in Jakarta. As with a car, the dashboard displays a number of indicators and reports when one or more threshold values are exceeded.
The dashboard Water and Safety for Jakarta will build on the conclusions from previous studies using latest internet and GPS techniques, allow easy upgrading of forecasting systems and providing a solution to meet the hesitance in agency collaboration. An important asset of the Dashboard is that it is fully transparent, removing an important hurdle for organisations to share their information. By disseminating the available data through one interface -a Smartphone with the dashboard installed -, agencies are more susceptible to share their valuable flood information and cooperate while informing all stakeholders in flood prone areas with their contribution.

PDD7.2-03 CLIMATE CHANGE IN THE PICTURE ON LOCAL LEVEL

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Governments at different levels are put to the challenge to set up climate adaptation policy. This policy is needed to reduce the vulnerability for the effects of climate change. In projects we do for local governments in the field of climate policy and spatial planning, we are confronted with policy makers who have difficulties developing policy on climate adaptation. Tauw has developed two tools to overcome these difficulties: the National Adaptation scan and the Urban Storm Water Flooding Map.
In the policy practice we notice two obstacles that governments face when developing climate policy.
First, climate change is a wicked problem characterized by uncertainties about the causes, consequences and possible solutions (VROM-raad, 2007). Policy makers therefore need instruments to deal with these uncertainties and to assess the consequences of climate change for their province or city. In research programmes such as 'Climate changes Spatial Planning' and 'Knowledge for Climate' scientists and policy makers cooperate to develop these instruments. However we notice a gap between the scientific domain and the local policy domain, which can be explained by two factors. Scientific knowledge on the effects of climate change in Dutch cities is less available (Rijke, et al., 2009) and only a few municipalities are participating in the aforementioned research programmes.
Second, in projects on climate adaptation policies and environmental impact assessments we see policy makers struggling to find ways to balance climate interests with other (e.g. economic) interests. This struggle is primarily caused by the complex social context in which climate policy makers operate: a context characterized by different levels at which the effects of climate change occur and policy is formulated. At each of these levels different actors with different perspectives, norms and values are involved.
To overcome these obstacles, environmental consulting and engineering companies can, following a context driven and constructivist vision on the science-policy interface (Gibbons, 1994; Funtowitcz and Ravetz, 1993), play an important role as 'boundary workers' (Gieyrin, 1983) between science and policy. In this light Tauw has developed two decision making tools. 1) The National Adaptation scan, which translates (scientific) knowledge to the local policy domain of climate adaptation. This tool enables a collective quest for the impacts of climate change and possible adaptation measures. The outcome can be presented in words and maps. 2) The Urban Storm Water Flooding Map, which visualizes urban flooding during storm events, can be used in spatial planning and communication towards citizens.
Through these decision making tools the gap between the science and the local policy domain can be closed by unlocking relevant scientific knowledge. Also the output, primarily the visualizations, of these tools gives local policy makers ammunition to start the dialogue with other policy fields and relevant stakeholders. It enables policy makers to talk in clear images, just like the successful iconography used by Al Gore. These tools show the urgency of climate change and also provide the building stones for climate adaptation policy. In this way climate change will really come in the picture on local level.

PDD7.2-04 THE BWN MAPTABLE: A TOOL TO SUPPORT DESIGN AND DECISION-MAKING

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The innovation program "Building with Nature"(BwN) aims at developing knowledge and methods to be able to build using the dynamics of nature. This ambition of BwN requires matching the desires and requirements of people, businesses and politicians and the opportunities to use natural processes. The design and planning process is the linking pin crucial to this matching process.
An automated impact assessment tool can facilitate the interconnection between the different parties. Such tool is capable, in an inter-active way, to visualize different geographical options and to provide indications of their potential effects in an early stage of the project. It consists of GIS based software, combining spatial databases and models that can predict impacts.
An example of such tool is "MapTable", which has been developed for a river environment and has proven its use in several Room for the River projects. For these projects, the hydrodynamic model WAQUA was plugged into the MapTable. This made it possible to show the effects of a project alternative on the water levels within several minutes: thus allowing for an interactive design process.
In Building with Nature, the existing MapTable is being extended. This BwN MapTable not only aims at predicting the impact of a measure on water levels, but also on a number of design parameters, such as safety, ecology, recreation, costs and benefits. It is therefore especially useful in projects with respect to climate change adaptation and sustainable spatial development, as these projects have to deal with multiple objectives and multiple stakeholders. The MapTable can be used both in design and decision-making processes. It assists in screening (geographical) options, ranking criteria and getting all parties involved in dialogue with each other in an early stage. Involving stakeholders at an early stage using the BWN MapTable also educates the stakeholders on the different impacts. The stakeholders gain insight in the impact relevant for the opposing stakeholders.
This article gives an overview of the possibilities and restrictions of the BwN MapTable. The BwN MapTable will be illustrated with a case study of the Friesian Coast in the Lake IJssel. For this area, a coupling is made between the hydrodynamic model WAQUA and the wave model SWAN. With this coupling, it is possible to get an impression of the impact of a measure on the safety. At this moment we are working on a second coupling: between the hydrodynamics and the ecological model PCLake. This coupling will make it possible to show the impact of a measure on the vegetation. Several designs aiming at reducing the hydraulic load on the primary defences will be assessed.

PDD7.2-05 ASSESSING CHESAPEAKE BAY WATER QUALITY POLICIES IN A CHANGING CLIMATE

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The Chesapeake Bay, one of the world's largest estuaries, is of great ecological and economic significance in the United States. Pollution in the Bay is a point of local and national concern, and standards regulating runoff from agricultural and urban nonpoint sources continue to be under development. The role of these standards in balancing

the needs of a growing population with ecosystem integrity and water quality may hinge upon future land use changes and environmental changes. For example, sea level rise in the state is proceeding at nearly twice the global average. Some scenarios project that Maryland could experience as much as 2 to 3 feet of sea level rise by the end of this century. The resulting subsidence is likely to impact the population living in the coastal zone, which comprises about two-thirds of the state's population. At the same time, state population as a whole is projected to grow 15 percent over 2010 levels by 2030.
As a major consumer of water and a major polluter of water, agriculture is often a focal point of water quality policy and research. However, few studies view agricultural systems within their broader contexts, which include complex interactions with neighboring urban communities and with multifaceted policy networks aimed at both mitigation and adaptation strategies in response to climate change. We develop a dynamic model of the Maryland watershed that includes climate change impacts, population changes, and agricultural and urban land use dynamics. We test the feasibility of meeting stated pollutant load reductions from Maryland to the Chesapeake Bay watershed along specified time lines and identify how external environmental or social variables may impact these goals.
To highlight the general utility of our model, we discuss how it could be calibrated for other locations using the example of the Northwest German Basin. The final discussion presents the dynamic modeling approach as a useful and comprehensive tool to incorporate future land use and climate change into development of contemporary policies on water.

PDD7.2-06 IMPROVING ACCESS TO DATA ON CLIMATE CHANGE AND ITS IMPACTS

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Recent research on climate change, possible impacts and adaptation options in the Netherlands has been substantial and promising in the Netherlands. However:
- Results are often not available in a format that can be used directly by stakeholders who need to develop climate adaptation strategies. For example, the information on climate change in the brochure on the KNMI'06 climate scenarios (KNMI, 2006) only indicates the percentage change in the average and extreme rainfall. However, hydrologists, ecologists, agricultural researchers need time series or statistics to simulate the impact of changes in rainfall on groundwater levels, nature and crop production.
- In the Netherlands several organisations work for example on hydrology and ecosystems, all with their own specialisations. A cross-sectoral overview of the available data and information on climate change and its impacts is not available.
- Between various disciplines the results are often inconsistent. Firstly, because different climate scenarios, different spatial and/or temporal scales and different reference periods are used to compile the climate data sets. Furthermore, assumptions and simplifications made in one discipline (f.e. water levels in agricultural models) may not reflect the knowledge from other disciplines (in this case hydrology).

These shortcomings hamper the dissemination and proper use of data and information on climate change and its impacts. In order to overcome some of the above-mentioned shortcomings, the "Climate Knowledge Facility - Tailoring"project was started. In this project we work on:
- A common web portal (pilot) to access to data and information on climate change and impacts to give more overview. A common structure for all disciplines will be used for background information on, amongst others used models, assumptions and uncertainties;
- Consultation on stakeholder requirements and feedback on the web portal;
- Pre- and post processing of data and information on climate, hydrology, nature/ecology, agriculture and land use scenarios (tailoring to stakeholder needs). In the first instance we will focus on tailoring of existing databases and existing tools/methods and the accompanying guidance for the use of the data;
- Identifying inconsistencies in approaches between the above mentioned disciplines. For example, the projections for potential evapotranspiration in the future from the meteorological institute do not include the possible effect of increased CO_2;
- Where possible, improving consistency between datasets from different disciplines by promoting the use of a limited number of combinations of climate scenarios and land use scenarios.

The project has a broad range of stakeholders: in the first instance we give most attention to researchers (universities, consultants), but in a later stage also to policy makers.
Results of the project and the set up of the web portal will be presented, this will be used for feedback from potential stakeholders in a later stage of the project.

PDD7.2-07 IMPROVING ACCESS TO DATA ON HYDROLOGICAL IMPACTS OF CLIMATE CHANGE

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Recent research on climate change, possible impacts and adaptation options has been substantial and promising in the Netherlands. However:
- Results are often not available in a format that can be used directly by stakeholders who need to develop climate adaptation strategies. It is often difficult to get an overview of the available data and information on climate change and its impacts. In the Netherlands several organisations work for example on hydrology and ecosystems, all with their own specialisations.
- Between various disciplines the results are often inconsistent. Firstly, because different climate scenarios, different spatial and/or temporal scales and different reference periods are used to compile the climate data sets. Furthermore, assumptions and simplifications made in one discipline (f.e. water levels in agricultural models) may not reflect the knowledge from other disciplines (in this case hydrology).

These shortcomings hamper the dissemination and proper use of data and information on climate change and its impacts. In order to overcome part of the above shortcomings, the "Climate Knowledge Facility - Tailoring"project was started. (Bessembinder et al. present an overview of the results of this project in another contribution to this conference.)
This contribution focuses on disseminating results of studies into the effects of climate change on the hydrology of the Netherlands. In recent years, a number of tools have become available to quantitively investigate the effects of

climate change on the hydrology of the Netherlands, and a number of studies have done just that. The Netherlands Hydrological modeling Instrument (NHI) is a hydrological model of the Netherlands, modeling both groundwater and surface water flow. The NHI has been used to assess effects of different climate scenarios on evapotranspiration, the groundwater reserve, freshwater demand et cetera. A number of models for both the Rhine and Meuse basins have been used to model the effects of climate change on their respective flow regimes.
The hydrology section of the 'Climate Knowledge Facility - Tailoring' will serve as a portal to the results of these studies. We used an upscaling approach to describe hydrological effects of climate change on representative landscape units. The idea is to present information on climate effects on a scale that is directly useable by fellow researchers and stakeholders. Considerable attention will be given to also present the limitations apply to these results.

PDD7.2-08 CLIMATE ADAPTATION SCAN PROMOTES THE USE OF CLIMATE INFORMATION IN POLICY MAKING

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Climate change increases the vulnerability of The Netherlands. Not surprisingly, adaptation of spatial planning is high on the political agenda. Dutch provinces all share the intention to develop [simplequote]climate proof[simplequote] policies. Integration of knowledge on climate change into spatial planning requires bridging the gap between science and policy making. The development of an adaptation strategy is not a straightforward policy activity. Adaptation planning typically includes a multitude of aspects and affects a wide variety of stakeholders. It requires dealing with uncertainties and impacts that occur over the middle and long term. The Climate Adaptation Atlas is an effort to disclose spatial information on the impacts of climate change. The Atlas contains information about projected impacts of regionalised climate change scenarios, including flooding, ecosystem shifts and agricultural production.
If properly developed, decision support tools have a great potential in the complex process of implementing the National Adaptation Strategy. However, often a mismatch occurs between the capabilities of the decision support tools and the requirements of decision makers and end-users. This paper addresses how a close collaboration between science and policy making has helped to prevent such a mismatch. In conjunction with the Atlas the Climate Adaptation Scan has been developed as an interactive design tool, which visualises the impacts of the data and knowledge in a simple and transparent way. This interactive scan is being used for adaptation planning at the local/ regional scale, exploring impacts and possible solutions and strategies. Most of all it facilitates a better understanding of common interests and concerns.
The Climate Adaptation Scan offers easy access to regionalised state-of-the-art knowledge on impacts of climate change. According to the results of case studies, a tool for adaptation strategies requires four crucial elements:

1. Close collaboration between scientists and policy makers. It is crucial to identify the type of problems to determine a suitable approach. Where structured problems can be solved through knowlegde, unstructured problems require a more design driven approach.
2. A multidisciplinary approach. Although trivial, cooperation between disciplines (hydrology, ecology, meteorology, spatial information sciences, decision and policy sciences) is essential. Depending on the objectives, requirements and the context, tailoring the information is important.
3. Visualization. Translating science and data to maps improves communication and use of science and data. By now a lot of information about climate change and impacts available, yet it is often difficult to express the information in a spatial way. Spatial presentation is important since spatial planners are used to working with information that is presented in maps.
4. Address uncertainties. There is always the urge to produce more accurate data and better predictions. However, dealing with climate change and adaptation will always leave some level of uncertainty. Adaptation issues are not to be solved through more science and data alone. Incomplete data and uncertain maps can indeed be helpful in investigating robust adaptation strategies.

DD7.3-02 INVESTING IN FLOOD PROTECTION MEASURES UNDER CLIMATE CHANGE UNCERTAINTY

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Recent severe river flooding in Europe has triggered a debate among scientists on historical observations and future projections of flood occurrences and their relation to the possible impacts of climate change, and among decision-makers on the need for adaptation investments, such as flood protection measures. Currently, there is mixed evidence on the impact of climate change on flood events. It is unclear to what extent climate change will affect extreme peak discharges, which normally cause flood events. Thus, there exists uncertainty about the real extent of the impact of climate change on flood risks in river basins. For decision-makers responsible for flood protection, the relevant question is how to deal with the uncertainty of climate change impacts on investments in flood protection measures. The timing of investments and uncertainty provides a trade-off. Decision-makers are reluctant to invest in flood protection measures because of uncertainty on climate change effects, especially when the costs of these measures are irreversible. When the timing of investment is flexible, the investment decisions may be postponed until more information about the effects of climate change has arrived. The objective of this paper is to show how climate change uncertainty affects the decision to invest in climate adaptation alternatives and thereby provides decision support for decision-makers.
We develop a model that incorporates flexible timing of investment decisions and scientific uncertainty on the extent of climate change impacts. Such a model allows decision-makers to cope with the uncertain impacts of climate change on the occurrence and severity of river floods and minimises the risk of under- or over-investment. We make a distinction between two categories of climate adaptation alternatives. Structural and non-structural adaptation alternatives aimed at flood protection that vary in their cost structure and capacity to reduce damage. We adapt a model by Hennessy and Moschini (2006) on costly regulatory action under scientific uncertainty to the case of flood protection. We first introduce the model in a discrete two-period setting, after which we relax the discreteness assumptions to allow for a wide range of possible climate change impacts and a continuous range of investment in both structural and non-structural measures. In addition we introduce a three-period model, to analyse the effect of gradual resolution of uncertainty.
The results show that the effect of uncertainty depends on the cost structure of the adaptation alternative under consideration (i.e. the levels of fixed and annual costs). The discrete-state two-period setting shows that when the expected resolution of uncertainty moves closer in time, investing now becomes less likely as the decision-maker prefers to postpone the uncertain decision until uncertainty is resolved. However, when the expected damage costs increase, the decision-maker faces higher expected costs when postponing his investment decision, thus investing now becomes more likely. In the continuous-state setting, preliminary results show that depending on the shape of the cost functions and damage function, the decision-maker aims to diversify between structural and non-structural adaptation measures in order to minimise the total expected costs.

