BUILDING ADAPTIVE CAPACITY FOR FLOOD PROOFING IN URBAN AREAS THROUGH SYNERGISTIC INTERVENTIONS

W Veerbeek[1,2], R M Ashley[1], C Zevenbergen[1,2] , J Rijke[1,2], B. Gersonius[1]

1.Flood Resilience Group, UNESCO-IHE Institute for Water Education, Westvest 7, Delft, 2611 AX, the Netherlands.
2. Delft University of Technology, Stevinweg 1, Delft, 2628CN, the Netherlands

ABSTRACT

Few, if any urban areas are nowadays built in isolation from existing developments. Therefore, urban expansion and making existing urban areas more sustainable is a contemporary goal. There are major opportunities to do this through the 'normal' renewal of urban infrastructure and building stocks both now and in the future. However, significant building renewal cycles occur every 30-50 years and major infrastructure renewal cycles at even longer timescales of more than 100 years. Despite this there are significant opportunities to make buildings and infrastructure more resilient to external stress (an easier to realise goal than sustainability) beginning immediately. The challenge is to change the current norms for owners; urban planners; builders; professionals and policy makers to accept the need and urgency of doing this. Given the pace of climate and other changes and the need to manage carbon and energy better, there is an urgent need to begin to incorporate flexible, adaptable and more resilient measures by synergistic inclusion within refurbishment and renovation programmes. This needs to be recognised and planned as soon as possible, so that inclusion of such measures becomes the norm. Failure to do this will miss vital and unique opportunities that will hinder the delivery of carbon reduction targets. This is illustrated in the paper by recent studies in the Netherlands that have mapped urban flood and heat island vulnerabilities and identified where adaptive potential can best be targeted at the current building stock through refurbishment, renewal and regeneration and by reference to the latest developments in England and Wales.

KEYWORDS

Adaptation; climate proofing; flood risk management; redevelopment;

INTRODUCTION

The challenges of climate change uncertainty and now, economic uncertainty together question the capacity of human settlements to continue in their current form. In the so-called developed world, 'smarter' urban areas are needed that can adjust to rapidly changing external drivers (e.g. Litman, 2010) and there has to be a recognition that water in cities especially needs to be considered as a '*dynamic system*' that is changing relatively rapidly (Mayor of London, 2009). Keeping up with the external system changes, like climate, is a major challenge for policy makers and city planners and may lead to '*maladaptation...likely given the time lag between changes in climate and changes in institutions*' (Barnett & O'Neill, 2010). Whereas adaptability may be defined as: '*those characteristics of a plan, strategy or scheme that sustain and enhance the function of a system in the face of continuing change or uncertainty. Adaptability is about building in flexibility, not closing off future options prematurely but enabling evolution of both the strategy or scheme, and also the function of the system'* (Defra, 2010). Adaptability of what? In this case of our urban environments; to make them more resilient to future shocks, either short or longer term.

There are many opportunities to intervene in our urban areas to make them more resilient and recent ideas call for: "*..new forms of adaptive governance that go beyond the conventional notions of urban adaptation planning...to move from the dominant focus on physical structures towards the improvement of planning tools and governance processes and structures themselves"* (Birkmann et al, 2010). It is possible to envisage a host of structural and non-structural options for new developments within and on the fringes of urban areas, for example, greening infrastructure (GI) and development in general, part of a growing vision that is equally applicable to dense urban areas or more rural settings (e.g. Natural England, 2009; Matel, 2010). There are also new tools emerging to evaluate the monetary value of implementing GI over and above the primary infrastructure function (Center for Neighborhood Technology, 2009). Much of this is also applicable to retrofits, redevelopment and regenerating areas rather than 'green field' developments on previously undeveloped parcels of land. In most existing urban areas, there is a continual turnover of existing property and infrastructure; which is renewed, replaced or enhanced in processes of rehabilitation and renovation. The opportunities this affords for greening and climate proofing urban areas as part of a resilience enhancing process is a key element of adapting to cope with an uncertain future. Many such adaptations, which may include climate proofing measures, can be effected synergistically with 'routine' redevelopment and enhancement of existing urban areas. However, there is still a 'silo' mentality in which those responsible for buildings (and also researching) consider only certain aspects of climate proofing, particularly related to energy and heating/cooling (e.g. Jentsch et al, 2008) rather than looking at climate proofing as a whole. This paper considers opportunities to climate proof urban areas in England and in the Netherlands, illustrating opportunities arising from the autonomous renewal and development cycles for properties and neighbourhoods.

LINKING URBAN RENEWAL WITH ADAPTATION

England

Despite many studies in England into flood risk, climate change, vulnerabilities and how best to respond to future challenges (Thorne et al, 2007; Pitt, 2008) that have pointed to the need to make urban areas more adaptable to cope with future risks, the significant disjoints between the responsibilities for acting between the various Government departments and regime players and for joining together the various threads of mitigating and adapting to future climate change impacts make this seemingly impossible. For example, the Department for Energy and Climate Change (DECC) concentrates on carbon reductions and has no reference to flooding in any documents although it does deal with carbon target setting for building and infrastructure development and hence (by implication) any carbon implications of flood defences. Issues of property planning related flood risk management are handled by the Department of Communities and Local Government (DCLG) who deal mainly with the built environment, urban form and healthy living. There is also involvement of the Department of Business Innovation and Skills (BIS) and the Department of Environment, Food and Rural Affairs (Defra), the latter being the parent department for one of the largest UK Quangos[1], the Environment Agency (EA), who oversee pollution control and all aspects of flood risk management and advise Defra on related matters. Defra has recently published its' plans for climate change that include a vision for sectoral adaptation (Defra, 2010). However, as DCLG has responsibility for urban planning, a more consensual and joined-up approach is required across these key Departments dealing with urban development, which is still awaited.

