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Sea Level Impacts of Climate Change

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INTRODUCTION

Sea-level rise has been seen as a major threat to low-lying coastal areas around the globe since the issue of human-induced global warming emerged in the 1980s. What is often less appreciated is that more than 200 million people are already vulnerable to flooding by extreme sea levels around the globe. This population could grow fourfold to the 2080s just due to rising population/coastward migration. These people generally depend on natural and/or artificial flood defences and drainage to manage the risks, with the most developed and extensive artificial systems in Europe (especially around the southern North Sea) and East Asia. Most threatened are the significant populations (at least 20 million people today) already living below normal high tides in many countries such as the Netherlands and the USA. Hurricane Katrina's impacts on New Orleans in 2005 remind us of what happens if such defences fail. Increasing mean sea level and more intense storms will exacerbate these risks. Despite these threats, the actual consequences of sea-level rise remain uncertain and contested. This reflects far more than the uncertainty in the magnitude of sea-level rise and climate change, with the uncertainties about our ability to adapt to these challenges being a major uncertainty (Nicholls and Tol, 2006; Nicholls et al., 2007a).

CLIMATE CHANGE AND GLOBAL/RELATIVE SEA-LEVEL RISE

Human-induced climate change is expected to cause a profound series of changes including rising sea level, higher sea-surface temperatures, and changing storm, wave and run-off characteristics. Although higher sea level only directly impact coastal areas, these are the most densely-populated and economically active land areas on Earth, and they also support important and productive ecosystems that are sensitive to sea level and other change. Rising global sea level due to thermal expansion and the melting of land-based ice is already being observed and this rise is likely to accelerate through the 21st century. From 1990 to the last decade of the 21st century, a total rise in the range 18–59 cm has been forecast by the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) (Meehl et al, 2007). It is worth noting that the current satellite observations of global sea-level rise are at the high end of the predicted SRES scenarios (Rahmstorf et al., 2007), and if recent ice sheet discharge continues through the 21st Century at current rates, the maximum projected rise increases to 79 cm[1]. Even this scenario excludes uncertainties due to collapse of the large ice sheets, and as noted in the IPCC Synthesis Report (2007), the quantitative AR4 scenarios do ***not*** provide an upper bound on sea-level rise during the 21st Century. A global rise of sea

[1] Allowing for ice-melt uncertainties

level exceeding one metre remains a low probability, but physically-plausible scenario for the 21st Century due to large uncertainties concerning ice sheet dynamics and their response to global warming. While these high end scenarios may be relatively unlikely, their large potential impacts makes them highly significant in terms of climate risk. There is also increasing concern about higher extreme sea levels due to more intense storms superimposed on these mean rises, especially for areas affected by tropical storms. This would exacerbate the impacts of global-mean sea-level rise, particularly the risk of more damaging floods and storms.

When analysing sea-level rise impacts and responses, it is (Nicholls, 2010) fundamental that impacts are a product of ***relative*** (or local) sea-level rise rather than global changes alone. Relative sea-level change takes into account the sum of global, regional and local components of sea-level change: the underlying drivers of these components are (1) climate change such as melting of land-based ice, thermal expansion of ocean waters, and changing ocean dynamics, and (2) non-climate uplift/subsidence processes such as tectonics, glacial isostatic adjustment, and natural and human-induced subsidence. Hence relative sea-level rise is only partly a response to climate change and varies from place to place. Relative sea level is presently falling due to ongoing glacial isostatic adjustment (rebound) in some high-latitude locations that were formerly sites of large (kilometre-thick) glaciers, such as the northern Baltic and Hudson Bay, while RSLR is more rapid than global-mean trends on subsiding coasts, including many populous deltas. Most dramatically, human-induced subsidence of susceptible areas due to drainage and withdrawal of groundwater can produce dramatic RSLR, especially cities built on deltaic deposits. Over the 20th century, parts of Tokyo and Osaka subsided up to 5 m and 3 m, respectively, a large part of Shanghai subsided up to 3 m, and most of Bangkok subsided up to 2 m[2]. Such human-induced subsidence can be managed by stopping shallow sub-surface fluid withdrawals, but natural “background” rates of subsidence will continue. The four example cities have all seen a combination of such policies combined with the provision of flood defences and pumped drainage to avoid submergence and/or frequent flooding. In contrast, Jakarta and Metro Manila are subsiding cities where little systematic action to manage and reduce the subsidence are in place as yet.