DD7.3-03 IMMATERIAL DAMAGE VALUATION IN THE CONTEXT OF FLOOD RISK

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This paper offers context-specific estimates of immaterial damage for cost-benefit analysis of flood protection measures in the Netherlands and enriches existing valuation literature in a number of ways. First, it offers an estimation of value of statistical life (VOSL) in the context of a natural hazard (flooding). Next, alongside with VOSL we also provide estimates of other two immaterial damage indicators useful for cost-benefit analyses for considerations around improvements in flood protection measures. These are an estimate of the value of injury (VOI), and an estimate of the value of evacuation (VOE). Being able to separate the three indicators, we offer less biased estimated of the VOSL and VOI.
Our estimated indicators are robust for the multinomial and mixed logit estimations, and are in conformity with the values found in the literature. For flood protection policy in the Netherlands, a higher value of VOSL forthcoming from this research would imply 'underprotection' under current conditions and may lead to an update of key figures of avoided immaterial damages used in CBA. Another important finding concerns the value of evacuation per one fatality, which under some circumstances may even exceed the value of VOSL. This implies that first, while conducting a CBA, differentiation between areas with varying nature of flood risk should not be neglected; and second, that including only VOSL as a proxy for immaterial damages might in some cases significantly understate prospective benefits of designated protective measures.

DD7.3-04 CLIMATE CHANGE AND WETLANDS: SOCIO-CULTURAL VALUES FOR ADAPTATION MEASURES

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Australia's national water policy requires water planning processes to consider climate change. Recent assessment of its implementation finds that this important requiement has not been explicitly addressed. Climate change will bring not only sea-level rises in coastal areas but more frequent droughts resulting in prolonged stress on wetlands.
This paper concentrates on water planning for the River Murray within South Australia. Within the planning area are two 'icon' sites - Chowilla and the River Channel - and it flows into Ramsar listed wetlands. As a consequence of prolonged drought and unsustainable diversions, South Australia has received smaller portions of its entitlement flow under the Murray Darling Basin Agreement. The current water plan made no provision for management in the event of reduction of entitlement flow. Therefore no water has been recently provided for wetlands resulting in drastic consequences for them and other parts of the riverine environment.
In the context of a progressively drying climate and an over-allocated system, hard choices will have to be made about volumes of water for the environment and where that water should be applied. Use of deliberative tools in water planning processes for the River Murray Prescribed Watercourse contributes to the understanding of the community values in wetlands. Working with water agencies and communities in South Australia, this research determines how to integrate social and cultural values into prioritisation of water for wetlands. A nested methodology involves two deliberative tools:

1. Concept: a software-driven agent-based modelling tool which is used to explore the elements (stakeholders and values), their condition and interactions.
2. Deliberative Multi-Criteria Evaluation (DMCE): a tool to support decision making against multiple, often conflicting criteria. Through a process of identifying options, criteria and preferences, in this study it is used to identify values and their priority and then investigate trade-offs between them.

Early results show that the use of Concept was effective in surfacing a comprehensive list of over 30 socio-cultural values in wetlands. After deliberation by a representative group, this list was grouped into eight criteria for prioritisation namely ecological health; social wellbeing; significant sites; Indigenous values; recreational activity; threatened species; regional economy and research/education.
Two iterations of weighting of these criteria resulted in decreases in the standard deviation of participant responses indicating a progression towards a higher degree of consensus in their relative prioritisation. In all but one instance – research and education – there was a decline in the deviation of responses - indicating that the group substantially increased its level of consensus on the weightings between the first and second iterations.
DMCE scenarios were built around attributes that water managers take into account in decisions for allocating environmental water, namely size of wetland, its accessibility and whether it is temporary or permanently filled. Stage 2 of the DMCE will occur in April 2010. Early results show that use of these tools encourage deliberation and build consensus between representatives of sectoral interests. Rigorous evaluation of these tools will be undertaken by community participants and water agencies.

DD7.3-05 MULTI CRITERIA ANALYSIS AS A TOOL FOR CLIMATE ADAPTATION POLICY ASSESSMENT

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Deltaic areas are in general confronted with a high concentration of climate vulnerability. At the same time, the impacts of climate change on deltaic areas are increasingly becoming apparent. To avoid that inhabitants of deltas are becoming even more vulnerable to climate change in the long term, actions by policy makers are required in the short term. Whilst impact studies have been able to calculate the aggregate impacts of climate change on vulnerable areas to a certain extent, the assessment of adaptation measures and strategies is much less advanced in scientific terms. Furthermore, decision analysis and assessment of adaptive measures to climate change in deltaic areas are still in their infancy. There is an urgent need to develop decision support tools to appraise and evaluate adaptation options in order to design appropriate climate change adaptation strategies for deltaic areas.
Since adaptation responses are currently considered as integral to sustainable development and planning, the adaptation assessment process has become more sophisticated over the years and the scope and extent of the assessment tools has broadened. Assessment tools for climate change adaptation policies should currently not only measure the capability of individual policies to enhance adaptive capacities of target populations and systems, but should also indicate the relationship with the overall sustainable development paradigm.
Integration of adaptation measures against climate change impacts within a sustainable development context is a complex task for final decision makers. A large variety of criteria and objectives need to be considered against the often scarce financial resources available. Furthermore, decisions need to incorporate the multidisciplinary and multi - sectoral nature of the climate adaptation issues. Various stakeholders, ranging from government departments to different groups of society are among the affected parties by the decisions taken in the field of climate adaptation

and thus their objectives and preferences should be taken into account. To capture the diversity of interests and complexity of impacts on the environment, the local economy and the society, transparent and multidisciplinary decision support techniques are deemed necessary.
This paper examines the opportunities of Multi Criteria Decision Analysis (MCDA) as a decision support tool for the assessment of adaptation policies and measures. The MCDA is a relatively new method in the field of climate change adaptation but has already successfully been utilised in other environmental and climate policy evaluation areas. The paper examines whether and how MCDA performs under circumstances of multidisciplinarity, inclusion of stakeholders' interests, transparency and efficiency. At first, a conceptual overview of MCDA method will be offered along with a discussion of its respective strengths and weaknesses. Secondly, the feasibility and usefulness of the MCDA tool will be examined in the climate adaptation context for both developed and developing countries, highlighting the opportunities and threats of its application. Finally, the potential of MCDA to climate change adaptation policy assessment will be examined by looking at past and current applications at national as well as local level.

DD7.4-01 DECISION MAKING IN A CHANGING CLIMATE: EXPERIENCES IN THE COASTAL ZONE

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As a result of the unprecedented rate of human-induced climate change, there is now widespread consensus that unless proactive adaptation efforts are embraced, people and ecosystems will have to contend with significant and sustained climate impacts. While mitigation activities will help curb greenhouse gas emissions, adaptation efforts will bolster the resilience of human-built and natural environments.
Climate change will necessitate both anticipatory decision making for future impacts, some of which are uncertain and will only manifest themselves in decades to come but require early planning, and reactive decision making for unexpected change. However, unfortunately human society has historically found anticipation challenging and our decision-making processes are often slow to react to, learn from, and foresee change. Additionally, those most vulnerable have little to no resources to wrestle with today's climate impacts, let alone contend with unpredictable future impacts. Existing planning processes tend to prioritize current risks, even if efforts would be better spent towards mitigating future risks. This is problematic because many policy, planning, and management goals will not be achieved if future climate risks are not taken into account.
The World Resources Report 2010, a joint publication of the UN Development Programme, UN Environment Programme, the World Bank, and World Resources Institute, will explore the topic of "decision making in a changing climate"over the course of 2010 It will shed light upon how decision-making processes can be designed to both anticipate and respond to climate change impacts, and will focus on planning and policymaking processes in developing countries.
The Report will employ a number of research tools to examine this topic, including the collection of policy-relevant commentaries from experts and practitioners, the convening of scenario-based exercises with developing country decision-makers as the participants, and the development of case studies that will elucidate how decision-making processes can plan for the uncertain future that climate change will bring about. For both the scenario-based exercises and the case studies, we will explore how processes play out in a number of sectors, and one such sector will relate to coastal zone management.
In this presentation, we will discuss our findings regarding the capacities required for folding climate risks into decision-making processes, as well as some of the primary hurdles encountered in doing so. Our findings will be informed primarily by the case study research we perform and by the exercises we convene. The case studies will be

based upon existing literature as well as interviews and correspondence with on-the-ground actors and stakeholders. In the scenario-based exercises, we will present developing country practitioners with a potential scenario related to coastal planning that will draw out the knowledge, resources and capacities that are necessary to manage future uncertainty, change and variability, and lag of climate impacts, among other problem attributes of climate change. These two streams of research will allow us to provide a relevant, useful summation of the challenges and opportunities related to coastal planning in a changing climate, and will also inform policy recommendations for how to effectively manage key planning processes.

DD7.4-02 USE AND MISUSE OF SCENARIOS IN THE CLIMATE CHANGE DEBATE IN THE NETHERLANDS

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Errors and mistakes in the latest IPCC report generated political discontent; the Netherlands Minister of Environment exhaled that climate scientists should provide trustworthy and correct figures as politicians need to build their policies on facts! Being an environmental scientist herself, this Minister should know better. In science, theories and facts derived from these theories are social constructs, especially when these facts are generated through complex models. Moreover, making mistakes is part of human nature. Nonetheless, most mistakes, like the estimated melting speed of the Himalayan glaciers can be prevented and misperceptions about the reliability of scientific facts and methods should be corrected. One such persistent misperception is the reliability and correctness of the climate change scenarios as presented and defended by the Netherlands KNMI. These scenarios that predict how the Netherlands may look like in the future, are prominent in the discussion on mitigation and adaptation to climate change in the Netherlands and abroad. Recently, the Dutch Delta committee based its advice to strengthen the Dutch coastline on these scenarios, thereby taking the 'worst case' as a basis for their calculations in order to be on the safe side. The above, illustrates the misunderstanding and consequent misuse of scenario methods in the climate debate. In the highly politicized debate on climate change, scenarios are considered proven, reliable estimates of the future and are used accordingly. This is not what scenarios have been invented or are intended for. Scenarios, being an analytical tool for exploring uncertainty, are generated to design 'possible' or 'plausible' futures rather than 'likely to occur' futures as presented in the climate debate. Consequently, the KNMI institute is mistaken when it boasts about the fact that their improved models underlying the figures in their climate scenarios allow them to ever better predict what will happen to the Dutch climate. In this paper, we explore the use and misuse, and the understanding and misunderstanding of scenarios in the climate debate in the Netherlands. We focus on uncertainty and how uncertainty is framed in scenarios, perceived in scientific circles, and in the political debate on climate change.

DD7.4-03 EXPLORING PATHWAYS FOR SUSTAINABLE WATER MANAGEMENT IN A CHANGING ENVIRONMENT

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Exploring adaptation pathways into an uncertain future can support decision making to achieve sustainable water management in a changing environment. Our objective is to develop and test a method to identify such pathways for sustainable water management by including dynamics such as the interaction between water system and society. Existing studies on long term management are often limited in the amount of futures they describe: they often use a few plausible futures for one or two projection years. These end-point scenarios ignore the pathways towards the endpoint, neglecting the possibilities that events and disasters may change such pathways drastically, and may even change cultural perspectives on what is deemed as a desirable final situation. The alternative approach to include a larger number of plausible futures and, analysing the effectiveness of many pathways with existing computer models would take a long calculation time. To fully explore this alternative pathway new tools and model approaches are needed. Our approach is to explore pathways with many transient scenarios and an Integrated Assessment Meta Model (IAMM). The technique of meta modelling is used to overcome the problem of long calculation time. The purpose of the IAMM is to model the Pressures, States and Impact (PSI) on the physical river system for transient scenarios and to integrate this with a policy and perspective response from users. Transient scenarios describe time series of pressures like climate change and socio-economic developments. The result is a set of storylines describing the whole PSIR chain, thus including response.
This paper presents our first application of the developed method for a hypothetical case. The case shows the possibilities to explore and evaluate adaptation pathways. In this way it is possible to identify the sequence and when to take measures. By including the dynamics of water system and society the influence of uncertainties in both systems becomes clearer. Climate variability appears to be important for decisions in water management. Changes in objectives do not change so much the form of the adaptation pathways. They do change the timing of an adaptation tipping point.

DD7.4-04 SCENARIOS AS AN INFORMAL INSTRUMENT OF CLIMATE ADAPTATION GOVERNANCE

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Problem definition
Impacts of Climate Change intensely influence cities and their surrounding areas. Metropolitan regions are directly affected by the risks and impacts of climate change. Delta areas are confronted with extreme precipitation events

like heat waves, intense rain, drought, or flood, but also creeping changes like sea level and temperature rise. These changes will not only put pressure on urban areas but also inhabitants. At the same time, the governance structures of metropolitan regions are complex. Considering this, it is essential for the process of adaptation to climate change to raise awareness among local stakeholders and to initiate dialog and communication. One of the most complex problems but also a capacious chance for adaptation is the discussion of land utilization and allocation. Therefore many different aspects have to be considered for adaptation to climate change.

Theoretical framework and methods
The main challenge for both science and politics in the next years is to deal with risk and adaptation for climate change. From the urban planning perspective is important consider the uncertainties of climate change while attempting to minimize potential risks and strengthening urban resilience. One way to face the different challenges together with affected stakeholders is the use of scenario workshops. Scenario workshops can be seen as informal instruments of climate adaptation governance that provide the opportunity to discuss adaptation options with multiple actors. A scenario works with different future circumstances based on possible development tracks. Scenarios best represent future development prognoses based on present action.
A reasonable method to begin with is a case study assessment of local vulnerabilities for determining the effect of climate change impacts in the metropolitan delta region. With a basic knowledge of local vulnerabilities, future scenarios can be discussed with affected stakeholders in order to develop solutions and, in this case, sustainable adaptation strategies. In a world-cafÃ©-structure the stakeholders get the chance to discuss different developing lines and to analyze impacts of adaptation strategies. The focus will be put on land utilization and allocation in short and long term borderlines. The results can be integrated with tools and instruments to help explore adaptation options and negotiation processes to create visions for sustainable development in the metropolitan area.