In England the planning of urban areas is undertaken by municipalities under the auspices of DCLG and flood or climate proofing is not a main consideration, although there is strong guidance that discourages building in flood plains, known as Planning Policy Statement No. 25 (PPS25) (DCLG, 2009) and current consultation about planning for a changing climate *for new developments* (DCLG, 2010). There is also a lot of pressure to reduce carbon emissions as part of a climate change mitigation perspective. There are, however, national indicators (NI188 and NI189, dealing with Adapting to Climate Change and Flood and coastal erosion risk management respectively) that have to be used as guidance and reported on. NI188 is of most interest here (LRAP, 2010) as it identifies the need for building adaptive capacity; albeit in this context it deals with knowledge and people. Post-flood recovery from major events is seldom encouraged to include climate proofing measures, largely because the insurance industry in the UK (which insures the majority of properties) discourages any restoration differently to the state of the properties compared with the pre-flood condition; i.e. wasting an opportunity to fit flood proofing measures at less cost (ABI, undated). There is guidance on how best to climate-proof new homes (e.g. WWF, 2008) and the need to build in adaptation potential is recognised for new housing in London (Mayor of London, 2009) but there is a lack of guidance for adapting existing properties.

Much of the renovation and rejuvenation of properties in England and Wales is the responsibility of municipalities and for social housing; housing associations. For example, the recent 'Schools for the Future' programme, under yet another Government department, the Department for Education and Skills (DES) provided opportunities to include climate-proofing and more contemporary ideas about adapting to climate change (NAO, 2009). Sadly, this was not considered in many instances, and a traditional approach to building and renovating existing schools was more often taken with scant regard for the additionality of either building in adaptation capacity or resilience. There were notable successes; however, for example in the East Riding of

[1] Quasi non-Governmental organisation (the EA has more than 13,000 employees and a budget in excess of £1bn) [http://www.guardian.co.uk/news/datablog/2009/jul/07/public-finance-regulators accessed May 2010]

Yorkshire, specific retrofit measures were implemented to manage surface water runoff from schools in the programme to the benefit of others in the catchment downstream.

Statistics for renewal of urban built areas are difficult to find for the UK (the DCLG web link to housing statistics has been suspended) and even the DCLG Housing Market Renewal Programme provides information only that as a result of the renewal programme some 59,000 properties were refurbished and 3,700 new properties built in the past decade; out of a total of some 846,000 eligible dwellings (in 2005) (DCLG, 2007); i.e. a tiny amount. There is no mention of the need to provide adaptable provision within these renewals and the only 'climate' mentioned is that of economic uncertainty.

Retrofitting the UK housing stock has been seen as a means of achieving carbon reduction targets and specific initiatives have been set up for this, although the economic situation in the UK is now hindering delivery (Duxbury, 2010). Nonetheless there seems no attempt to link these initiatives with wider aspects of climate proofing and flood risk management is not included in efforts to reduce energy and greenhouse gas emissions. The evidence suggests that because of the plethora of Government departments, agencies, short-term initiatives and organisations, a comprehensive and integrated approach has not been achieved or even envisaged in England. This is despite calls for this: "*...we may also want to ensure that a broader range of infrastructure and buildings is capable of adaptation, considering adaptation pathways, so that retrofit or replacement is not costly and difficult at a later stage as impacts become clearer and more immediate. Public attitudes may limit acceptability of high levels of early adaptation*" (DCLG, 2010). There have been plans to establish a Retrofit Consortium to oversee the adaptation of existing building stocks in England, but it is not clear whether or not this would intend to establish 'adaptation capacity' rather than simply to adapt existing buildings and properties. The subtle distinction is the ability, or capacity of the existing building stock to be further adapted in the future once knowledge about future drivers develops; i.e. not just being adapted to what is believed now to be the future challenges of climate and other changes.

The estimated damage costs for various socio-economic scenarios and for flooding in rural, coastal and urban areas in England and Wales were estimated in the Foresight study (Evans et al, 2004) and recently re-appraised as possibly being even more damaging than as given in Table 1 (Evans et al, 2008). The intra-urban flooding presented in the Table refers only to pluvial flooding damage. An explanation of the four socio-economic scenarios is given in the Evans et al (2004, 2008) references, or Tait et al (2008) but each refers to a logical and consistent view of socio-economic conditions in the UK in 2080s.

Table 1 flood damage costs in England and Wales under different socio economic scenarios (£M per annum)

Risk	2004	Socio-economic scenario			
		World markets	National enterprise	Local steward-ship	Global sustainability
Fluvial and coastal flooding	1040	20500	1550	1500	4860
Coastal erosion	14	126	87	51	46
Intra-urban flooding	248	7223	4634	678	1714

The potential damage costs given in Table 1 can be offset by measures taken in response to these risks. However, the Foresight study and follow-up in 2008, showed that much of the risks cannot be dealt with by conventional measures such as defences and/or larger storage areas (above or below ground). Alternatives are required, including climate proofing buildings in an integrated way, dealing with all of the drivers from climate change (Thorne et al, 2007), extremes of: heating; cooling; water stress; water excess; winds and social, environmental and economic impacts from this (Van Nieuwkerk et al, 2010). Recent adaptation approaches in England and Wales focus on traditional infrastructure, although the recommendations advocate the use of 'Real Options' (Gersonius et al, 2010) in order to determine the value of staged adaptation. However, the guidance (HM Treasury, 2009; Defra, 2010a) does not provide enough information to implement the suggested approach.