SEA-LEVEL RISE AND RESULTING IMPACTS

Relative sea-level rise has a wide range of effects on the natural system, with the five main effects being summarized in Table 1. Flooding/submergence, ecosystem change and erosion have received significantly more attention than salinisation and rising water tables. Along with rising sea level, there are changes to all the processes that operate around the coast. The immediate effect is submergence and increased flooding of coastal land, as well as saltwater intrusion into surface waters. Longer term effects also occur as the coast adjusts to the new environmental conditions, including wetland loss and change in response to higher water tables and increasing salinity, erosion of beaches and soft cliffs, and saltwater intrusion into groundwater.

[2] The maximum subsidence is reported as data on average subsidence is not available.

These lagged changes interact with the immediate effects of sea-level rise and generally exacerbate them. For instance, coastal erosion will tend to degrade or remove natural protective features (e.g. saltmarshes, mangroves and sand dunes) so increasing the impact of extreme water levels and hence the risk of coastal flooding.

A mean rise in sea level also raises extreme water levels, as shown by Zhang et al (2000) on the US East Coast, and this is widely applied in impact studies for future conditions. Changes in storm characteristics could also influence extreme water levels both positively and negatively. For example, the widely debated increase in the intensity of tropical cyclones would increase in general terms extreme water levels in the areas affected.

Changes in natural systems as a result of sea-level rise have many important direct socio-economic impacts on a range of sectors with the effect being overwhelmingly negative. For instance, flooding can damage the extensive coastal infrastructure, ports and industry, the built environment, and agricultural areas, and in the worst case lead to significant mortality (e.g., Cyclone Nargis (2008), Myanamar). Erosion can lead to losses of the built environment and related infrastructure and have adverse consequences for sectors such as tourism and recreation. In addition to these direct impacts, there are indirect impacts such as adverse effects on human health: for example, mental health problems increase after a flood, or the release of toxins from eroded land fills and waste sites which are commonly located in low-lying coastal areas, especially around major cities. Economically, sea-level rise will also have direct and indirect effects (see Tol, 2011, these abstracts). Thus, sea-level rise has the potential to trigger a cascade of direct and indirect human impacts.

RECENT IMPACTS OF SEA-LEVEL RISE

Over the 20th century global sea level rose about 18 cm. While this change may seem small, it will have had many significant effects, most particularly in terms of the return periods of extreme water levels (e.g., Zhang et al., 2000; Menéndez and Woodworth, 2010), and promoting a widespread erosive tendency for coasts. However, linking sea-level rise quantitatively to impacts is quite difficult as the coastal zone has been subjected to multiple drivers of change over the 20th Century (Rosenzweig et al., 2007). Good data on rising sea levels has only been measured in a few locations, and defences and other coastal infrastructure have often been upgraded substantially through the 20th Century, especially in those (wealthy) places where there are sea-level measurements. Most of this defence upgrade reflects expanding populations and wealth in the coastal flood plain and changing attitudes to risk, and relative sea-level rise may not have even been considered in the design. Equally, erosion can be promoted by processes other than sea-level rise (Table 1), and human reduction in sediment supply to the coast must contribute to the observed changes. Decline in intertidal habitats such as saltmarshes, mudflats and mangroves is often linked to sea-level rise, but these systems are also subject to multiple drivers of change, including direct destruction (Nicholls, 2004). Hence, while global sea-level rise is a pervasive process, it is difficult to unambiguously link it to impacts, except in some special cases – most recent coastal change was a response to multiple drivers of change.

On the US east coast, relative sea levels have risen at variable rates between 2 and 4 mm/yr over the 20th century, reflecting a combination of global rise and subsidence. Both sea level and coastal change has been measured during the 20th century, providing a laboratory for exploring shoreline response to sea-level rise. Comparing the rate of shoreline retreat and the long-term rate of relative sea-level rise away from inlets and engineered shores, supports the concept of the 'Bruun Rule' where the shoreline retreat rate is 50 to 100 times the rate of sea-level rise (Zhang et al., 2004), although this relationship remains controversial. Near inlets, the indirect effects of sea-level rise which cause the associated estuary/lagoon to trap beach-sized sediment can have much larger erosional effects on the neighbouring open coasts than predicted by the Bruun Rule (Stive, 2004). Hence, more general relationships are required to understand coastal change taking account of sea-level change, sediment supply and coastal physiography. Human responses to sea-level rise are even more difficult to document. Human abandonment of low-lying islands in Chesapeake Bay, USA during the late 19th/early 20th century does seem to have been triggered by a small acceleration of sea-level rise and the resulting land loss (Gibbons and Nicholls, 2006).