Results
The results of workshops are transferred in development visions for climate adaptation and recommendations for decision makers. Another goal is to initiate the dialogue between the stakeholders and decision makers. Local adaptation strategies can benefit from coordinating local interests and concerns for affected actors. Workshops provide the opportunity to link the results of the discussion to the actual planning and decision making process in the local political structure.

PDD7.4-01 MODELLING FARM VULNERABILITY TO FLOODING TO APPRAISE ADAPTATION POLICIES

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In the context of climate change, extreme events such as flooding are supposed to occur more frequently. But, recent catastrophic flood events such as Elbe in 2002 or RhÃ´ne in 2003 have shown limits of flood management policies relying on dykes protection: worsening of flood impacts downstream, increased damage by dykes rupture. In Europe, two new kinds of flood management policies are promoted: floodplain restoration and vulnerability mitigation. Few experience feedback exist on these policies but they may have strong impacts on farms. Our case study is located on RhÃ´ne river downstream including Camargue delta. Flood management on RhÃ´ne River is highly illustrative of these policies and local authorities would like to appraise the efficiency of these policies with an economic tool (Cost-Benefit Analysis) to help decision making. But the current methods of flood damage modelling do not make the appraisal of these policies possible; mainly because they do not take into account the organizational and temporal

dimensions of damage formation and propagation at farm scale. After a presentation of the RhÃ´ne River context and policies, we review existing methods of flood damage modelling for agriculture and show the interest to focus on the farm scale instead of land plot scale. Based upon theoretical frameworks for systemic approach, we detail the construction of our conceptual model of farm vulnerability before presenting a case study that shows how the model can be implemented to compute flood damage at farm scale. Finally, the outlooks concerning the use of the model to appraise vulnerability mitigation policies and its application at regional scale are developed.

PDD7.4-02 HO CHI MINH CITY: OPPORTUNITIES FOR ADAPTATION VIA SPATIAL PLANNING STRATEGIES

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In inter-tropical low elevation coastal zones, climate change represents one of the greatest challenges facing densely populated urban regions in Southeast Asia. With more than half of Vietnam's population now living in low elevation coastal zones, Vietnam´s settlements and infrastructure are concentrated in two sprawling urban regions located in the country's main river deltas. The fast emerging megacity of Ho Chi Minh City (HCMC), the largest city in Vietnam, situated in an estuarine area of the Dong Nai River system, fifty kilometres from the South China Sea and northeast of the Mekong Delta, has historically exhibited sensitivities to natural hazards. The flood prone metropolitan area is surrounded by low-lying marshes on the lower reaches of the embedded fluvial system. The tidal influenced Saigon River, Dong Nai River, Nha Be River and Long Tau River as well as an adjoining canal network all flow through the city, increasing the city´s climatic sensitivity. Climate change will likely change the current climatic conditions and lead to ongoing sea level rise and an increase in the occurrence of extreme weather events such as heavy rainfall and heat waves. However, vulnerabilities of lives and livelihoods to climate related environmental processes are primarily the result of inadequate and unsustainable urban planning practices. HCMC is characterised by urban structures of both planned and informal expansions of the urban morphology, which are both degrading valuable environmentally multifunctional natural areas in the hinterland and increasing the vulnerability of existing structures to climate-related impacts. Future urban development scenarios for the mega-urban region of HCMC are required to be interrelated with climate change adaptation potentials. In the foreseeable future climate change, strong demographic growth followed by urbanisation are envisaged to cause a multitude of indirect, cumulative and synergistic adverse impacts of a severe nature, with more frequent occurrences of urban flooding or thermal increases to the existing heat island effect, disturbances to the urban energy supply and public infrastructure. Domain specific GIS applications, analytical models and thematic assessment methods will be used to generate urban climate and urban flooding sector-specific risk and vulnerability analyses in a spatially explicit manner. With the comprehensive aim to develop and incorporate adaptation potentials into the urban decision-making and planning processes, via the utilisation of planning recommendation maps. The integration of climate change adaptation measures and instruments will be achieved based on a common spatial framework using an Urban Structure Type approach. The research is envisaged to lead to an increase in HCMC´s resilience to climate-related vulnerabilities. The main objective of the integrated adaptation planning framework is to advance and disseminate knowledge and inform decision-makers and the general public about the climate change risks, to increase their capacity to implement necessary adaptation measures and to strengthen the response capacity of the urban system in general. The research project "Integrative Adaptation Planning Framework for Climate Change in the Urban Environment of Ho Chi Minh City (http://www.megacity-hcmc.org)"is part of the research programme 'Megacities of Tomorrow' funded by the German Federal Ministry of Education and Research (BMBF).

PDD7.4-04 WIKI-LIST OF LIMITING FACTORS TO LAND USE FUNCTIONING IN A CHANGING CLIMATE

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In order to perform climate-robust spatial planning and decision making, an approach is needed to assist the decision maker to deal with the inherent uncertainty in climate change scenarios. To this end, the 'tipping point' analysis has been developed: instead of progressing the climate change scenario's into wide uncertainty bands of future changes, with limited use for decision makers, it is assessed at which moment in time the system solution, envisaged by the decision maker, may not function anymore and intervention is required to ensure the system will remain manageable and effective. This is done by first identifying how much climate change the system and its underlying functions can handle, after which it is estimated at which moment in time this amount of change may occur.
To identify how much change the system can handle, a long list is required of factors, which may change in a changing climate, and which influence the effectiveness of envisaged functions (such as housing, public works, water system, drinking water, industry, agriculture and nature). In this paper, we identify the need for such a list, which is open to the public and continuously updated by expert knowledge coming from climate-related projects, applying the tipping point method. The list can be used as a baseline for tipping point studies. In the Knowledge for Climate project Hotspot Haaglanden 01, we are applying the tipping point method to set up a dialogue-supporting framework to tune the water manager's and spatial planner's needs. Within this project we have collected all previously gained knowledge to draft such a long-list and we have published this list on a wiki-page, which can be supplemented by anyone who performs a tipping point analysis.

PDD7.4-06 CREATING SECURE URBANITIES: THE CITY AS A WEAVE OF ECO-INFRASTRUCTURES

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Climate change impacts such as increases in global temperatures, loss from flooding and hurricanes accompanied by rising sea levels is becoming an all too frequent occurrence in many countries; particularly, in cities where people and assets are concentrated. This is generating concerns over the environmental security of these cities. This means that urban centers must be prepared with specialized tools to deal with climate change impacts to guarantee the environmental security of their urbanities through the protection of flows of ecological resources, infrastructures and services at the urban scale. Moreover, given the potential devastation associated with future climate change-related disasters, it is vital to change the way we build and manage our cities, through new strategies to reconfigure them and their infrastructures in ways that help secure their ecological, social and economic reproduction. In an era of climate change and resource constraint, economic growth means addressing simultaneously these challenges of sustainable development that are intertwined at the urban level. The management, growth and spatial planning of cities require the consideration of climate change impacts as vital components of urban development. Adaptation to and mitigation of climate change are components of the sustainable development of cities which in turn can enhance mitigative and adaptive capacities. Cities need tools to actively engage in learning, capacity building, and developing strategic responses to the opportunities and constraints of climate change, resource constraints and

the environmental security of cities. In this paper, I zoom in on the city of Cartagena-its lagoons and slums-, located on the Caribbean coast of Colombia and vulnerable to storm surges; and start to outline the challenges posed and the responses required to address the environmental security of its urbanities. The issue of environmental security still needs to be pushed up the agenda of the national and local governments. In order to start to build up the case for the strategic relevance of the city in generating responses to climate change, it is important to design tools and guides for local governments, communities and stakeholders to better understand the concepts and consequences of climate change and resource constraint (First part of the tool); how the impacts of climate change generate urban environmental in-security (second part of the tool), and what needs to be done to build ecological secure urbanities (third part of the tool). I propose an eco-infrastructure approach for reducing urban vulnerabilities and start to explore a series of strategic responses which I characterize as a weave of self-sufficient eco-infrastructures (the environment as infrastructure) which points in the direction of a new logic of infrastructure provision. It is critical that the definition of urban infrastructures must be expanded from just basic services to include climate change impact and hazard management investments for a secure built environment. These are still preliminary arguments and propositions about how cities attempt to secure their ecological reproduction under conditions of urban insecurity due to climate change, as well as a preliminary exercise of spatial planning that considers climate change impacts as components of urban re-design.

PDD7.4-5 RIMAROCC - RISK MANAGEMENT FOR ROADS IN A CHANGING CLIMATE

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The worlds changing climate has possible impact on road infrastructure in several ways. It is generally recognized that road owners should deal with these effects of climate change with a structured risk based approach.
The objective of the Rimarocc project is to develop a common ERA-NET ROAD method for risk analysis and risk management for roads with regard to climate change. The purpose is to support decision making concerning climate change adaptation measures in the road sector. To facilitate the work of end users the method will be based upon, and compatible with existing methods for risk analysis (and management) within the ERA-NET ROAD funders and other relevant methods. The project is focusing on both Risk Analysis – including risk assessment, risk management, cost-benefit analysis and level of acceptable risk, and on Risk management Options including identifying different options and implementation of action plans.
The Rimarocc method consists of seven steps and is a cyclic process to continuously improve the performance and capitalize on the experiences. It starts with an analysis of the general context where criteria to assess hazards, vulnerability (sensitivity) and consequences are established and ends with a reflective step where the experiences and results are documented and made available for the road organisation. In practice the steps are not always totally separated.
The development and implementation of the Rimarocc method is made considering the following important points:
- Climate change research and risk management are both fields under rapid develoment. Therefore this project focuses on finding a robust framework rather than the perfect solution for a fixed moment in time.
- The methodological framework is developed:
- on the basis of strong and long lasting principles (e.g. in line with ISO 31000 draft)

- to be as compatible as possible with similar approaches for other transport modes, sectors, etc.
– Valid for all scale; territory, network, section and structure.
– The method is valid for climate induced risks; however it also considers other risks and the same framework may be used for structuring risk analysis and management in general for the road system.

DD7.5-02 ROADMAP TO A CLIMATE-PROOF NETHERLANDS - FRAMEWORK FOR ADAPTATION STRATEGIES

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Problem definition
Trends in climate change are expected to continue, although there is uncertainty about the rate and the possible impact. Possible consequences such as the increasing temperature and the frequency and intensity of weather extremes, increasing river discharges, and sea level rise may have a substantial negative impact on a country like the Netherlands and require a targeted long-term adaptation strategy lowering the country's vulnerability. The adaptive ability of the Netherlands is, however, influenced by (choices in) spatial and non-spatial developments and the political and societal willingness to adapt. The Dutch Ministry of Housing, Spatial Planning and the Environment (Min VROM) has therefore requested the Netherlands Environmental Assessment Agency (PBL) to develop a roadmap for a climate-proof Netherlands.

Theoretical framework and methods
The PBL roadmap study is conducted using a structured, stepwise framework to develop adaptation strategies. The framework consists of the following critical elements:
- Potential impacts
- Possible adaptation options
- Relevant criteria to judge adaptation options
- Selection of relevant adaptation options
- Possible governance mechanisms
- Targeted adaptation strategies
Besides strategic themes like 'agriculture and nature' and 'water safety', the PBL roadmap study also focuses on urban resilience and health, the subject of this paper.

Results
This paper will present the development of the PBL framework to guide the development of adaptation strategies for a climate-proof Netherlands. Illustrations will be presented on how the framework is being used in developing adaptation strategies to develop climate-proof cities: heat stress, drought, water safety, and water nuisance, specified on the level of buildings, infrastructure and public space. Furthermore, using the same framework structure, adaptation options are developed to limit possible health effects: heat stress, smog, allergies, and infections. Adaptation strategies will be generally discussed in terms of co-benefits with existing and new urban and health policies.

DD7.5-03 CLIMATE ASPECTS AND STRATEGIC ENVIRONMENTAL ASSESSMENT IN SPATIAL PLANNING

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Various aspects of climate change call for explicit attention in spatial planning as they may limit potential future spatial developments (Kabat et al., 2005; Van Leeuwen et al., 2009). Conversely, spatial planning may impact climate change aspects. Strategic Environmental Assessment (SEA) is a useful method to help address the interrelations between climate change and spatial planning in a consistent manner as will be proposed in this paper. The paper first describes how SEA should ideally be used to incorporate climate change aspects in spatial planning. It then analyses current practice in two recent Regional Spatial Strategies drafted by Dutch provinces (regional administrations) and then discusses existing barriers to the proper inclusion of climate change considerations in planning. Finally a number of suggestions is presented to overcome these obstacles.
SEA is “a process that aims to integrate environmental and sustainability considerations in strategic decision-making”(Therivel, 2004, p. 3). It is based on the idea that knowledge leads to better-founded decisions and aims to ensure that environmental consequences of a proposed policy or plan are fully included and appropriately addressed at the earliest stage of decision making on par with economic and social consideration (Sadler and Verheem, 1996).
The paper focuses on a specific, new type of strategic spatial plans -Regional Spatial Strategies- that are the main guiding documents in spatial planning at the regional and local level in the Netherlands. They are an essential step in translating relatively abstract global and national level developments and regulations to the more practical local level. They are a relatively new phenomenon in Dutch spatial planning and follow from the new national Spatial Planning Act introduced in 2008 that calls for a more pro-active role of Dutch provinces in spatial planning. Regional Spatial Strategies typically focus on the year 2020, but often have a further outlook on additional developments until 2040 and should thus take note of potential changes in climatic conditions and related impacts such as flood risk and the urban heat island effect.
The paper analyses the incorporation of climate aspects in two recent Regional Spatial Strategies (Province of Overijssel, 2009; Province of Zuid-Holland, 2009) and concludes that the relationship between the planning and SEA processes can be strengthened with the following organisational provisions. First of all SEA should be started early in the planning process. Secondly SEA should be actively linked with the steps and milestones of the planning process. Following the legal requirements of SEA too strictly poses a barrier to the adequate incorporation of climate aspects in spatial planning.
Furthermore, it is clear that ample attention should be given to the specific role of climate aspects in each of the subsequent phases of SEA. In the exploration phase, for instance, attention should especially be paid to the constraints posed by (changes in) climatic conditions. A barrier for properly addressing climate change issues in SEA is the lack of accessible knowledge on specific climate impacts. Even when such knowledge exists, it is often too dispersed or abstract to be directly useful.