The Netherlands

Climate adaptation is historically focussed on flood management in the Netherlands because of the country's location in the delta of the rivers Meuse and Rhine. In 1993 and again in 1995 the rivers Meuse and Rhine almost flooded the country. These near-misses acted as 'wake up calls' and a few years later hurricane Katrina fed the debate in the Netherlands on the limitations of trying to control extreme events by technical means alone, and also drew attention to the challenges posed by the increasing value of property investments in the lowest lying parts of the country. In that same period, a nationally Integrated Water Management Strategy (WB21) (Room for Water, damage reduction through planning and zoning) resulted in a new policy that advocated the transition from the traditional focus on probabilities of flooding towards a more integrated approach. Nonetheless, the huge levels of investment in developments and dependence on existing flood defence systems in the most densely, low lying Randstad (conurbation area in Western Holland) of the Netherlands is now so high that options for change in approach are severely limited. The inability to change is also as a consequence of the strong regime interconnectivity between water institutions, management structures, routines and infrastructural entrapment that exists in the Netherlands. Although much emphasis is placed on the institutional integration of spatial planning and water management, the actual implementation in the Netherlands of the resulting integrated plans is constrained (van der Brugge et al., 2007)). In 2007 the Dutch government launched the National Adaptation Strategy entitled ‘Making Space for Climate’ and also several sector plans including a national plan for heat waves (VWS, 2007) and a state advisory commission, the so called ‘Delta Commission’ (DC, 2008).

The Delta Committee has concluded that a possible relative regional sea level rise of 0.65m to 1.3m by 2100, and of 2m to 4m by the year 2200 should be taken into account. This includes the effect of land subsidence. These rises represent plausible extreme values based on the latest scientific insights (DC, 2008). It is recommended that these be taken into account so that the decisions that are made and any response measures will have a lasting effect, when set against the background of what can be expected for the Netherlands. For the Rhine and the Meuse rivers, it is expected that the summer discharge rates will decrease and winter discharge will increase due to temperature increases and changed precipitation patterns. By the year 2100 or so, the maximum (design) discharges of the Rhine and Meuse are likely to be around 18,000 m^3/s and 4,600 m^3/s, respectively. Present design discharges are 16,000 m^3/s and 3,800 m^3/s. A rising sea level, reduced river discharge in summer, salt water intrusion via the rivers and ground water, all put pressure on the Netherland’s drinking water supply, agriculture, shipping and those sectors of the economy that depend on water, for cooling or otherwise. The decision of whether to build in low-lying flood-prone areas must be based on a cost-benefit analysis to include present and future costs for all parties. Costs resulting from local decisions must not be passed on to another administrative level, or to society as a whole. They must be borne by those who benefit from these plans. The present flood protection levels of all diked areas must be raised by a factor of 10. To that end, the new standards must be set as soon as possible (around 2013). In some areas where even more protection is needed, the Delta Dike concept is promising (these dikes are either so high or so wide and massive that the probability that these dikes will suddenly and uncontrollably fail is virtually zero). With regard to specific or local conditions, this will require a tailor-made approach. All measures to increase the flood protection levels must be implemented before 2050.

Traditionally, Dutch urban planning is largely government controlled. Through a series of tightly integrated planning instruments, National spatial policies are distributed top-down to municipal level. Contrary to many other European countries, more than half of the Dutch housing stock is owned by semi-privatized housing corporations (although this figure is even higher in the UK). Over the past decades the level of government control has reduced and housing has been left to market conditions. This is to some extent due to the changing role of government; which no longer operates in project development and financing. Except for a normative framework of planning and building regulations, a streamlined adaptation of new climate proofing policies is therefore hampered by this lack of central direction. Normative frameworks for climate mitigation are limited to the National building codes that provide standards for energy efficient building (EPC and EPN-norms) which extends the European Energy Performance of Buildings Directive (EP, 2002). Specific climate mitigation measures are mostly facilitated through a series of incentives (e.g. tax refunds) by national and local programmes. National programmes on climate adaptation are absent although some municipalities in combination with local Water Boards are initiating pilot projects that offer a sewage tax reduction to homeowners when utilising ‘green roofs’; although this has little effectiveness in reducing flood risk. Widespread use of these programmes is limited partially due to the complex refund procedures.

BRINGING RENEWAL TOGETHER WITH CLIMATE PROOFING

While many metropolitan areas in developing countries are growing rapidly, the urban extent of most European and North American cities remains relatively stable. This apparent stability hides considerable change; for example, the ECTP (2005) estimated that within 30 years about one third of the building stock in European cities will be renewed. This substantial renewal operation covers many post-1945 neighbourhoods comprising low-cost social housing areas that were not built to what is now accepted to be current and likely future standards. Within the often historically and functionally mixed downtown areas in European cities, this renewal will concentrate on the replacement of large numbers of unique and individual buildings. Since urban refurbishment is largely dependent on market conditions, ownership distribution and governmental incentives, the actual rate and extent of redevelopment varies locally and will be influenced strongly by the economic crisis post 2008. Although currently many buildings and urban neighbourhoods are coming to the end of their intended lifespan, urban refurbishment of especially low cost housing areas is often being postponed (Boelhouwer and Primus, 2006). Furthermore, the economic crisis has led to the postponement of many planned redevelopments. Yet, the urban redevelopment agenda towards greater resilience is likely to be inevitable and will change the character of European cities significantly.