There have certainly been impacts from the relative sea-level rise resulting from large rates of subsidence, such as the Mississippi delta where relative sea-level rise is 5 to 10 mm/yr. Between 1978 and 2000, 1565 km^2 of intertidal coastal marshes and adjacent lands were converted to open water, due to sediment starvation and increases in the salinity and water levels of coastal marshes due to human development and wider changes (Barras et al., 2003). By 2050, about 1300 km^2 of additional coastal land loss is projected if current global, regional and local processes continue at the same rate. There have also been significant impacts of relative sea-level rise in deltas and in and around subsiding coastal cities, in terms of increased waterlogging, flooding and submergence, and the resulting need for management responses (Nicholls et al., 2007b). The flooding in New Orleans during Katrina in 2005 was significantly exacerbated by subsidence compared to earlier flood events such as Hurricane Betsy in 1965 (Grossi and Muir Wood, 2006). In terms of response, all the major developed areas that were impacted by relative sea-level rise have been defended, even when the change in relative sea-level rise was several metres over several decades. In New Orleans, the pre-existing dike system before Katrina have been rebuilt and substantially upgraded at a cost of $15 billion over 6 years. In less developed areas, coastal retreat has occurred such as south of Bangkok where subsidence has led to a shoreline retreat of more than a kilometre.

Hence observations through the 20th Century reinforce the importance of understanding the impacts of sea-level rise in the context of multiple drivers of change – this will remain true under more rapid rises in sea level. Of these multiple drivers of change, human-induced subsidence is of particular interest, but this remains relatively unstudied in a systematic sense. Observations also emphasize the ability to protect against RSLR, especially for more densely-populated areas such as the subsiding Asian cities already discussed, or around the southern North Sea, including London and Hamburg.

FUTURE IMPACTS OF SEA-LEVEL RISE

The future impacts of sea-level rise will depend on a range of factors, including the degree to which sea-level rise accelerates, the level and manner of coastal development and the success (or failure) of adaptation (Nicholls, 2010). Assessments of the future impacts of sea-level rise have taken place on a range of scales from local to global. They all confirm potentially large impacts following Table 1, although comprehensive studies are limited and most available assessments only consider a subset of possible impacts. Taking account of population exposure, sensitivity and adaptive capacity, South and South-East Asia and Africa appear to be most vulnerable in absolute terms due to storm-induced flooding combined with sea-level rise. Small island regions in the Pacific, Indian Ocean and Caribbean stand out as being especially vulnerable to flooding (Mimura et al., 2007), even though relatively few people are affected in global terms. The populations of low-lying islands such as the Maldives or Tuvalu face the real prospect of increased flooding, submergence and forced abandonment: this perception may trigger a collapse in investment and general confidence blighting these areas and triggering abandonment long before it is physically inevitable (Barnet and Adger, 2003). An important lobby group for small islands and sea-level rise is the Alliance of Small Island States (AOSIS), which contains 37 UN votes.

However, adaptation can greatly reduce the impacts. Benefit–cost models that compare protection with retreat generally suggest that it is worth investing in widespread protection as populated coastal areas are often of high economic value (Fankhauser, 1995; Tol, 2007; Sugiyama et al., 2008). (It is worth noting that if no economic growth is assumed, protection is much harder to justify and hence the impacts of sea-level rise depend on both climate and socio-economic scenarios (Nicholls, 2004; Anthoff et al., 2010)). With or without protection, small island and deltaic areas stand out as relatively more vulnerable in most analyses and the impacts fall disproportionately on poorer countries (Anthoff et al., 2010; Sugiyama et al., 2008).

Regional and global scale assessments

Compared to national assessments, regional and global assessments provide a more consistent basis to assess the broad-scale impacts of sea-level rise.

Coastal Flooding

Globally, it was estimated that about 200 million people lived in the coastal flood plain (below the 1 in 1,000 year surge-flood elevation) in 1990, or about 4% of the world’s population (Nicholls et al., 1999). Based on estimates of defence standards, on average 10 million people/year experienced coastal flooding in 1990. These numbers will change due to the competing influences of relative sea-level rise (due to local subsidence and global changes), changes in coastal population and improving defence standards as people become more wealthy (Nicholls et al., 1999). Relative sea-level rise is assumed to displace extreme water levels upwards (assuming constant storm characteristics). The analysis is designed to explore the impacts of global-mean sea-level rise if it is largely ignored. Therefore, the increasing protection standards only consider existing climate variability (i.e. surges in 1990) and the analysis is considering a world that is completely ignoring the issue of global-mean (and relative) sea-level rise. (This follows recent behaviour globally). Outputs include:

- people in the hazard zone (PHZ) – the population living below the 1 in 1,000 year flood plain (or the exposed population);
- people at risk (PAR) – the average number of people who experience flooding per year (a measure of risk that takes account of flood protection);

Table 2 illustrates the impacts of no global-mean sea-level rise and the IS92a global-mean sea-level rise scenarios on flooding (for a global-mean rise in the range 19 to 80 cm from 1990 to the 2080s). Generic results include:

- Even without sea-level rise, the number of people flooded each year first increases significantly due to increasing coastal populations (i.e., exposure), and then diminishes as increasing protection standards due to rising GDP/capita become the most important factor.
- Significant impacts of sea-level rise are not apparent until the 2050s or later so sea-level rise is a slow onset hazard.
- The uncertainty about impacts is large with relatively minor impacts for the low rise scenario in the 2080s, a 10-fold increase in PAR under the mid rise scenario and a 27-fold increase in PAR under the high rise scenario for the 2080s.

Looking at 20 world regions, they all see an increase in the incidence of flooding compared to the baseline, most especially under the higher sea-level rise scenarios. The most vulnerable regions in relative terms are the small island regions of the Caribbean, Indian Ocean and Pacific Ocean. However, absolute increases in the incidence of flooding are largest in the southern Mediterranean (largely due to the Nile delta), West Africa, East Africa, South Asia and South-East Asia – these five regions contain about 90% of the people flooded in all cases for the 2080s. This reflects the large populations of low-lying deltas in parts of Asia, and projections of rapid population growth around Africa's coastal areas. While developed country regions have relatively low impacts, sea-level rise still produces a significant increase in the number of people who would be flooded assuming no adaptation for sea-level rise. These results show that sea-level rise could have a profound impact on the incidence of flooding – the higher the total rise, the greater the increase in flood risk, all other factors being equal. Any increase in storminess would further exacerbate the predicted increase in coastal flooding.

Using the DIVA model, we can examine flood impacts with and without dike upgrade (Nicholls, 2010). No upgrade leads to results that are qualitatively similar to those in Table 2. The behaviour assuming dike upgrade is quite different and independent of the magnitude of the sea-level rise scenario, the number of people flooded is projected to decline through the 21st Century. This reflects that the dikes are raised more than the magnitude of sea-level rise as people adapt to sea-level rise and become more risk adverse as they become more wealthy. This illustrates that the success or failure of adaptation is fundamental to understanding impacts as discussed later.

Environmental Refugees

Sea-level rise is often associated with a large potential for environmental refugees forcibly displaced from their homes (Myers, 2002). Potentially, many tens or even hundreds of millions of peoples could be so displaced, especially given that coastal populations are growing significantly worldwide. However, if we can successful adapt to these challenges, this is a much smaller problem than is often assumed. Adaptation could include flood defences for urban areas, and land use planning for new developments to avoid the more risky areas. As a reference, Tol (2002a; 2002b) suggests that most coastal areas are worth protecting in a benefit-cost sense (protection costs are less than damage costs). This formulation suggests that $\leq$75,000 people/year will be displaced by a 1-m sea-level through the 21st Century, after allowing for protection: incrementally this is of order 1% of the potentially displaced population. This result has a large uncertainty, but it illustrates again that the success or failure of adaptation is a key element to understanding the scale of the problem.

Global Costs of Sea-Level Rise

Global estimates of the incremental costs of upgrading defence infrastructure[3] suggest the costs are much lower than the expected damage (Tol, 2007). IPCC CZMS (1990) estimated the costs of defending against a 1-m sea-level rise at $500 billion. Hoozemans et al (1993) doubled these costs to $1000 billion. Looking at the total costs of sea-level rise including dryland and wetland loss and incremental defence investment, Fankhauser (1995) estimated annual global costs of $47 billion using the IPCC CZMS (1990) data. Tol (2002a; 2002b) made similar estimates using the Hoozemans et al. (1993) data, supplemented by other data sources and adding the costs of forced migration. The protection was optimised and it was estimated that the annual costs of sea-level rise are only $13 billion/year for a 1-m global rise in sea level: much lower than estimated by Fankhauser, and much lower than widely assumed. However, any failure in protection will lead to much higher costs. Sugiyama et al (2008) noted that that the spatial distribution of infrastructure and wealth along the coast influences costs: the more wealth is concentrated the smaller the protection costs.

[3] These incremental costs should not be compared directly with projects such as the post-Katrina defence of New Orleans as they only reflect the sea-level component of these needs.