DD7.5-04 ADAPTIVE POLICYMAKING APPROACH FOR CLIMATE CHANGE

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In this paper, we argue that commonly used approaches for making policy are inadequate for dealing with climate change uncertainties in infrastructure planning, and we propose an alternative approach “‘ the adaptive policymaking approach. What adaptive policymaking offers is a clear structure for thinking about and evaluating uncertainties and making explicit trade-offs. In short, while we may not be able to foresee all the consequences of an uncertain future, we can plan to protect ourselves from unforeseen contingencies.
Adaptive policymaking helps us make more robust plans by not ignoring uncertainty and acknowledging that we cannot know the future. Unlike the other approaches that either provide a single forecast of the future, or a range of futures, adaptive policymaking calls for taking action based on what we know, and requires a system for monitoring developments that could potentially affect the effectiveness of the chosen policy.
Also, adaptive policymaking explicitly incorporates the element of time in policymaking. Whereas, other approaches are based on the notion that policymaking is a discrete one-time event, adaptive policymaking is explicitly a continuous process in time that involves changes to existing policy in response to unforeseen developments.
Finally, adaptive policymaking requires an explicit system for monitoring developments in the real world, and the performance of policy once it has been implemented. In all other approaches this is done, if it is done at all, on an ad-hoc base. This ex-post monitoring of policy and the monitoring system are an integral part of the adaptive framework.
We apply adaptive policymaking to the case of how the Netherlands can cope with the possibility of sea level rise. Climate change is expected to affect the entire low-lying part of the Netherlands and its coast. The issue is whether policies can be developed that make the Netherlands ‘climate proof’ in the long term. In this example we focus, for illustrative reasons, on one specific part of the Netherlands: the North Sea coast. The extent to which sea levels will rise in the future, and how quickly they will rise, is still deeply uncertain. As such, policies are needed that are flexible and adaptable, enabling learning to take place on the relationship between climate change and sea level rise.

DD7.5-05 EXPLORATORY MODELING IN SUPPORT OF ROBUST POLICIES FOR FLOOD RISK MANAGEMENT

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In the Netherlands, authorities design and build water works to reduce the risks of flooding by lowering the probability of flooding and/or reducing the expected damages. Model-based policy analysis is used to support the decision in which water works to invest (e.g. the reinforcement of existing dikes or creation of emergency flooding areas). The uncertainty associated with the input data and model structure (the quantification of relationships used in the model) is large and affects model outcome. Neither the probability of flooding, nor the expected damages of flooding, or the costs of investments can be predicted with accuracy. One way to deal with these uncertainties is to assume probability functions. However, our ability to select probability functions for such uncertainties is limited, for lack of

data and conflicting sources of information. The use assumed probability functions hides how the different uncertain factors affect the model outcome. In flood risk management, these so-called deep uncertainties should not be ignored. In recent years, exploratory modeling has been presented as a method that can deal with deep uncertainties and support the development of robust policies. This method has not been applied yet in model-based policy analysis for flood risk management.
Exploratory modeling (earlier applied to model-based decision support for infrastructure planning by Lempert and others) appears to be a promising method. A large ensemble of computational experiments is used to assess system behavior across a set of plausible system representations, rather than attempting to predict system behavior based on assumptions of the probability of model parameters.
In this paper, we apply exploratory modeling to a real-world case of policy analysis for flood risk management in the Netherlands, which was carried out in 2007. Data and models from this study, also known as the RBSO-Maas study, were made available to carry out an exploratory modeling analysis of costs and benefits of 14 policy options. Tens of thousands of model runs were performed. The results of the sensitivity analyses from the RBSO-Maas study were compared with the results from exploratory modeling analyses and discussed with experts, including analysts that contributed to the RBSO-Maas study. Results indicate that the use of exploratory modeling has added value for flood risk management:
(1) Insight is generated into the performance of each policy option across the full range of uncertainty. Which policy option is the best, differs across this range. Also, the vulnerability of policy options to external factors can be included in the selection of measures.
(2) The information of exploratory modeling can be useful for planned adaptation: knowing the conditions under which policy option perform well and where they start to fail can help in crafting adaptive policies.
Exploratory modeling cannot replace sensitivity analysis. For support of robust decision-making, the use of both methods should be considered. This may empower analysts in conveying their knowledge to decision-makers and draw attention to the discussion on how a policy of ongoing adaptation may be shaped, considering the ongoing changes in both climate and economy.

DD7.5-06 IMPACTS, ADAPTATION, AND COMPARABILITY: SUPPORTING DECISION PROCESSES IN DELTAS

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Barriers for the development of effective strategies to cope with climate change are not primarily a lack of knowledge. Rather, one main barrier is the deficit in making the available knowledge accessible and usable for decision-makers and stakeholders. Thus, it is a challenge to effectively support adaptation policy. This requires the processing of complex scientific knowledge in a useful, understandable, and comparable way specifically for non-scientific audiences on their spatial scale of interest.
Climate change impacts are not evenly distributed across sectors or regions. Thus, to be able to prioritize where adaptation projects are to be implemented, approaches to comparatively assess climate change impacts are inevitable. Such a prioritization of impacts and corresponding adaptation is essential in times when resources for adaptation are limited.
The problems we are addressing in order to support these decisions have several components. Impacts of climate change on different delta regions need to be identified in a comparative way. The relation between the climate-induced impacts and possible adaptation measures needs to be clarified. Moreover, this complex set of inseparable elements needs to be translated in to a clear and accessible concept for decision-makers.

Deltas are tangible examples for illustrating these problems and possible solutions to them. At the sub-national scale of deltas climate change driven stresses converge with a unique set of geographical characteristics and exert pressure on human-environment systems. Various deltas of the world share a typical set of these features, while the manifestations thereof vary. Such an analysis allows deriving in how far knowledge from one delta or delta area is comparable and transferable to another.
To address this complex set of problems, we propose to conceptualize the elements introduced above in an impact-chain consisting of causes (stimuli) and effects (impacts) of climate change. This provides an ontology that is capable of describing how a given climate stimulus triggers direct and indirect climate impacts on societal and natural systems, how those propagate through a geographical region (in this case, deltas) and how they relate to each other.
We exemplify this approach in a comparative study of climate change impacts for 1m and 2m sea level rise scenarios on sub-national level for deltas in Brazil, South Africa, India, China and Indonesia. We derive impact chains in a regionalized, sub-national context, including effects on agriculture, population, and settlements. We identify adaptation measures already in effect or in progress in these case study regions.
An analysis of the studied impacts and socioeconomic characteristics reveal a set of clearly distinguishable groups of similar administration units. These ‘typical’ expressions, or impact profiles, suggest to which other similar administration units existing adaptation measures are transferable to.
We are confident that such an approach provides valuable guidance towards identifying and implementing adequate, intelligent adaptation measures, while making the complex field of climate change research more transparent to local and regional stakeholders and decision makers.

DD7.5-07 FRAME ANALYSIS AS A TOOL FOR CLIMATE CHANGE ADAPTATION

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Problem definition
The complexities of climate change are confronting decision-makers with different sorts of “reality”. During much of the past three decades, for example, they had to deal with a reality in which climate change mitigation and adaptation were sharply separated both in science and in politics. Recently, however, adaptation, and more particularly, a strategic approach to adaptation has been recognized as an essential part of climate policy. These contrasting interpretations of adaptation reflect crucial differences in the frames that shape how individuals and institutions conceptualize the relevant aspects of an issue. It is especially at points of policy-uncertainty that climate change issues can be framed and reframed in several ways, which gives different actors chances to define the frame that is taken-for granted by all, at least temporarily. Hence, it is important for decision-makers to be made aware that frames, including the frames that are “built-in”in decision tools, can subtly shape their conceptions of reality.

Theoretical framework and methods
Based on the multidisciplinary literature on frame analysis, the paper examines how frames can be made more explicit in the context of decision strategies for climate change adaptation. Frames can be expressed by various representations, such as how a problem is stated, who is expected to make a statement about it, what questions appear relevant and what range of answers might be appropriate. However, frame analysis is often hampered by the difficulty of unravelling the sheer flexibility and context-dependency of frames. One way of avoiding such difficulties is to look at a strategic level for contrasting patterns of frames that shape public discussions on policy relevant science-

related issues. These patterns, such as the difference between approach and avoidance strategies, are based on a shared cultural background of perceptions, beliefs and practices. Our analysis of these patterns has been developed in interaction with a number of climate adaptation projects at the regional and local level.

Results

Our results show that two strategic contrasts can lay the ground for a framework to highlight some crucial interpretations of climate-related issues. The first contrast is the difference between a promotion or prevention orientation to interventions in the natural world; the second involves taking a distal view on interventions (long term, abstract aims) or a proximal view (short term, contextualized aspects). Taken together the two contrasts improve our understanding of how climate issues may be framed. Each frame has its strengths and weaknesses in articulating the specifics of a situation. Our interaction with a number of adaptation projects showed that frame analysis works as an eye-opener for actors involved in decision-making. More specifically, introducing a contrasting frame can be used to open-up the process of decision-making, for instance, by looking at weak signals through various scenario lenses or by reflecting on conflicts between planners with abstract long-term visions and implementers with more narrowly defined experiences.

Deltas in Depth Theme 8:

Climate change and health in delta areas

DD8.1-02 IMPACTS OF CLIMATE CHANGE ON WATER HYGIENE AND PATHOGENS IN GERMAN WATERWAYS

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Even if the quantification is still pending there is sufficient evidence that climate will change in the next decades and beyond, leading to increased global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea levels. Water resources may be particularly vulnerable towards the impacts by climate change since global warming and associated changes in local climate are projected to affect patterns, intensities and duration of precipitation and droughts. Changes in climate are also likely to increase risks of water-borne diseases, and to alter their geographic range. Heavy rainfall and run-off for example can alter the transport and dissemination of microbial pathogens, and temperature may affect their survival and growth.

The German departmental research programme KLIWAS investigates potential impacts of climate change on German waterways in order to further guarantee and develop their performance and use. One of the aspects to be assessed within this interdisciplinary programme is the potential effect of climate change on waterborne infectious diseases and the hygienic state of coastal waterways and estuaries (project carried out by the German Federal Institute of Hydrology).

Within this project the occurrence and distribution of hygienic relevant or potentially pathogenic microorganisms in the free water phase or bound to surfaces and particles are analysed. Additionally, it will be investigated how the expected potential consequences of climate change such as higher average temperatures, regional increases in extreme weather events as well as changes in biotic and abiotic environmental parameters may influence water hygiene. One of the main aspects is, whether changes of these factors may support the survival and/or growth of hygienic relevant or potentially pathogenic microorganisms or their entry into the water body, respectively. In this project already available hygienic data will be evaluated, supplemented by own field analysis and the impact of changing environmental parameters on pathogens will be analysed by means of laboratory experiments.

One model organism is the halophilic, gram-negative bacterium Vibrio vulnificus, which belongs to the normal marine flora in estuary and seawater environments worldwide. Microbiological analyses revealed high concentrations in sea water when water temperature exceeds 20°C. Human infections with V. vulnificus are associated with consumption of raw seafood (primary septicaemia) or occur when water containing V. vulnificus contaminates pre-existing superficial wounds (secondary septicaemia). In Germany the first infection occurred in 1994. In hot summer 2003 two severe cases of V. vulnificus wound infection with secondary septicaemia occurred, thereof one terminal. It is presumed that a continuing trend towards higher water temperatures during summer may increase the possibility of severe V. vulnificus wound infections. Therefore we currently monitor monthly the distribution of Vibrio spp. in water and sediment at 10 sampling sites along the North Sea coastline of Lower Saxony and the Weser estuary (Germany). The monitoring lasts from October 2009 until October 2010. For analysis of Vibrio ssp., cultivation on selective growth media with subsequent differentiation by commercial API-system is used. Here, we give insights into our first results and an outline of our future planned work.

DD8.1-03 HEALTH IMPACTS OF CLIMATE CHANGE IN CASCAIS, PORTUGAL

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In this study we present the potential adverse health impacts of climate change in the Cascais municipality, Portugal. The aim of the study is to indicate the potential direction of change and suggest adaptation measures to avoid/reduce these adverse impacts in this coastal region. Current and future health impacts associated with heatstress and vector borne diseases are presented.
Downscaled future climate scenarios were developed specifically for this study region. For the future impact assessment we used daily climate data indicative of the period of 2020-2047 and 2070-2097 for all four IPCC SRES scenarios (A1, A2, B1, B2). Heatstress impacts were assessed based on the local temperature and daily mortality relationship that was determined using Generalized Estimating Equations (GEE) modelling. The risk of transmission of vectorborne diseases was assessed based on biological temperature thresholds for disease transmission.
Heatstress impacts: Our results show that increases of 1oC in the maximum temperature above the threshold of 30ºC results in a 4.7% increase risk of mortality. Since all the future climate scenarios used in this study indicate significant increases in days with maximum temperatures above this threshold, we concluded that the risk of dying from heatstress will increase in the future. Improvements to current adaptation measures are identified to help reduce these future fatalities.
Vector-borne disease Impacts: Diseases endemic to Cascais such as leishmaniasis and Mediterranean spotted fever were studied as well as those currently not endemic to the region such as malaria, dengue, West Nile fever, yellow fever, Chikungunya fever and murine typhus. Climate change may change the disease transmission risks of these diseases throughout the year. There is also a real risk that transmission risks of diseases currently not endemic will increase significantly under current as well as future climates if infected vectors are introduced to the region. It is therefore urgent that vector surveillance systems be developed and implemented in Cascais.

DD8.1-04 EFFECTS OF APPARENT TEMPERATURE ON SUMMER MORTALITY IN LISBON AND OPORTO

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Evidence that elevated temperatures can lead to increased mortality is well documented, with population vulnerability being location specific. However, very few studies have been conducted that assess the effects of temperature on daily mortality in urban areas in Portugal.
In this study, time-series analysis was used to model the relationship between mean apparent temperature and daily mortality during the warm season (April to September) in the two largest urban coastal areas in Portugal: Lisbon and Oporto. We used generalized additive Poisson regression models, adjusted for day of week and season.

Our results showed that in Lisbon, a 1°C increase in mean apparent temperature is associated with a 2.1% (95%CI: 1.6, 2.5), 2.4% (95%CI: 1.7, 3.1) and 1.7% (95%CI: 0.1, 3.4) increase in all-causes, cardiovascular, and respiratory mortality, respectively. In Oporto the increase was 1.5% (95%CI: 1.0, 1.9), 2.1% (95%CI: 1.3, 2.9) and 2.7% (95%CI: 1.2, 4.3) respectively. In both cities, this increase was greater for the elderly.
Even without extremes in apparent temperature, we observed an association between temperature and daily mortality in Portugal. Additional research is needed to allow for better assessment of vulnerability within populations in Portugal in order to develop more effective heat-related morbidity and mortality public health programs.