Globally, major weather-related natural catastrophes have increased significantly, from about 1.5 in the 1950s now to more than 4.5 per year. Storms and floods are the most frequent and costly extreme weather events occurring in Europe, representing 77% of the economic losses caused by weather-related disasters between 1980 and 2006 (or 69% of overall natural catastrophic losses), with, for example, floods causing around € 15bn of economic damage in 2002 (CEA, 2007). As illustrated for the UK and the Netherlands above, many cities bear the brunt of impacts from these natural hazards with economic damage increasing year on year. In combination with climate change, the physical characteristics of these cities often exacerbates these problems. This pertains especially to downtown commercial areas. These generally have a high building density, expressed in a large floor area ratio in relation to land area and in combination with substantial soil sealing with impermeable surfaces due to infrastructural demand. Heat stress, flooding and drought tend to concentrate mainly in these downtown areas, for which impacts are higher because of population and asset concentration (Nicholls et al, 2008).

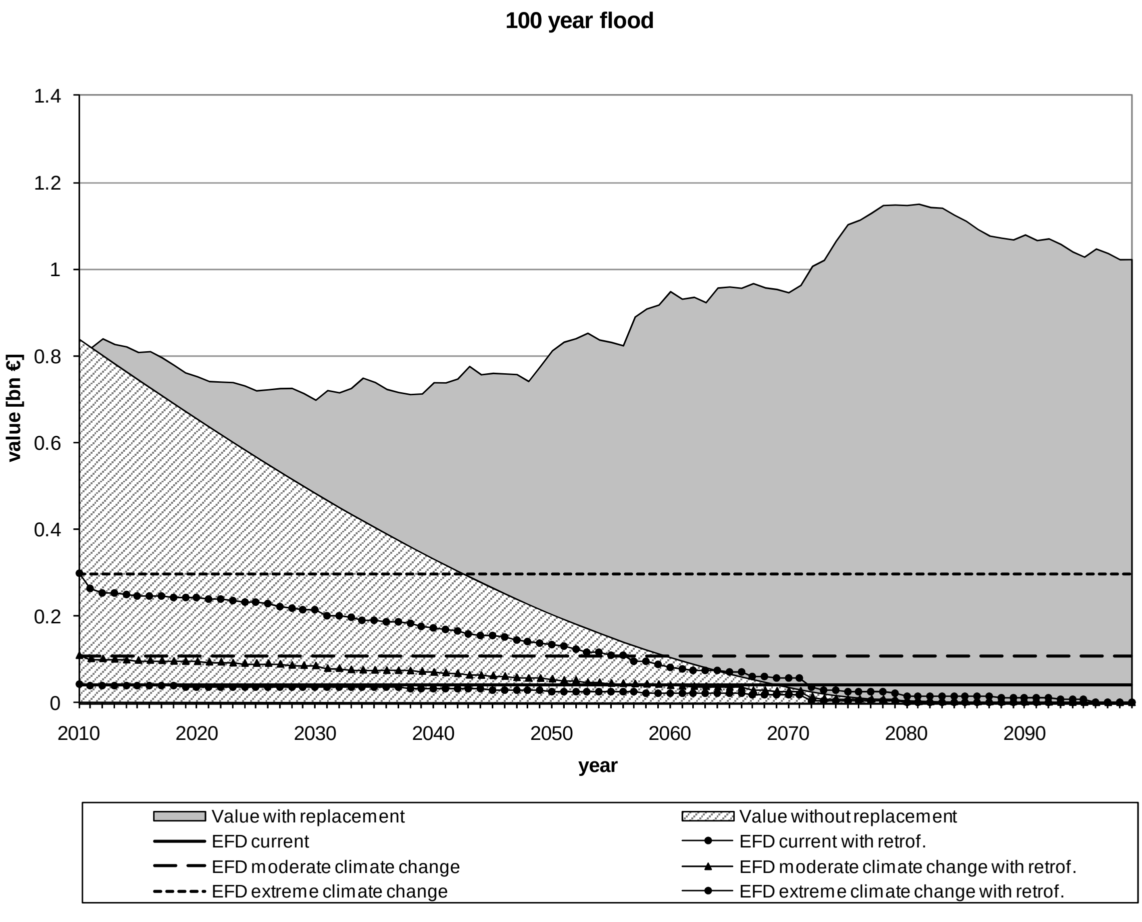


Figure 1: Development value and expected flood damage (EFD) for the 57,000 units of housing stock in the areas of the Rijnmond-Drechtsteden region outside the dikes

Apart from the obvious direct and indirect consequences, many unforeseen problems may arise: for example, in the Netherlands, a substantial part of the historic building stock is located within polders (reclaimed land defended from flooding behind dikes). Extreme dry weather conditions as witnessed in 2006 make it difficult to maintain groundwater levels which increases the chance of drying out, oxidation and failure of the wooden foundation piles supporting many of these buildings. In England, only limited planning related attempts have been made, e.g. to stop the paving over of permeable surfaces in urban gardens via the introduction of new planning regulations compelling property owners to obtain municipal approval for placing paving in front gardens (DCLG, 2008a); this neglected the much bigger problem that still allows entire back gardens to be paved without any permission and also preferentially directs new construction into back gardens that are classed, by the same Government Department as ‘brown field’ areas.