DD8.1-05 A FRAMEWORK OF (NON-)CLIMATIC DRIVERS FOR INFECTIOUS DISEASE RISK IN DUTCH DELTAS

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Nowadays, many climatic and non-climatic changes are taking place at an unprecedented rate. These changes can give rise to (unexpected) infectious disease risks and influence overall population health outcomes. As climatic and non-climatic factors of global change mostly play out simultaneously, a multiplication of risks can occur in some cases, or in other cases non-climatic factors can mitigate the effects of climate-induced changes and vice-versa. Therefore, non-climatic drivers should be taken into account when assessing climate-induced consequences for health or specifically infectious disease risk. The dynamics of delta regions, such as in the South-West Netherlands Delta, pose additional complexities to the relationship between (non-)climatic health determinants and health outcomes. The multidimensional nature of the interactions responsible for changing infectious disease risk is broadly recognized. Accordingly, a multilevel approach should be employed in order to improve our understanding of the complex multi-causal system underlying current infectious disease outcomes, and their more general effects on population health. The research project ENHanCE (ERA Net Health and Climate in Europe) aims to assess the impacts of future climate change on the spread of infectious diseases in Europe and its outcomes for human health and well-being. Within this project, a conceptual multilevel integrated framework of (non-)climatic drivers for (future) infectious disease risk will be developed. This conceptual framework will be applied to the Dutch national context, taking into account the role of deltas. Next, the insights gained from this framework could be placed within a broader context for the purpose of formulating scenarios for future health and well-being in Europe. In addition, the conceptual framework could be a useful input for the development of adaptation strategies and mechanisms to deal with the impacts of climatic and non-climatic factors on health outcomes in the Netherlands. Increased understanding of the health determinants in delta regions can foster good governance of health impacts and can serve as a base for sharing best practices and international cooperation between deltas.

DD8.1-06 TOWARDS A NATIONAL STRATEGY TO INTEGRATE PUBLIC HEALTH

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Kampung Laut village is located in a very small island called Nusa Kambangan and partly surrounded by Segara Anakan lagoon and the citanduy delta which was due to large scale sedimentation in outlet of citanduy , cimenes,

cibeureum and cikonde rivers together in the are of Cilacap district central java, the village is occupied by nearly 3000 inhabitants who live in harmony mostly as formal and informal workers such as sub standard traditional fishermen and conventional farmers.
Due to illegal mangrove deforestation, Citanduy river outlet sedimentation and other ecosystem degradation as well as increasing population density therefore the coastal biodiversity was disrupted and the local community was affected by vector borne and water borne diseases , the situation was complicated by rainfall which caused floods which sometimes occurred at the delta area and was identified as the global climate change impact in the country.
The multi sector intervention was launched by the government supported by private sector and international donor to mitigate the risk by integrating the public health and delta protection strategy such as reducing sedimentation by forest rehabilitation, sediment excavation and increasing local community awareness to stop mangrove deforestation through law enforcement besides health promotion and diseases prevention as well as community empowerment efforts to minimize the vector borne breeding places in the community to mitigate and adapt the climate change . The role of private sector through corporate social responsibility and the international donors program were intended to fill the gaps that the government was not able to fulfill to mobilize needed resources at the local level.
The objective of the paper is intended to overview a good practice of integrated public health and delta conservation program to achieve a better people's welfare and a healthier life.

DD8.1-07 EXPERT ASSESSMENT OF HEALTH-RELEVANT ADAPTATION OPTIONS

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Problem definition
Health impacts of climate change (CC) are poorly known but are expected to occur - also in the Netherlands. Much research has explored how the Netherlands can adapt to changes in sea level, river runoff, fresh water supply and extreme weather events, but adaptation to CC-related health impacts has received little attention yet. The Netherlands Environmental Assessment Agency (PBL), the WHO Regional Office for Europe and the Utrecht University (UU) have joined forces to work together to assess the appropriateness of adaptation options on CC-related health impacts.

Theoretical framework and methods
We developed a framework to judge the appropriateness of health-relevant adaptation options. The framework consists of four assessment dimensions including a set of assessment criteria, of which the principal ones are listed:
1. 'Impact': health gain, risk of not intervening, and social impact;
2. 'Required efforts': economic costs, encroachment, and co-benefits;
3. 'Uncertainty-proof': robustness, flexibility, and no-regret;
4. 'Political salience': urgency, control type, and public support.
An extensive set of adaptation options was derived from suggested policy measures in international and European position papers on CC and health. The four strategic objectives of the European Regional Framework for Action offered the structure for categorising these options, capturing four themes: (a) health in all policy, (b) health systems, (c) awareness raising, (d) research, information systems, methods and tools. Next, the options were evaluated in a guided discussion setting as part of an international expert meeting: 'Policy options for climate change and health'.

In four parallel groups, one for each strategic theme, experts jointly selected the most health relevant options from the gross list and subsequently scored them using the set of criteria. These criteria were first collectively discussed to generate shared understanding and consequently, each expert individually filled out a score card of criteria for each option.

Results
The assessed options are positioned along the 2nd assessment dimension of 'required efforts' and 3rd assessment dimension 'uncertainty-proof'. Moreover, from perspective of decision support, the options are additionally positioned according to the 4th assessment dimension of political salience. Table 1 [insert table 1 here] demonstrates the analysis matrix for the strategic theme 'health systems'. For example, the option B2 on early-warning and alarm systems requires the lowest effort and is the most uncertainty-proof and politically salient. The analysis does not include the 1st assessment dimension 'impact'. All options were selected because of their high impact and therefore cannot be distinguished on these grounds. Positioning along these dimensions eventually allows for linking possible adaptation responses to characteristics of CC-related health impacts, such as plausibility, degree to which science can reliably quantify the impact given the state of knowledge, and relevance for adaptation. These latter characteristics were collected in a separate expert elicitation study on uncertainty in a wide range of potential health impacts of climate change. The paper will describe the process of linking the adaptation options with their scores to the findings of the elicitation study on the various health impacts, herewith illustrating opportunities for appropriate adaptation response.

For illustrations see website: www.climatedeltaconference.org/results

DD8.1-08 CHOLERA TRANSMISSION CYCLES IN BENGAL DELTA: IMPLICATIONS FOR CHANGING CLIMATE

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Cholera remains a major public health problem in developing countries around the world. Despite major advances in the ecological and the microbiological understanding of the bacterium, the role of the underlying climatic, hydrologic, and environmental processes in transporting the causative agent through the regional ecosystem and propagating transmission through seasons remains unexplained. Consequently, no 'climate-informed' cholera prevention effort exists in affected regions that may preemptively target areas with high chances of epidemic outbreaks.
Cholera incidences in the Bengal Delta region, the native homeland of cholera, show distinct biannual peaks, as opposed to single annual peaks in most other affected regions. A coupled analysis of the regional hydroclimate and cholera incidence records reveal a combination of two distinct, pre and post monsoon, seasonal transmission processes operating in an annual spring-fall cyclic manner. At a seasonal scale, the cycles appear contrary to the prevalent knowledge of a fall-spring pattern. This interpretation of the seasonal progressions of infection has major water and climate implications. Increasing water scarcity and abundance, and coastal sea-level rise, as projected by the Intergovernmental Panel for Climate Change, will adversely impact seasonal cholera transmission in South Asia in the 21st century.
Our results provide new insight by suggesting two distinctly different, pre and post monsoon, cholera transmission mechanisms related to large scale climatic controls that prevail in the Bengal Delta region. Water scarcity and abundance, influenced by changing regional climate patterns and large scale climatic phenomena, will adversely impact seasonal cholera transmission cycles in South Asia in the coming decades. Extreme hydroclimatic events such as prolonged droughts and record floods may cause major disruption in the ecosystem and subsequently trigger

large epidemics. A quantitative understanding of the hydroclimatic controls and dominant processes will form the basis for forecasting such epidemic outbreaks in coming decades. Formulating effective cholera intervention and mitigation efforts, and understanding and adapting to the adverse impacts of changing climate patterns on seasonal cholera dynamics are thus imperative for this region.

PDD8.1-02 MODELLING OF AIR QUALITY IN A CHANGING CLIMATE

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Climate change may have a significant impact on the dynamics and chemistry of the atmosphere and thus on air quality. Ozone and particulate matter are known to cause adverse health effects. Increased temperatures in a warmer climate will lead to higher ozone concentrations in polluted areas. The few available climate change studies for particulate matter, mostly performed outside Europe, do not provide consistent results, including the sign of the effect. To investigate the effect of climate change on air quality in Europe, the regional chemical transport model LOTOS-EUROS was forced by meteorology from the RACMO regional climate model. First, hindcast results for the present day climate were calculated to investigate the model performance and characterize biases. Then simulations were performed for a climate scenario representing the end of this century. Due to the biases, climate scenario calculations should be interpreted with care. But they indicate directions and causal relationships, which we will discuss at the meeting. The results also provide a scientific basis for policy making, for example to investigate whether the effectiveness of emission reduction strategies increases in a warmer climate or not. Although the spatial resolution of the model is not high enough to study individual cities, our results are representative for the densely populated delta areas in Europe, like the agglomeration of cities in the west of the Netherlands.

Deltas in Depth Theme 9:

Managing risks of extreme climate events

DD9.1-02 PUBLIC PERCEPTION OF FLOOD RISK IN THE SACRAMENTO-SAN JOAQUIN DELTA, CALIFORNIA

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Climate change poses an increasing threat of catastrophic flooding to Delta inhabitants around the world. Sea-level rise, increasing urbanization, and aging infrastructure combine in California to present a significant challenge to residents of the Sacramento-San Joaquin Delta where a flaw in the United States National Flood Insurance Program (NFIP), though intended to minimize risk, actually increases risk by encouraging development in flood hazard areas. What is worse is that residents are uninformed about the risk they are taking by moving into such areas.
The NFIP was established in 1968 in response to severe flooding from a series of hurricanes in 1963, 1964, and 1965, and demands for insurance coverage for residents of lands vulnerable to flooding. The basic idea behind the NFIP made good sense: the government would provide subsidized flood insurance coverage to populations who otherwise could not receive coverage, and in return, communities participating in the program were required to adopt land-use regulations that would prevent further development in flood-prone lands. Under the NFIP, if a property is in a floodplain, and if the property is secured by a federally-backed mortgage, then the owner must purchase a flood insurance policy. For the purposes of the program, the 100-year floodplain was adopted as the regulatory threshold. We focus on the consequences of a critical decision of how to treat lands protected by levees in the NFIP. As the program was being implemented, the question arose of whether floodplain lands protected by levees were still 'floodplain.' The decision was made that these lands were outside the official floodplain, and thus residents would not be required to purchase flood insurance nor were they required to elevate or retrofit houses to be "floodproof." In fact they would not be informed that they were living in (or purchasing a house in) the floodplain, because according to the program rules, they were not. This element of the program has had unintended consequences, and may have led to greater development on flood-vulnerable lands than would have been the case in the absence of the program. Nearly two million people live on lands protected by levees in the Central Valley of California alone.
We first review the concept of residual risk to levee-protected lands, and then consider the question of how well those residents understand their true level of risk. We surveyed 500 residents in one sub-sea level neighborhood in Stockton, California protected by a "100-year levee." Results show that residents do not understand their true level of risk, they believe a 100-year levee protects them from all flooding, and they are unprepared for a flood. Implications of the study in light of climate change warrant a look at floodplain planning and development policy with greater attention to 1) human safety and to 2) increasing risk awareness and coping capacity among vulnerable populations.

DD9.1-03 WATER MANAGEMENT AND EXTREME EVENTS IN SANTA CATARINA COASTAL RIVER BASINS

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Coastal cities of Santa Catarina State (Brazil) are frequently affected by weather related extreme events. On Nov. 2008, Northeastern Santa Catarina suffered one of its worst natural disaster. Heavy precipitation, which in some areas over passed 700 mm on 24 hours, caused severe flooding and landslides that resulted on 135 deaths and 78,707

homeless people. Over coastal cities, like Itajaí, Camboriú, Balneário Camboriú, Joinville, Tijucas, and Itapema, storm surge associated with onshore winds may have aggravated the inundations. In 1974, a great flood at Tubarão County, situated over an intra-lagunar delta, caused 199 deaths. Araranguá, another important coastal city of Southeastern Santa Catarina, also frequently suffers with floods. In addition, climate change is a great concern. Besides the effects of sea level rise, the IPCC points out that the frequency and intensity of storms should increase. During the past 5 years, two tropical cyclones have developed over Santa Catarina coastal waters, the only ones ever registered over the South Atlantic Ocean. One of them, the Catarina Hurricane, made landfall at southeaster Santa Catarina with heavy rain and winds over 180km/h. Despite the known vulnerability of these cities, for many years there has been a lack of governmental initiatives. Only recently, the Santa Catarina State Water Resource Department (SDS/DRHI) is being restructured to be more effective in management focusing, amongst others, on coastal river basins. The aim of this work is to present some of those management initiatives and to discuss the main challenges in disaster management, reduction and mitigation in the context of water resource management on coastal regions. One of the most important projects in course is the aerial survey, which includes the generation of Digital Terrain and Elevation Models, and river restitution at scales of 1:5.000 over all Santa Catarina State's territory. This project will be a great advance in basic cartography information for planning and researching not only to water resource management, but also for many other sectors, like infrastructure, agriculture, environment, amongst others. This year the Santa Catarina State Water Resource Plan is being carried out and it incorporates a scope for an Integrated Coastal Zone and River Basin Management. Flood mapping of the affected areas during Nov. 2008 with RADARSAT images was conducted and it has been used for spatial flood damage assessment. Investments are also being applied on the improvement and modernization of the state's hydrometeorologycal network. The assimilation of weather radar data by hydrological models for early warning systems is another project, which is being conducted by the SDS/DRHI, the National Institute for Space Research, the National Institute of Meteorology, and the Ministry of Defense. The DRHI/SDS also supported the elaboration of a Disaster Reduction Plan to the Itajaí River Basin. Most of these projects should be concluded by the end of the next two years, but programs like water resource plans should be conducted for the next 6 years. Despite the challenges, these projects will represent a great advance to Santa Catarina State water resource management and disaster risk reduction and mitigation.

DD9.1-04 ASSESSING FUTURE EXTREME WEATHER RISK: CURRENT APPROACHES AND ESTIMATES

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Problem definition
Impacts from natural disasters matter. They cause human suffering, disruption and damage, and can set back development in many nations. While the largest single catastrophes are related to geophysical events, in particular earthquakes, the many weather-related disasters around the globe create the largest number and largest share of casualties and damages. Many attempts have been made to assess future changes in the occurrence of extreme weather events. Few studies however, have projected the potential economic losses from such changes. Most studies over the past decades on climate change impacts have been limited to estimating the more gradual changes caused by climate change, such as changes in sea-level, agricultural production, heating and cooling demand, and incidence of diseases. There are only a few of scientific studies that have attempted to study the potential changes in economic impacts from those extremes in detail. Projecting losses is more complex than projecting climate change, as this requires insight in both the changes in the weather hazard, and changes in exposure and vulnerability to such hazards.