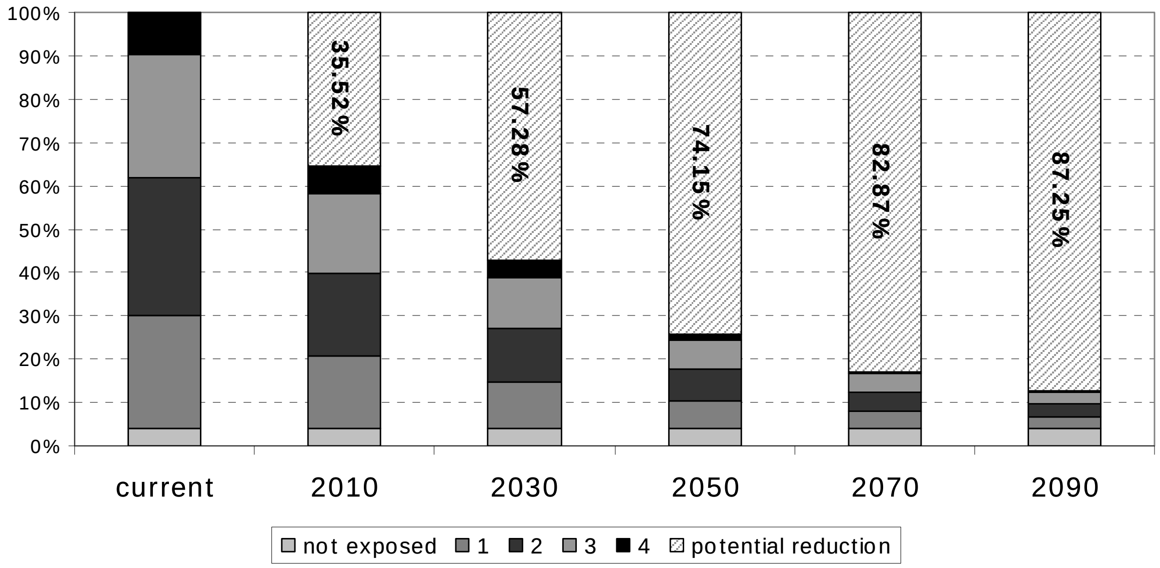
Only recently has urban dynamics been recognized as an active component for potentially mitigating current and future climate impacts (e.g. Zevenbergen et al, 2008). Such an approach can be used to relate urban redevelopment cycles to expected climate change impacts. In the Netherlands, an assessment of the potential benefits stemming from integrating flexibility and adaptation options by retrofitting measures into the redevelopment of two large development locations will be made in a forthcoming ‘Hotspot Rotterdam 09’ project for areas not protected by dikes in the Rijnmond-Drechtsteden area. In this project alternative cost-benefit projections will be made based on mainstreaming ‘climate proofing’ measures with building and infrastructural development. This is expected to lead to potential cost reductions since adaptation measures can be integrated into the building designs at an early stage instead of being applied separately. Initial studies on housing value depreciation and expected flood damages for the areas have already been made in the ‘Rotterdam Hotspot 02’ project (Veerbeek, 2010) for which illustrative results are presented in Figure 1.

Figure 1 shows the expected value of some 57,000 units of housing stock, considered either with or without replacement after the estimated end-of-lifespan (EOL). Value is estimated using a linear depreciation scheme based on cadastral data for the year 2009. Maintenance costs, ground and market values are omitted since these are highly volatile and uncertain. The replacement value of individual buildings is initialized using the original estimated value, which is potentially inaccurate since buildings are never replaced with an exact copy. While strongly conceptualised, the Figure gives an initial estimate of the value of the development over several decades. On average, buildings reach the EOL in about 100 years (empirical studies Hoogers et al, 2004). What can be clearly seen is the approximate linear decay of value for the current stock to almost zero by the year 2070. Replacement, however, increases the value in a non-linear fashion into the future. The question then is how the renewal cycle might benefit the need for climate adaptation of this stock of properties.

Located in the Dutch delta, the Rijnmond-Drechtsteden area is susceptible to flooding mainly from the Meuse River. In Figure 1 the expected flood damage (EFD) costs are shown for a 100 year return period for current climate conditions, a moderate climate change scenario for 2050 (Van den Hurk et al, 2006) and an extreme climate change scenario (Deltacommissie, 2008) for the year 2100. Note that the area is relatively well protected against flood impacts. Due to a generally high ground level inundation depths are limited and flood damage mostly results from the relatively large flood extent which covers a substantial part of the housing stock, rather than depth of flooding. Given that the housing stock does not change (i.e. buildings are replaced by ‘exact copies’), the EFD for a flood with a given return period and climate change scenario remain constant. Flood damages are independent from the actual value of the building stock (Grigg & Helweg, 1975) since they signify repair and replacement costs rather than insured or market value. What can be seen from Figure 1 is that for the current conditions, the expected flood damage is modest when compared with the value of the housing stock. However, application of climate change scenarios changes this. While currently the expected damages are about 5% of the estimated value, this may rise to 13% in 2050 and 36% in 2100. These values are substantial and could threaten the economic viability of the area. For less frequent floods, these become even higher. Furthermore, in the case of postponed redevelopment (i.e. no replacement), value depreciation causes expected damages to increase relatively; since as the expected value gradually declines, the significance of expected flood damage gradually increases.