Theoretical framework and methods
To arrive at some assessment of the potential impact from climate change on weather disaster losses relative to other processes, a comparison can be made of the handful of impact studies on projected economic weather losses that exists. These have been developed for specific hazards and for specific regions and countries. Although the individual studies suffer from many of the elements of uncertainty mentioned above, a comparison can identify the current range of expected disaster losses in the near future for different hazards, and gives some indication of uncertainties. Here I provide s synthesis of some state-of-the-art projections of future loss trends, and the role of climate change until the year 2040. Particular attention is paid to the different approaches and assumptions underlying these estimates.

Results
All projections of future risks show increases in losses due to climate change, and river flood losses are on average projected to increase more rapidly than losses from tropical and extra-tropical cyclones. However, for the period up 2040, the contribution from increasing exposure and value of capital at risk is expected to be about four times larger than the anticipated impacts from anthropogenic climate change. Given the fact that the loss events are stochastic, and their occurrence varies over time due to natural climatic variations, the relatively small signal from anthropogenic climate change is likely to be lost among the other causes for increasing and varying losses. Only few studies have examined the potential future increase in disaster losses using a comprehensive approach that includes both climate and socio-economic change. More efforts are required to better incorporate changes in exposure, vulnerability and adaptation in impact studies.

DD9.1-05 PRECIPITATION AND RESULTING LOSSES FOR INSURERS IN RELATION TO CLIMATE CHANGE

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Climate change is one of the major policy issues these days. Insurers are affected by the growing global exposure to natural disasters like floods en extreme precipitation, heat waves, forest fires and hurricanes as a result of climate change. In this context, the Centre for Insurance Statistics (the statistics and research department of the Dutch Association of Insurers) researched the effects of extreme precipitation on the related losses for non-life insurers. The study is limited to the precipitation related damage of private dwellings and contents which are covered in the 'fire' insurance of households.
For this study the individual loss and policy data of several insurers were linked to the precipitation data of the KNMI, the Dutch Metereological Institute. The data of the insurers consisted of about 1.4 million dwelling policies (on annual basis), for the period 1987 to 2008. In addition, about 0.7 million contents policies (on annual basis) are used, for the period 1992-2008. The KNMI data include the daily precipitation data of 14 country wide stations for the period 1987 to 2008. On the basis of all these data sets a model is estimated that relates losses to precipitation.
The research showed a clear statistical relationship between precipitation, i.c. rainfall, and losses. The frequency of claims (the number of losses claimed per 100 policies) increases when rainfall increases, while the average claim sum remains more or less constant. This means that, above all, with heavy rainfall the number of losses increases and not so much the damage amount per claim. The intensity of rainfall proves to be more important than the total rainfall on a day.
The research findings are in line with the KNMI'06 scenarios which say that the rainfall intensity per hour during extreme rains in the summer will increase more than the extremes of the total daily rainfall. Rainshowers are likely to intensify while their duration will reduce.

The models that were developed by the Centre for Insurance Statistics are used for the calculation of the KNMI'06 scenarios for the year 2050. For the different scenarios the models estimate that the increase of the claim sum in 2050 vary from 6 to 22% (compared to the year 2008). In addition the models can now directly be applied by the Dutch Association of Insurers to estimate the losses soon after a heavy rainfall.

DD9.1-06 CHANGES IN FLOOD PREPAREDNESS DUE TO A FOCUSING EVENT

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It is expected that flood risk will continue to rise in response to a combination of a changing climate and an increase in vulnerability, e.g. due to increasing flood plain occupancy, and changes in the terrestrial system, e.g. land cover changes, and river regulation. Decreasing the impact of floods can only be achieved with significantly improved risk management. Using the focusing event framework, a comprehensive analysis of the preparedness of private households and companies was undertaken in the aftermath of the 2002 and 2006 flood events on the Elbe River in Germany. In August 2002, preparedness of households (n = 235) and companies (n = 103) was low: 30% of the households and 54% of the companies took no precautionary measures before the flood event. Many undertaken emergency measures were ineffective, since only 26% of all households knew how to react when the flood warning came, and only 9% of companies had an emergency plan in place. Due to this extreme flood, double loop learning occurred in many households and companies, so that many did implement precautionary measures. The distribution of adopted precautionary measures for households fits well to Preisendörfer's low-cost hypothesis, but does not apply for companies. Only 10% of the households (n = 112), but still 29% of the companies (n = 41) were unprepared before the flood in 2006. Significant improvement in flood preparedness activities is still necessary. Particularly for companies, regulatory programs and programs encouraging proactive behaviour should be implemented. The focusing event framework proofed to be an useful tool for a differentiated analysis of the responses to and learning due to a disaster also in the commercial and private sector.

DD9.1-07 MONETARY VALUATION OF INSURANCE AGAINST CLIMATE CHANGE RISK

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Climate change is expected to increase the frequency and severity of certain natural catastrophes, such as flooding. This is likely to increase the willingness to pay (WTP) for natural catastrophe insurance, even though it is uncertain how large this effect will be. In various countries the public sector offers partial compensation of damage caused by natural catastrophes, which may reduce the need for private insurance coverage and hamper the development of insurance markets. We present a stated preference survey using choice modelling with mixed logit estimation methods to examine the effects of climate change and availability of government compensation on the demand for flood insurance by Dutch homeowners. Currently, insurance against flood damage is not offered in the Netherlands. We estimate the dependence of WTP on prior risk perceptions, actual measures of risk, risk aversion, and socio-economic characteristics. Results indicate that opportunities for a (partly) private flood insurance market exist.

DD9.1-08 A MANAGEMENT STRATEGY FOR THE EBRO DELTA IN THE CONTEXT OF FLOODING

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The Ebro delta is located on the Spanish Mediterranean coast about 200 km southward of Barcelona. It has an approximate subaerial surface of 320 km2 with about the 50 % lying below the height +0.5 m above MWL. Human action on the river basin has led to a drastic decrease of solid river discharges and, as a consequence of this, the delta has become more influenced by wave action and it has been subjected to an intense reshaping process, especially since the 60's. In practical terms, this has resulted in coastal areas with large erosion rates supplying sediment for the net longshore sediment transport to fed deposition areas such as the spits.
The combination of a very low-lying morphology and the long-term erosive behaviour of some coastal stretches has determined the delta to be highly sensitive to floods of marine origin. Coastal floods in the Ebro delta are originated by two main agents: RSLR and the impact of storms. The first one is a long-term process in which the difference between projected sea level and deltaic elevation will drive the inundation of low-lying areas in a permanent manner, whereas the second one is a transient process integrating the result of beach/dune erosion and overwash. Climate change effects have a very significant influence on both phenomena.
The apparent increase in the frequency of storm-induced flood events on the Ebro delta during the last decade (or, at least, their consequences in terms of affected territory) together the projected increase in sea level (eustatic plus subsidence) has increased the awareness on the delta's future. Climate change phenomena, also, have influence in Ebro delta coastal area behaviour. As a consequence, different alternatives to design a long-term "solution"to the "problem" have been proposed, significantly differing among them depending on the target of the solution (sector affected).
Within this context, the main aim of this paper is to present the strategy selected to manage the area for the next decades taking into account processes and responses at present and under a scenario of rising sea levels, including climate change effects. The adopted solution is based on a combination of adaptation and defense strategies. In terms of adaptation, a change in the properties of the deltaic plain closest to the most vulnerable coastal areas has been designed. The objective is to change agriculture lands -with some economic interest but very low (if any) resilience to floods- by originally low-lying coastal habitats -with high environmental values and very resilient to floods-. In the northern hemidelta, a 500 m wide fringe behind the beach is planned to be recovered along the coast. In terms of protection, the landward limit of this recovered natural delta is reinforced by constructing a dune-sand dike which will serve to protect the hinterland from occasional flooding events.
In the final paper, full details on the adopted solution and, how this solution behaves for different scenarios of storms, climate change effects and RSLR will be presented.

DD9.1-09 WORKING APART TOGETHER - FILLING THE WATER SAFETY GAP

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"God created the world, but the Dutch created Holland"is an old proverb, and it still holds some truth. And although large floods occurred like the Saint Elizabeths' flood in 1421 and the large flooding of the South-western part of the Netherlands in 1953, living behind strong dikes became the main protection against flooding.
The Dutch law states, that the dikes and levees have to be build and maintained to withstand a water level that occurs once in 1,250 to 10,000 years. For the Island of Dordrecht the level is set at once in 2,000 years. Dordrecht lies between the rivers Rhine and Meuse and nearby the North Sea. Therefore a high water level can occur by high discharges of the river, or by storm surges from the sea. Due to climate changes and sea level rising, the safety situation will have to be reevaluated.
In the Water Plan (2009) the government issues a new policy concept, the "multi layer safety' (MLS), in which the dikes are the first layer: preventing the area from flooding. The second and third layer are developed to mitigate the effects of a flooding. The second layer aims at the urban and regional planning and the building codes. The third layer consists in proper safety plans for flooding, with evacuation plans and regular exercises.
The regional water authority Hollandse Delta is responsible for the dikes around Dordrecht. The municipality of Dordrecht is responsible for the urban planning and the regional safety authority Zuid-Holland-Zuid is responsible for the safety plans in the whole area. These three governmental authorities have started together a regional pilot study on MLS of the Island of Dordrecht.
This pilot study aims to establish the best solution for coping with climate change and sea level rising according to the new MLS-policy. Especially with the new safety levels (that will be issued in 2011) it will be very interesting to research which optimum can be found between structural and non-structural measures in a combination of the three layers. Therefore the water authority, the municipality and the safety authority have joined forces to research the possibilities for a new governmental arrangement combining these three layers. This is even more important for the parts of Dordrecht that lie outside the dikes and levees. For instance the historic harbor has no prevention layer, so the safety against flooding has to be from the urban planning and building codes and from the safety plans. The pilot aims not only at the area behind the dikes but at the whole Island in which one water authority, one municipality and one safety authority are each responsible for one layer of the flood prevention. By working together more economic effective and social acceptable solutions can be found. The challenge is to come up with a governance arrangement or institutional design to implement this MLS policy concept.

PDD9.1-01 ARE WE REALLY CONCERNED? CLIMATE AND LAND USE CHANGES IN FLOOD PRONE AREAS

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Lowland, flood prone areas can be found all over the world, along the coasts, in river floodplains and as inland depressions. Generally they are by their nature sensitive areas with a high ecological value. Due to their physical conditions and environmental value they are basically unsuitable for development. However, due to the in many cases strategic location and/or suitability for agricultural production there is often a tremendous pressure to develop these areas for various types of land use. We therefore may observe a rapid population growth, a significant increase in agricultural exploitation, urbanisation and industrialisation in lowland, flood prone areas. Due to this such areas become increasingly vulnerable for extreme weather conditions that will have their effect on the requirements for drainage and flood management. The various relevant issues are summarised in this paper. Attention is paid to the impacts of developments in land use, land subsidence and climate change. Although the changes due to these processes may be of different speed and magnitude, they all result in an increase in vulnerability and requirement of an increase in measures to be taken with respect to drainage and flood management.

PDD9.1-02 UNCERTAINTY AND SENSITIVITY OF CURRENT AND FUTURE FLOOD RISK ASSESSMENTS

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Floods are one of the most frequent and costly natural disasters. In order to protect human lives and valuable assets from the effect of floods, many defensive structures have been build. Despite these efforts economic losses due to catastrophic flood events have, however, risen substantially during the past couple of decades because of continuing economic developments in flood prone areas. On top of that, climate change is expected to affect the magnitude and frequency of flood events. Because these ongoing trends are expected to continue, a transition can be observed in various countries to move from a protective flood management approach to a more risk based flood management approach. In a risk based approach, flood risk assessments play an important role in supporting decision making. Most flood risk assessments assess flood risks in monetary terms in order to feed cost-benefit analysis of management measures or set up insurance schemes. Such flood risk assessments contain, however, considerable uncertainties. This is the result from uncertainties in the many different input parameters propagating through the risk assessment and accumulating in the final estimate. Whilst common in some other disciplines, full uncertainty and sensitivity analyses of flood risk assessments are not so common. Various studies have addressed uncertainties regarding flood risk assessments, but have mainly focussed on the hydrological conditions. However, uncertainties in other components of the risk assessment, like the relation between water depth and monetary damage, can be substantial as well. This research therefore tries to assess the uncertainties of all components of monetary flood risk assessments, using a Monte Carlo based approach. In this approach, the total uncertainty will be estimated and attributed to the different input parameters using a variance based sensitivity analysis. This helps to identify which parameters are most important when it comes to uncertainty in the final estimate and therefore deserves additional attention in research. On top of uncertainties in the current situation, future projections of flood risk contain additional

uncertainties because of climate change and socio-economic changes. The effect of uncertainties in these future developments is assessed in the same framework and their effect compared to existing uncertainties.

PDD9.1-03 CLIMATE CHANGE CHALLENGES REVIEW LEADING TO SUSTAINABLE SOLUTIONS IN NILE DELTA

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Throughout history, the Nile River has proved to be an immense asset to Egypt's agricultural and economic industries. Large amounts of water and sediment have produced rich soils that accommodated agricultural development. However, the Nile delta regions, which are regarded as the most fertile part of Egypt, are highly threatened by climate change. Sea level is already rising in the Nile delta due to a combination of factors including coastal seduction and reduced sediment loads due to the construction of the dams such as the High Aswan Dam. Climate change, induced sea-level rise, reinforces this trend. In addition to this, Egypt's infrastructure and development is along the low coastal lands. The loss of this land due to saline intrusion will therefore have a direct impact on different aspects e.g. groundwater salinization, social, economical, food security, water resources, land degradation and population distribution. A detailed examination of the current impact of sea level rise on coastal zones and the mainstreaming of adaptation responses efforts e.g. using artificial recharge of ground water, management of irrigation and drainage water and cultivating tolerant crops to saline water are reviewed and provided throughout the paper. This highlights and reviews different assessments of the potential impact of sea level rise in the near future. The paper briefly discusses the most important researches and studies which deal with the challenges and adaption strategies from different aspects.
Major findings of the review is that sea level rise might cause inundation of large areas which will result in migration of up to 3 million persons and loss of many economic activities that might result in major socio economic impacts unless serious adaptation measures are considered. The most practical solution is studying ground water salinization problem and providing new land use management plan for vulnerable community along the deltaic area to explicitly address long-term issues and, integrate this planning with short-term issues.