As outlined earlier, climate adaptation measures at a local level can be readily mainstreamed into the renewal cycle. This could potentially reduce expected damage and other impacts. This assumption has been tested for the area above, where the potential flood damage for a 100-year flood have been calculated after pro-active retrofitting of the renewed housing stock; i.e. every new unit is developed in a flood proof manner. The outcomes are presented in Figure 1 and show that the expected flood damage gradually decreases to nil in the year 2070 (EFD with retrofitting). While for all 3 climate scenarios the period over which the EFD declines to nil remains the same, the impact of the measures differ. While currently, damage reduction barely improves the ratio of property value to damage, the consequences after consideration of climate change scenarios are much more substantial. The additional costs of climate proofing are limited. Since the expected inundation depths are limited, application of retrofitting measures does not necessarily imply replacement using elevated houses or application of technology for intensive dry proofing measures. Simply increasing the doorstep height by a small elevation or changing the layout of floor plans might be enough to cope with the increasing damage risk. This approach may provide an alternative to traditional flood proofing of such areas; instead of large scale protection schemes (e.g. increasing the ground elevation of the complete area), individual retrofitting should provide a feasible and effective solution within a foreseeable horizon. However, whilst promising in this test area, the approach might not be generally applicable when applied to other urbanized areas within the Netherlands or elsewhere.

A similar approach has been applied in the study ‘Building the Netherlands Climate Proof’ Commissioned by the Dutch Environment Agency (Van Nieuwkerk et al, 2010). Instead of focussing on a small case-study area, the aim has been to create a comprehensive assessment of natural hazards related to climate change and adaptation options for the complete urban extent of the Netherlands. The range of climate hazards studied has been extended to coastal, river and pluvial flooding, drought and heat stress. While these problems are not uniformly distributed over the complete Dutch urban area, many areas are threatened with one or more of the identified hazards. Since it was not feasible to assess and combine the different vulnerabilities to the identified climate hazards, the study has been limited to classifying the exposure to flooding, drought and heat stress of Dutch urban areas. Apart from extreme events, currently about 4% of the Dutch building stock is safeguarded against all of the four climate hazards, while some 10% is potentially susceptible to impacts from all four. Determination of the adaptive capacity was assessed in a similar fashion as in the ‘Rotterdam Hotspot 02’-project outlined above. The effects of pro-active retrofitting during redevelopment have been assessed by applying a somewhat stricter replacement scheme than assumed above in which the building cycle is assumed to be some 80 years. Assuming that the applied retrofitting measures would reduce the sensitivity to climate hazards to zero; currently a reduction of about 35% in exposure to the identified climate hazards could be achieved if all buildings reaching the EOL today were to be replaced by retrofitted buildings. In the future, this reduction would increase to about 57%, 74%, 82% and 87% in the years 2030, 2050, 2070 and 2090 respectively (Figure 2).



Key: 1-coastal and river flooding; 2-pluvial flooding; 3-drought; 4- heat stress

Figure. 2: Components of the total combined exposure (100%) to drought, heat stress and flooding (pluvial and fluvial) in combination with the potential reduction in exposure for all Dutch urban areas.

While these results are speculative in terms of rate and potential impact reduction, they provide insight into the significant potential for decentralized approaches to climate change adaptation of building stocks. Often localised measures are overlooked, typically with large-scale interventions being focused on despite the planning and implementation of large-scale interventions being heavily dependent on available (public) resources as well as political will. Within the Netherlands for instance, recent large scale infrastructural projects have exceeded their budgets significantly which makes policy makers reluctant to start new and seemingly ambitious projects and is not a problem confined solely to the Netherlands (Flyvbjerg et al, 2003). Focussing on a more decentralized approach to climate adaptation also has another advantage: flexibility. Current debates on climate change scenarios provide politicians with ambiguous information, which does not fit into traditional normative discussions about exceedance probabilities (Dessai and Hulme, 2004). Even more so, Milly et al (2008) emphasise that in the water sector society is moving towards an inherently dynamic and uncertain state which requires continuous adaptation. Using the ‘normal’ urban dynamics as the main driver of adaptation confirms this notion intuitively; measures can be applied at a very local level according to the most recent insights. Finally, decentralized adaptation might better support the resilience of our urban areas to cope with climate hazards. Instead of depending on a single protection measure (e.g. a levee structure or desalination plant), risk can be distributed over a large number of individual units which makes it less prone to overall failure at a system level.

CONCLUSIONS

Much of Europe has urban areas that are long established and relatively stable, with urban renewal cycles of up to 100 years. In these areas, many commentators and responsible authorities are now recognising and being honest about the need to adapt flood risk management systems to climate change using a variety of approaches, including fewer large scale hard-infrastructure solutions. This is in part driven by economic constraints but also by a growing realisation that such systems will not be able to provide what has traditionally been seen as a risk-free urban environment due to the uncertainty in climate and other changes. However, there is still only limited realisation on the part of urban planners and decision makers that there are other opportunistic synergistic means of effecting significant flood risk reductions at local scale by property flood proofing linked to normal property and neighbourhood renewal and regeneration processes. It has been shown in this paper, that for the Netherlands at least, significant synergistic opportunities pertain at the present time as part of renewal cycles. This needs to be acted upon and made a part of routine 'smart urban planning'. Even in the Netherlands the incumbent regime players dealing with water and city planning are not well enough connected for this to happen in the foreseeable future. In the UK the regime is even more restricting; with a plethora of government departments, agencies and others each developing their own plans for 'bits of' the adaptation challenge; concentrating mainly on carbon and energy and links to mitigation of climate change. Elsewhere in the world, especially in Asia, where urban development is increasing the size and density of towns and cities due to expansion and inward migration, there is a greater opportunity to ensure that climate proofing is built in to any new developments and where there is renewal of existing properties and surrounding areas, this is also properly taken into account. Nevertheless, in these areas building cycles are generally shorter and could therefore provide a means in future to cope with more severe natural hazards and potential consequences of climate change, learning from European experience and taking advantage of increases in knowledge about climate change and how to deal with vulnerabilities over time.