PDD9.1-04 IMPLICATION OF CLIMATE CHANGE IN THE DESTINATION PATH OF GBM BASIN

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Bangladesh is a lower deltaic country in the basins of the Ganges, the Brahmaputra and the Meghna (GBM), the largest basin in the world. Being located at the lower ends of the three major rivers and head of the Bay of Bengal,

the region faces severe threats of climate change (coastal zone is <10 m above MSL). In addition, poverty and higher dependence on climate sensitive sectors like agriculture are intensifying the vulnerability day by day. Intense and frequent cyclone with tidal surge, subsequent flooding, sea level rise, salinity ingression, extreme temperature and precipitation along with local problems like river erosion, water logging and weak institutional framework at local level makes the income and employment generating sectors more and more vulnerable in that region. Present alarming situation of food and livelihood security are forcing people to move permanently or temporarily for work in the urban centers. Questionnaire survey, personal interview and focus group discussion with local people and stakeholders is the basis of the current study, where present problematic situation faced by coastal communities have been reflected. The study will also make a critical discussion of the initiatives taken by government and NGOs in managing and adapting the changed situation and how it is influencing local people decision to stay in that place to adapt or move from the place to avoid the disastrous situation. Finally, it will discuss the lacking of policy initiatives by government to combat climate change and suggest strategies to bring all parties under the same umbrella toward a climate proof development.

PDD9.1-05 RURAL FARMING HOUSEHOLDS' ADAPTATION TO CLIMATE CHANGE IN THE NIGER DELTA REGION

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The Niger Delta region of Nigeria is characterised by unpredictable climate change events which affects the livelihood activities of the people of the region. Such climatic change include changes in rainfall patterns, incidents of drought and flooding which varies from year to year thereby causing agricultural stress for the farming household.This article examines using the Sustainable livelihood(SL) framework, the impact of climate change on the livelihood activities of the rural farming households. The aim of this research is two-fold (1) To examine the gendered impact of climate change on the rural farming household;and (2) to investigate and assess the differential coping strategies that both men and women in the rural farming households adopt in response to the problem. Data was gathered using the Focus Group Discussion (FGD) in three(3) States in the Niger Delta region. A gender perspective was applied in this study because of the gendered nature of livelihood generation as well as the differential impacts of climate change due to gender inequality. Publications and data on climatic variability and climate change were obtained for validity purposes.

PDD9.1-06 RESILIENCE AND CONTROL AS RATIONALES FOR FLOOD RISK MANAGEMENT

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The vulnerability of a social ecological system depends on its behavior under uncertain conditions. We define uncertain conditions to include both expected events where knowledge lacks on the timing or magnitude, and unexpected events. The system design influences the vulnerability of the system. For the management of flood risk we distinguish two basic rationales: system control and system resilience. To deepen the understanding of what these rationales imply we contrast the characteristics of both rationales based on a literature review. Next, we study to which extent the two rationales can be identified in Dutch flood risk policy to illustrate and further develop the contrast.

In a control rationale the aim is to reduce uncertainty to make the system more predictable, and thus prepare it for expected events such as peak river discharge. This enables efficient resource use under normal conditions, but reduces the system's potential to respond to surprises. In a resilience rationale the aim is to manage the system to cope with change und surprise, and the focus is on back-up mechanisms and quick adaptation to unexpected events. This strategy decreases the risk of system collapse, but also decreases efficiency for core activities and the reaction to expected disturbances.
Our literature review listed preferred system characteristics for resilience and control (see Table 1), which we made operational and applied to two Dutch flood policy documents: the Deltaplan of 1958 and the National Water Plan (NWP) of 2009. The Dutch flood policy is believed to have adopted elements of resilience recently, where historically it was dominated by control. This shift is confirmed in our analysis. The analysis discerns policy measures that contribute to resilience or control, while some measures contribute to both resilience and control on different indicators. We see a clear resilience rationale in, for example, the NWP's diversification of policy strategies (the strategies focus on embankment, spatial planning Ã¡nd disaster management), the involvement of stakeholders, and the focus on measures' flexibility. We see a clear control rationale in the Deltaplan's confinement of dynamics, the focus on central regulation and the refinement of policy to compensate for measures' adverse consequences rather than revision. In the NWP's new idea of a very broad Deltadike we find elements of both control and resilience: the over-dimensioning creates reserves, while future innovation is blocked by the inflexibility to revise the strategy.
The clear contrast of resilience and control indicators elaborated in this article facilitates an assessment of adaptation measures for the balance between efficiency and change coping ability.

For illustrations see website: www.climatedeltaconference.org/results

PDD9.1-07 FLOOD VULNERABILITY OF PORT INFRASTRUCTURE OUTSIDE PRIMARY FLOOD DEFENSES

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The government funded research programme "Kennis voor Klimaat"(Officially translated as Knowledge for Climate, see http://www.knowledgeforclimate.org) has defined several hotspot locations in the Netherlands that are especially vulnerable to the effects of climate change. The city of Rotterdam, and the Port of Rotterdam in particular, is one of these vulnerable hotspots. The Port of Rotterdam Authority participates in this research programme in cooperation with the municipality of Rotterdam, Water Boards and several private companies, including Royal Haskoning.
Climate change causes sea level rise. Some areas of the Port of Rotterdam are not defended by a (primary) sea defence system such as levees or flood gates. Several industrial facilities are located in these undefended areas. Future industrial facilities (these are to be built on newly created land) will also be located outside the primary sea defence system. The risk of flooding of undefended port areas is small because ground elevations are much higher than the ground elevation enclosed by the primary sea defence system, up to about 5m + NAP. It is expected that, due to sea level rise, the risk of flooding increases, especially in areas outside the primary sea defence system.
The undefended port areas are not surrounded by levees which can be easily raised, nor is it easy to raise the ground level of industrial built-up areas. Therefore, sea level rise predictions need to be taken into account in the establishment of a ground level elevation of new port areas already before construction. How to perform a flood risk assessment to establish the ground elevation of undefended industrial areas is the subject of this research. Also, the question has been raised what can be done in existing industrial areas to reduce the risk of flooding, and whether this is necessary. The paper will discuss the vulnerability of port infrastructure to flooding, with a focus on chemical plants. Vulnerability is defined as a measure of probability of severe damages to society, the environment, economy etc. due to accidents and damages as a direct result of flooding of a (chemical) plant. After this, a risk assessment methodology will be set-up and discussed in more detail, for which a chemical plant will be used as a starting point. Reference will be made to external safety standards of chemical plants as well as safety standards of flooding in other areas in the Netherlands.
The paper will present the methods and the overall result of the vulnerability assessment of port infrastructure in areas not defended by a primary sea defence system. It is believed that this risk assessment can be applied in port planning in Rotterdam, but also in other areas in the world where flood risk in port areas is significant. Especially for deltas in developed countries with a high concentration of industrial development, the present research will be more and more relevant.

PDD9.1-08 RISKS OF HIGH RIVER TEMPERATURES FOR ENERGY PRODUCTION UNDER FUTURE CLIMATE

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There is a growing concern that climate change will negatively affect the availability and quality of surface water for human use (e.g. agriculture, power generation, drinking water supply) and for freshwater ecosystems. Especially the expected increase in the frequency and intensity of climate extremes (e.g. heat waves, droughts) might have adverse effects for water use. Impacts of climate change and climate extremes on water resources have therefore been studied widely, but with a clear focus on water quantity aspects. In addition, it is also recognized that climate change and increases in the occurrence of heat waves will increase the risks of critically high water temperatures. This can have a direct impact on water quality and freshwater ecosystems and on the potential risks of cooling water shortage for industry and energy (thermal power). In addition, the quality of surface water for drinking water production could also be negatively affected by rising water temperatures.
The overall objective of this study is two-fold: 1) to assess the sensitivity of river temperatures to both atmospheric warming and changes in river discharge under climate change for major rivers globally; 2) to address the impacts of river temperature changes for energy (thermal power) production. To address these objectives, both an empirical and deterministic water temperature model are being developed and forced with future climate scenarios to produce projections of water temperature for large river basins globally for the current and future periods (2020s, 2050s and 2080s). These projections were used in combination with critical water temperature thresholds to address the implications for cooling water discharges (thermal power production) and drinking water production for a selection of river basins.
Results of our study showed that river temperatures are particularly sensitive to warm atmospheric conditions during droughts (low flow periods) when the thermal capacity of rivers is reduced. A sensitivity analyses showed that a combination of both atmospheric warming and decreasing discharges resulted in highest water temperature rises and probability of exceeded water temperature thresholds for cooling water discharges (thermal power production) and drinking water production. As the risks of droughts and heat waves are projected to increase due to climate change, periods where river discharge can significantly affect water temperature are expected to occur more frequently in the future. This is relevant as water temperatures can reach critically high values during these periods, with possibly negative environmental effects (e.g. exceeded water temperature tolerance values of freshwater species) and economical consequences (e.g. reduced cooling water potential for industries and thermal power plants). Impacts of

river discharge changes should thus be incorporated to provide more realistic estimates of river temperatures and the potential risks for energy production during historical and future projected dry, warm spells.

PDD9.1-09 FARM HOUSEHOLDS' VULNERABILITY TO CLIMATE CHANGE IN THE NIGER DELTA OF NIGERIA

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Climate change is currently an emerging problem in Nigeria. The Niger Delta region presents some vulnerability due to activities of some oil companies. This study provides an assessment of farm households' perception of climate change and vulnerability in the Niger Delta region of Nigeria. The data were obtained form 381 households that were randomly selected from 3 States in the Niger Delta region of Nigeria. The descriptive and Probit regression analytical methods were used. Results showed that only 20.21 percent of the farmers claimed to be adversely affected by climate change in the form of increased temperature, increased rainfall, delayed rainfall and deforestation. Farming households considered themselves vulnerable to climate change due to the nature of their primary occupation and lack of the required capital and skill for income diversification. In order to cope, majority of the respondents have resorted into weather monitoring, crop rotation and mixed farming. Also, results show that vulnerability tends to increase among those farmers that have land kept under fallowing, more livestock land, land problem, land conflict and recently sold land. It was recommended that efforts to sensitize the farmers on climate change and training on appropriate means of weather monitoring are required to reduce the negative effects of climate change, among others.

DD9.2-02 MONITORING EUROPEAN CHANGES IN EXTREME WEATHER AND CLIMATE EVENTS

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Changes in extreme weather and climate events are among the most serious challenges to society in coping with a changing climate. The sustainability of economic development and living conditions depends on our ability to manage the risks associated with extreme events.
For effective adaptation strategies, reliable and detailed knowledge of the behaviour of extreme values is required. In particular, the infrastructures we depend upon for food, water, energy, shelter and transportation are sensitive to high or low values of meteorological variables. Often, the motivation for analyzing extremes is to find an optimum balance between, on the one hand, adopting high safety standards that are very costly, and, on the other hand, preventing major damage to equipment and structures from extreme events that are likely to occur during the lifetime of infrastructure.
Climate change makes it likely that there are (or will be) some extremes that lie outside the envelope of constant variability assumed under stationary climate conditions. It is possible to account for this "non-stationarity", but the best way to do this is still under scientific debate. Nevertheless, adaptation strategies should begin to take into account the changes in extremes, both as observed and as projected. This paper deals with the former category. The key questions addressed are: what variations and changes in weather and climate extremes do we observe in Europe over recent decades, how certain are we about these changes, and are our monitoring systems adequate to address these questions?
The focus in this paper is on weather and climate extremes, which are defined as rare events within the statistical reference distribution of particular weather elements that are monitored daily, such as temperature, precipitation and wind. Monitoring information from the ECA&D and EURO4M projects will be presented.
ECA&D (European Climate Assessment & Dataset; eca.knmi.nl) provides vital ingredients for successful monitoring of climate extremes on a European scale. The project is embedded in worldwide activities that monitor extremes on the basis of station data. ECA&D is well on its way to becoming Europe's primary source of timely and reliable information about the state of the climate.
EURO4M (European Reanalysis and Observations for Monitoring; www.euro4m.eu) is a new EU-FP7 funded project for which KNMI is the coordinator. The aim of the project is to describe the evolution of Earth system components by seamlessly combining two different, but complementary, approaches: regional observation datasets of Essential Climate Variables (ECVs) – such as those provided by ECA&D – on the one hand, and newly developed (model based) regional reanalysis on the other.
Both ECA&D and EURO4M address the situation of fragmentation and scarcity of long-term climate change monitoring information for Europe. Both projects respond to the need for information about extremes at the appropriate level of aggregation - and even provide online reporting during emerging extreme events.

DD9.2-03 ECONOMIC MOTIVATION OF HOUSEHOLDS TO UNDERTAKE PRIVATE PRECAUTIONARY MEASURES

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A weakening of the trend of increasing flood losses can only be achieved by means of a significantly improved flood risk management, which besides public efforts like technical protection measures and increased natural retention, will also include improvements of the mitigation potential of private households. To gain more knowledge about the benefits and costs of household precautionary measures, telephone interviews with private households were undertaken in the Elbe and Danube catchments in Germany after the flood in 2002 and again after the floods in 2005 and 2006. For this study about benefits and costs of private precautionary measures, only detached, solid one-family houses were analysed, based on 759 completed interviews. Our comparison of benefits and costs shows that large investments, like the building of a sealed cellar, are only economically efficient, if the building is flooded very frequently (annually), thus built in highly endangered areas. In these situations it would be better not to build a new house, or at least built a house without a cellar. In contrast are small investments in existing buildings. For instance, the installation of an oil tank protection can prevent an enormous damage to house and environment. This investment is still profitable, if the building is flooded on average every 50 years, only. To further improve flood risk management, the motivation of people to invest in precaution should be improved also via financial incentives.

DD9.2-04 AMPHIBIOUS BUILDING: A NEW STRATEGY TO REDUCE VULNERABILITY TO EXTREME FLOODING

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Current evidence of global climate change is giving rise to predictions of increases in both the frequency and severity of urban flooding in deltaic regions. It is imperative to find new approaches to urban flood mitigation that can reduce vulnerability and enhance resilience by providing sufficient protection to avoid catastrophic damage during extreme events, without disrupting the existing social and physical structures of established communities. Building on amphibious foundations is such an approach.

Amphibious foundations are a proven, cost-effective strategy appropriate for housing in areas where extreme flooding is not accompanied by high flow velocities. There is growing awareness that homeowners in established urban communities such as New Orleans are resistant to the daily inconvenience of stairclimbing, the disruption to a neighborhood's appearance, and the lack of sufficient protection in an extreme flood event that are characteristic of permanent static elevation. This is especially so because of clear recognition that the benefit of reduced risk comes only at the cost of increased inconvenience and reduced neighborhood cohesion. It is a price that many displaced New Orleanians are not willing to pay, to the extent that they choose not to return to a home where their only options are either unmitigated vulnerability or unacceptable inconvenience.

Amphibious foundation systems provide an alternative. They retain a home's close proximity to the earth and relationship to the street by supporting the house at a slightly raised elevation under normal circumstances; yet, when extreme flooding occurs, they are capable of floating the house to as high a level as is necessary to remain safely above water. Successful amphibious foundation systems are functioning in Maasbommel, Netherlands, and at Raccourci Old River, Louisiana, where they provide flood protection that is both more reliable and more convenient than can be obtained from permanent static elevation. Two amphibious houses have recently been completed in New Orleans, and a prototype amphibious house for slum dwellers has just completed construction in Dhaka, Bangladesh. The Buoyant Foundation Project for retrofitting existing traditional housing in New Orleans with amphibious foundations is currently under development.

The use of amphibious foundations is a safe, permanent, sustainable approach providing proven, low-cost, low-impact flood mitigation that can protect established communities and cultures in the face of impending environmental changes. It increases a flood-prone community's resilience by diffusing risk rather than concentrating it. Amphibious building is a strategy that encourages an attitude of accommodating, rather than fighting, water. For coastal cities to achieve long-term survival in the face of extreme weather events spurred by global climate change, we must find ways to reduce vulnerability while living with more water. This challenge of living WITH water is one shared by deltaic communities around the world. Why must we fight floodwater when we can float on it?

DD9.2-05 FLOOD RISK DEVELOPMENTS AND ADAPTATION STRATEGIES IN THE RHINE-MEUSE DELTA

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With almost 9 million inhabitants the Rhine-Meuse delta is a densely populated area. It is also very important from an economic perspective, as up to 65% of Dutch GDP is produced here. The delta faces flood risks from both its rivers and the sea. Even though a substantial part of today's delta is already below sea level, the current risk of flooding mainly originates from its rivers, since river embankments have lower safety levels than coastal protection. Estimating (future) flood risk, defined as probability x damage, requires insights in both flooding probabilities and potential consequences. Changes in both of these parameters are expected in the future, which will increase overall flood risk. Urbanization and industrialization are projected to intensify in the delta's flood prone areas, thus enhancing potential damage. As a result of climate change, extreme peak discharges, and consequently flooding probabilities are also expected to increase. Against this background, a better understanding of the scale of these future flood risk increases is required. For the development of possible adaptation strategies it is important to comprehend the independent contributions of the main driving forces to the overall increase in risk. Since flood management strategies in the upstream parts of the basins can have a significant effect on flood risk in the delta itself, it is important to take the entire basin into account.

To estimate current and future flood risk we apply a uniform flood risk model for the rivers Meuse and Rhine and their delta. Our risk model combines information on flood probabilities and flood damage estimations, using two different climate change and socioeconomic scenarios. The change in the frequency of return periods corresponding to specific inundation scenarios are estimated by applying extreme value analyses to the output of hydrological models driven by climate scenarios data. Changes in land use as a result of socio-economic developments are derived from the 'Land Use Scanner' model. This GIS-based economics-oriented probabilistic model uses a logit-function to simulate demand for, and supply of, land in an iterative process. To estimate potential flood damages the information on land use (change) and inundation depths are combined by using depth-damage functions. By integrating both climate change and socio-economic scenarios we are able to discriminate the independent contribution of the two driving forces on overall flood risk. The model will also be used to evaluate the effectiveness of different adaptation strategies in terms of risk reduction.

The EU flood directive 2007/60/EC asks member states to consider the impacts of water-related or spatial policies and to evaluate risk management plans against the background of climate change (preamble 9 and14). The applied risk model allows assessing the impacts and long-term effectiveness of various flood management policies, ranging from spatial and non-structural to structural measures and thus contributes to the aims of the EU-flood directive. Furthermore, the derived insights are also indispensable to facilitate cooperation between upstream and downstream stakeholders and to inform the population at risk.

DD9.2-06

REGIONAL ECONOMIC EFFECTS OF FLOODING

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Problem definition
The paper evaluates regional flood risk effects of water safety policy options, assessing both flood probability and monetised flood damage to arrive at estimations of changes in flood risk. A case study is investigated in the Greater Rotterdam area. This urban conurbation was classified by the OECD as one of the largest low elevated conurbations in the world in terms of capital at risk. The area is protected by a flexible dam that can be closed during extreme weather events called Maeslantkering. Climate change will expectedly force port management to close the Maeslantkering dam with increasing frequency. However, closing the dam involves considerable loss of turnover for the harbour and cargo sector. Alternative policy options are therefore considered too. The first alternative is accepting a higher probability of floods while minimising the damage effects of floods in the surrounding area. A second alternative tot higher dam closure frequency involves construction of dikes around the area about ten times wider than current dikes.

Theoretical framework and methods
The impact of climate change on flood probabilities in the Greater Rotterdam region is estimated for the identified policy alternatives using the model PC-RING. This way the net effect of climate change and water safety policy can be assessed, assuming for 2050 (relative to 1990) 2 degrees average global temperature rise, 0,4 m sea level rise, 1 percent increase in average wind speed and maximum water discharge in the Rhine basin of 17.600 m3/s.
Concerning flood damage, the Dutch Ministry of Transport, Public Works and Water Management uses the flood damage model HIS-SSM to estimate the number of victims, physical damage and production loss. HIS-SSM limits its analysis to the inundation period due to a flood. However, major floods can lead to rather long term shocks in the economy due to indirect effects on product, housing and labour markets. The RAEM model, a spatial computable general equilibrium (SCGE) model for NUTS3 regions in the Netherlands, is applied to calculate total and indirect effects of flooding based on the HIS-SSM assessment for 25 flooding scenarios.

Results
Expectedly, flood risk will have doubled by 2050 in comparison to 2008, provided there will be no additional safety measures and currently planned maintenance works will be carried out. From the considered policy alternatives, only construction of wide dikes results in a net decrease of flood risk. Increase of dam closure frequency and minimisation of flood damage effects do not compensate completely for the autonomous increase in flood risk caused by climate change. Indirect economic damage of floods can account for up to about 55 percent of direct flood damage. The flood damage assessment shows as well regional dispersion of flood damage over time and expected (small) benefits in regions with sector specialisation identical to the flooded region.

Deltas in Depth Theme 9: Managing risks of extreme climate events
Session DD 9.2: Managing climate extremes in practice **ORALS**

DD9.2-07 FLOOD RISK MANAGEMENT IN JAKARTA

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Flood damage constitutes about a third of the economic losses inflicted by natural hazards worldwide, and is high on the agenda in climate change research. Cities are particularly vulnerable to floods as they have high population and infrastructure densities. As a result of expected future environmental and socioeconomic changes, the vulnerability of coastal cities to both coastal and riverine flooding is expected to increase in the coming decades. There is an increasing awareness that cities need to proactively adapt to these changes in order to reduce flood risk. Jakarta, the capital and largest city of Indonesia, is a case in point. This mega-city of ca. 9 million people, located in the Ciliwung Delta, has faced several major floods in the last decade, causing billions of dollars in damage. Large areas of the northern part of the city already suffer regular inundation as a result of monthly high-tides under current conditions, even without considering future climate change. Two important issues for flood risk management in Jakarta are: (a) assessing the flood risk under current and future conditions; and (b) assessing the capacity of the cities' governance structure to manage that risk. We here present the results of ongoing research into these two questions.
In order to assess the current and future coastal flood hazard we have set up a GIS-based flood model of northern Jakarta (population ca. 2 million), to simulate inundated area and the value of exposed assets under current conditions and future scenarios of climate change and land subsidence. Under current conditions, the damage exposure to extreme coastal flood events with return periods of 100 and 1000 years are high, at ca. 4.0 billion and 5.2 billion respectively. Under the scenario for 2100, the damage exposure associated with both of these events increases to almost 17 billion, with hardly any difference between low or high sea level rise scenarios. This increase is mainly due to rapid land subsidence, and excludes increased exposure due to socioeconomic developments. In parallel to this activity, we are setting up a rainfall-runoff model to simulate the impacts of climate and land use change on river discharge through Jakarta.
Clearly, urgent adaptation measures are required to address this problem. The Jakarta city government is currently working towards a plan for flood risk management. Based on a literature review, we will identify several governance lessons that can benefit a successful paradigm shift from traditional flood protection to integrated flood risk management, and examine the opportunities and bottlenecks for implementing these in Jakarta. Flood risk will be placed in the wider framework of climate proofing of the Greater Jakarta area. The project links up with the recently established Delta Alliance in which deltas facing climate change cooperate to share and exchange knowledge.

DD9.2-08 HAMBURG'S COASTAL FLOOD DEFENSE STRATEGY IN AN INTERNATIONAL CONTEXT

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There is accumulating evidence that rising sea levels are threatening coastal regions, especially cities, which are located in estuaries and river deltas. Heightening of the primary flood protection structures like sea dikes and barriers in city areas often causes problems due to a small availability of space. In order to face the challenges of rising sea levels, adaptation strategies are needed that fulfill both criteria a very high safety standard on the one hand and a small demand of space on the other hand.
The Free and Hanseatic City of Hamburg Agency of Roads, Bridges and Waters (LSBG), is responsible for the public coastal protection facilities in the Hamburg region. At the LSBG a study has been carried out, in order to compare the different flood protection strategies in Belgium, the Netherlands, United Kingdom and Denmark. It was aimed to investigate how coast protection is organized with respect to the responsibility of governments, safety levels and design methodologies nowadays and in future.
The study shows that countries along the North Sea Coast apply a variety of different coast protection strategies. Some of them are based on statistical analysis; others follow the deterministic approach or a combination of statistical and deterministic methods. Not only the design methodologies, but also the intended safety levels differ between the countries. In some countries, the degree of safety against flooding in coastal regions is determined by law.
In most of the investigated regions, local authorities plan to increase their level of flood protection due to climate change and expected sea level rise.
The presentation will give a short overview of the present coast protection strategies applied by cities along the North Sea coast and how the different countries aim to adapt to increased challenges due to sea level rise in future. It will be shown how the flood protection agencies of the city of Hamburg are going to react to the challenges caused by climate change.
The strategy of the Hamburg flood protection agency contains of a combination of different measures to withstand rising flood tides, such as dwelling mounts, dikes, seawalls, barriers and even adapted historic buildings. All measures of the 100 km of primary dikes and 77 structures must provide the full safety level without a main storm surge barrier in the river Elbe. Reaching a high safety level for the whole city behind the primary flood protection structures has highest priority.

DD9.2-09 ADAPTATION OF SPATIAL PLANNING SYSTEM FOR URBAN DISASTER PREVENTION IN TAIWAN

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Taiwan is situated in a region most exposed to multiple hazards, with 73% of the population living in more than three natural disaster impact zones (World Bank, 2005). About 70% of the population lives in areas which occupy less than 20% of the total land area and which are most at risk from earthquake, flood and landslide. Therefore, disaster management becomes an important issue for urban planning and the review of development projects in order to reduce risk.

Taiwan has established a spatial planning system for urban disaster prevention. The system incorporates scenario setting, risk estimation, supply-demand analysis of public facilities, disaster mitigating measures and strategy formulation so as to provide an advanced planning procedure and evaluation methods for allocating shelters, rescue sites, emergency road network, logistics, and so on in responding to natural hazards. It includes procedures and methods that combine the spatial system with multi-hazards risk analysis.
Due to its geographic characteristics, Taiwan is very sensitive to the changing climate and there has been research on the simulation of the impact of future climate change on Taiwan (GCRC, 2008). The major phenomena include temperature rise, precipitation change, high variation, extreme weather events, and sea level rise. These phenomena could increase the frequency and magnitude of natural hazards and bring about significant disaster. In order to strengthen the capacity of urban areas to adapt to extreme weather events, this paper reports on new research on the possible consequences of urban hazards under climate change, and the adjustment and future direction of the spatial planning system for urban disaster prevention. The elements of climatic risk can be involved to the process for the purpose of reducing the possible loss and damage. While in the effort of developing sound planning process, scientific simulation and impact assessment information should be well prepared for the reference and the public awareness should be promoted through efficient participation design.
The paper will explain the components of the planning system, the procedures, methods and demonstration projects on urban disaster reduction in Taiwan, in the context of increasing risk. With the consideration of the impact of climate change, the paper will propose some adjustments for the original process by means of the conjoint analysis and discuss its limitations and recommendations for further testing.

DD9.2-10 BEST PRACTICES FOR SAFE AND SUSTAINABLE DEVELOPMENT OF URBANISED DELTAS

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The disaster caused by Hurricane Katrina along the Gulf Coast in August 2005 has triggered a US Army Corps study on the possibilities for protection and restoration of the Louisiana coastline (LACPR). The experience from the Netherlands was requested as one component in this larger study by the Corps and resulted in the report 'The Dutch perspective on coastal Louisiana flood risk reduction and landscape stabilization'. This study attempted to translate the Dutch experience, which was gained after the 1953 storm event in the south-western part of the Netherlands, to the Mississippi delta. As such, this study identified best practices applicable for the situation in Louisiana.
Also in response to Hurricanes Katrina and Rita in 2005, the state of Louisiana initiated work on two major award winning planning efforts, both unprecedented in US history. The Comprehensive Master Plan for a Sustainable Coast, focused on integrating coastal restoration and hurricane protection. Working in partnership with the LACPR study and utilizing the Dutch input to the LACPR, Louisiana's Master Plan was completed in early 2007. The results of the Master Plan formed the first layer of Louisiana Speaks: A Regional Vision. This regional plan, also completed in 2007 and focused on growing smarter, recovering sustainably, and thinking regionally. The Louisiana Speaks plan was the first regional land use planning effort conducted in Louisiana and had the largest outreach effort in United States history with input from 27,000 citizens.
Following the above planning and technical efforts, ongoing research on best practices was carried out and a joint Dutch-American initiative worked out a matrix on the evolution of best practices in both the SW Delta in the

Netherlands and the Mississippi Delta. This matrix describes the developments in safety, nature awareness, socio-economics, institutional setting and planning approach before the storm events took place, immediately after, at present and as foreseen for the future. The results have been discussed at the National Planning Conference in New Orleans (APA, 2010).
As a next step to this search for learning experiences and best practices, the matrix has been extended to a few other urbanized and vulnerable delta regions that are affected by extreme weather events: Metro Manila region (Philippines), Red River Delta (Vietnam), Jakarta (Indonesia) and Andhra Pradesh (India). It was recognized that the best practices evolve in time and that their applicability strongly relates to the local situation (state of development, land use planning and the institutional setting).
Although there is no general recipe on how to best deal with extreme weather events some broad perspectives are distinguished related to preparedness and improved risk management. Examples are: improving the resilience of delta areas, upgrading of ageing infrastructure, preparing disaster management and climate adaptation plans and improving coastal erosion management.
The paper will discuss the above in relation to dealing with evolutionary best practices on safe and sustainable development of urbanized deltas.

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