ACKNOWLEDGEMENTS

The 'Rotterdam Hotspot 02' project was carried out in the framework of the Dutch National Research Programme Knowledge for Climate (www.kennisvoorklimaat.nl). Additional funding was provided by the Municipality of Rotterdam and the Rotterdam Port Authority. The 'Building the Netherlands Climate Proof'-project was carried out in the framework of the Dutch National Research Programme Climate Change and Spatial Planning (www.klimaatvoorruimte.nl). Additional funding was provided by the Netherlands Environmental Assessment Agency.

REFERENCES

ABI (undated) ABI (undated) Flood Resilent Homes – what homeowners can do to reduce flood damage. Association of British Insurers, London.

ABI (2009) Climate adaptation: Guidance on insurance issues for new developments. Association of British Insurers, London.

Barnett J., O'Neill S. (2010). Maladaptation. Editorial for Global Environmental Change 20 (2010) 211-213. doi:10.1016/j.gloenvcha.2009.11.004. Elsevier.

Birkmann J., Garschagen M., Kraas F., Quang N. (2010). Adaptive urban governance: new challenges for the second generation of urban adaptation strategies to climate change. Sustain Sci. (2010) 5:185-206 DOI 10.1007/s11625-010-0111-3.

BIS Department for Business Information and Skills [http://www.bis.gov.uk/; accessed 5th May 2010]

Boelhouwer, P. and Primus, H. (2006) Dutch housing policy realigned, In: Journal of Housing and the Built Envirnonment, 5 (1), pp 105-119

Brugge, van der R., J. Rotmans, and D. Loorbach. 2005. The transition in Dutch water management. Regional Environmental Change 5:164–176.

CEA (2007). Reducing the Social and Economic Impact of Climate Change and Natural Catastrophes Insurance Solutions and Public-Private Partnerships. [http://www.cea.assur.org/ accessed May 2010].

Center for Neighbourhood Technology (2009). National Green Values™ Calculator Methodology. Available from: http://greenvalues.cnt.org/calculator/methodology (accessed May 2010)

DC (2008), Working together with water; A living land builds for its future; Findings of the Deltacommissie 2008, Deltacommissie, Technical Report, Deltacommissie, The Hague
DCLG (2007) National Evaluation of the HMR Pathfinder Programme Baseline Report – housing. Product code: 06HC04324.
DCLG (2008) Flood Recovery Grant: The Approach and Methodology Applied in Determining Allocations Addendum to the January 2008 Scheme. www.communities.gov.uk. May.
DCLG (2008a). Guidance on the permeable surfacing of front gardens. September. ISBN: 978-1-4098-0485-7. www.communities.gov.uk.
DCLG (2009) Planning Policy Statement No. 25 (PPS25) Development and Flood Risk - Practice Guide. ISBN 9781409820550. Available online from the DCLG website.
DCLG (2010) Consultation on a Planning Policy Statement: Planning for a Low Carbon Future in a Changing Climate. www.communities.gov.uk.
DCLG (2010a) Communities and Local Government Departmental Adaptation Plan. March www.communities.gov.uk.
DECC Department of Enargy and Climate Change [http://www.decc.gov.uk/Default.aspx; accessed 5th May 2010]
Deltacomissie (2008), Working together with water; A living land builds for its future; Findings of the Deltacommissie 2008, Technical Report, Deltacommissie, The Hague
Defra (2010). Climate Change Plan 2010. PB13358 March 2010.
Defra (2010a) The Appraisal of Adaptation Options in Flood and Coastal Erosion Risk Management R&D Technical Report FD2617/TR March 2010. Department of Environment, Food and Rural Affairs.
DES Department for Education and Skills http://www.education.gov.uk/ accessed May 2010
Dessai, S. and Hulme, M. (2004) Does climate adaptation policy need probabilities?, in: Climate Policy, 4:2(107-128)
Duxbury N. (2010). Retrofit - wild goose chase or golden opportunity? Access at: http://www.insidehousing.co.uk/sustainability/retrofit-wild-goose-chase-or-golden-opportunity?/6509669.article. Accessed May 2010.
ECTP (2005) Strategic Research Agenda for the European Construction Sector. European construction technology platform Onine [http://cordis.europa.eu/technology-platforms/pdf/ectp2.pdf] accessed May 2010.
EP, European Pariliament (2002) Directive 2002/91/EC, [online: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:001:0065:0071:EN:PDF] . Accessed July 2010
Evans EP., Ashley R M., Hall J., Penning-Rowsell E., Saul A., Sayers P., Thorne C., Watkinson A. (2004). Foresight. Future Flooding Vol I – Future risks and their drivers. Office of Science and Technology. April.
Evans, E.P., Simm, J.D., Thorne, C.R., Arnell, N.W., Ashley, R.M., Hess, T.M., Lane, S.N., Morris, J., Nicholls, R.J., Penning-Rowsell, E.C., Reynard, N.S., Saul, A.J., Tapsell, S.M., Watkinson, A.R., Wheater, H.S. (2008) An update of the Foresight Future Flooding 2004 qualitative risk analysis. Cabinet Office, London.
Flyvbjerg, B., Bruzelius, N., Rothengatter, W., Megaprojects and Risks: An Anatomy of Ambition, Cambridge Univ. Press, Cambridge, UK, pp. 28-31.
Gersonius B., Ashley R., Pathirana A., Zevenbergen C. (2010). An options planning and analysis process for managing the flooding system's resiliency to climate change. Proc. Of the Institution of Civil Engineers. Engineering Sustainability. March Vol. 163, Issue E1, p15-22. Doi: 10.1680.ensu.2010.163.1.15. Paper 900020.
Grigg, N. S. and Helweg, O. J. (1975) State-of-the-art of estimating flood damage in urban areas, Water Resour. Bull., 11(2), 379–390.
HM Treasury/Defra (2009) Accounting for the Effects of Climate Change - Supplementary Green Book Guidance. June.
Hoogers, A., Gelinck, S., Trabsky, W., Van Luijk, P., Kortman, J., Andeweg van Battum, M. T., Hasselaar, E. and van Ewijk, H. (2004) (In Dutch). Bouwen met Tijd, Een praktische verkenning naar de samenhang tussen levensduur, kenmerken en milieubelasting van woningen, SEV, Rotterdam, Netherlands, ISBN 90-5239-198-X
Hurk Van den, B., Klein Tank, A., Lenderink, G., Van Ulden, A., Van Oldenborgh, G.J., Katsman, C., Van den Brink, H., Keller, F., Bessembinder, J. Burgers, G., Komen, G., Hazeleger, W. And Drijfhout, S. (2006) KNMI Climate Change Scenarios 2006 for the Netherlands, Scientific Report, WR 2006-01, KNMI, De Bilt
Jentsch M F., Bahj A S., James P A B. (2008) Climate change future proofing of buildings—Generation and assessment of building simulation weather files. Energy and Buildings 40 (2008) 2148-2168.
Litman T (2010) Affordable-Accessible Housing In A Dynamic City: Why and How To Increase Affordable Housing Development In Accessible Locations. Victoria Transport Policy Institute, 21st May.

LRAP (2010) Adapting to climate change Guidance notes for NI188. Version 1.7 Local and Regional Partnership Board. Available from: http://www.defra.gov.uk/corporate/about/with/localgov/indicators/ni188.htm. accessed May 2010.
Matel L J (2010). Creating an LID environment in an ultra urban setting. ASCE conference on Low Impact Development. San Francisco. April.
Mayor of London (2009). The London Plan - Spatial Development Strategy for Greater London. Consultation draft replacement plan. October. ISBN 978 1 84781 292 6.
Milly P.C.D., Betancourt J., Falkenmark M., Hirsch R.M., Kundzewicz Z.W., Lettenmaier D.P. and Stouffer R.J.(2008). Stationarity Is Dead: Whither Water Management? Science, 319 (5863), 573-574
NAO (2009) The Building Schools for the Future Programme - Renewing the secondary school estate. Report By The Comptroller And Auditor General. HC 135 Session 2008-2009 12 February.[http://www.nao.org.uk/publications/0809/schools_for_the_future.aspx]. accessed 5th May 2010
Natural England (2009). Green Infrastructure Guidance. Available from: www.naturalengland.org.uk. Accessed May 2010.
Nicholls, N., Skinner, C., Loughnan, M. & Tapper, N. (2008) A simple heat alert system for Melbourne, Australia. Int. J. Biometeorol., 52, 375-384
Nieuwkerk Van E., Stone, K., Veerbeek, W., Van de Ven, F. and Zevenbergen, C. (2010) Building the Netherlands Climate Proof; Urban Areas, Technical Report, Programme Climate Change and Spatial Planning, Utrecht, Netherlands, forthcoming
Pitt M (2008). Learning Lessons from the 2007 Floods. HMSO.
Tait S J., Ashley R M., Cashman A., Blanksby J., Saul A J. (2008). Sewer system operation into the 21st century, study of selected responses from a UK perspective. Urban Water journal Vol.5 No. 1, March. pp77-86.ISSN 1462-0758.
Thorne, C R, Evans, E P and Penning-Rowsell, E. Eds. (2007). Future Flooding and Coastal Erosion Risks, Thomas Telford, London, UK, ISBN 978-0-7277-3449-5.
Veerbeek, W. (2010) HSRR02: Vulnerability assessment based on direct flood damages, Technical Report, Knowledge for Climate, Utrecht, Netherlands
VWS (2007) Nationaal Hitteplan, Minisry of Health, Welfare and Sport, [http://www.rijksoverheid.nl/bestanden/documenten-en-publicaties/kamerstukken/2007/07/12/nationaal-hitteplan-2007/hitteplan.pdf] Accessed July 2010.
WWF (2007). The right climate for change: Using the carbon footprint to reduce CO_2 emissions – a guide for local authorities. Stockholm Institute. ISBN 1 85850 238 1.
Zevenbergen, C., Veerbeek, W., Gersonius, B and van Herk, S. (2008) Challenges in urban flood management: travelling across spatial and temporal scales. J Flood Risk Management, 1:2(81–88)