RESPONDING TO SEA-LEVEL RISE

The two potential responses to sea-level rise are mitigation and adaptation: only the latter is considered here. Adaptation to sea-level rise involves responding to both mean sea-level rise and extreme sea-level rise (Hallegatte, 2009). Planned adaptation options to sea-level rise are usually presented as one of three generic approaches (Klein et al., 2001) with examples in Table 1:

- *(Planned) Retreat* – all natural system effects are allowed to occur and human impacts are minimised by pulling back from the coast via land use planning, development control, etc.;
- *Accommodation* – all natural system effects are allowed to occur and human impacts are minimised by adjusting human use of the coastal zone via flood resilience, warning systems, insurance, etc.;
- *Protection* – natural system effects are controlled by soft or hard engineering (e.g., nourished beaches and dunes or seawalls), reducing human impacts in the zone that would be impacted without protection.

Given the large and rapidly growing concentration of people and activity in the coastal zone, autonomous (or spontaneous) adaptation processes alone will not be able to cope with sea-level rise. Further, adaptation in the coastal context is widely seen as a public responsibility. Therefore, all levels of government have a key role in developing and facilitating appropriate adaptation measures. The required adaptation costs remain uncertain, but as large amounts are already invested in managing coastal floods, erosion and other coastal hazards, the incremental costs of including global sea-level rise does not appear infeasible at a global scale over the coming decades (World Bank, 2010). However, in certain settings such as small islands, these costs could overwhelm local economies (Fankhauser and Tol, 2005; Nicholls and Tol, 2006). Another key issues are the adaptation deficit (Parry et al., 2009), and observed behaviour does not agree with the implicit model in many of the benefit-cost analysis. Lastly, maintenance can substantially raise costs compared to just capital costs, and this needs to be considered and poorly maintained flood defences are worst than no defences as the engender a false sense of security.

DISCUSSION/CONCLUDING REMARKS

The abstract illustrates that understanding the impacts of sea-level rise crosses many disciplines and embraces natural, social, and engineering sciences, and major gaps in that understanding remain. The success or failure of adaptation in general, and protection in particular, is an important issue which deserves more attention and has lead to what Nicholls and Tol (2006) termed the ‘optimistic’ and ‘pessimistic’ view of the importance of sea-level rise. The pessimists tend to focus on high rises in sea level, extreme events like Katrina, and view our ability to adapt as being rather limited resulting in alarming impacts, including widespread human displacement from coastal areas. The optimists tend to focus on lower rises in sea level and stress a high ability to protect and high benefit-cost ratios in developed areas and wonder what all the fuss is about.

The optimists have empirical evidence to support their views that sea-level rise is not a big problem in terms of the subsiding megacities that are also thriving. Importantly, these analyses suggest that improved protection under rising sea levels is more likely and rational than is widely assumed. Hence the common assumption of a widespread retreat from the shore is not inevitable, and coastal societies will have more choice in their response to rising sea level than is often assumed. However, the pessimists also have evidence to support their view. First, the socio-economic scenarios used in climate impact assessments assume substantial future economic growth and its more equitable distribution: lower growth and greater concentration of wealth in parts of the world may mean less damage in monetary terms, but it will also lead to a lower ability to protect in those poorer areas. Secondly, the benefit–cost approach implies a proactive attitude to protection with extensive management in place for the hazards of climate variability. However, experience suggests a widespread adaptation deficit in many parts of world and shows that most protection has been built as a reaction to actual or near disaster. The cost of addressing the adaptation deficit will often be significant in itself, although this has not been quantitatively assessed. If combined with high rates of sea-level rise this will probably lead to more frequent coastal disasters, even if the ultimate response is better protection. Thirdly, disasters (or adaptation failures) such as Hurricane 'Katrina' could trigger coastal abandonment, a process that has not been analysed to date. This could have a profound influence on society's future choices concerning coastal protection as the pattern of coastal occupancy might change radically. A cycle of decline in some coastal areas is not inconceivable, especially in future world scenarios where capital is highly mobile and collective action is weaker. As the issue of sea-level rise is so widely known, disinvestment from coastal areas may be triggered even without disasters actually occurring: for example, the economies of small islands may be highly vulnerable if investors become cautious (Barnett and Adger, 2003). Lastly, retreat and accommodation have long lead times – benefits are greatest if implementation occurs soon – but this is not happening widely as yet. For these reasons, adaptation may not be as successful as some assume, especially if rises in sea level are at the higher end of the range of predictions.

Thus the optimists and the pessimists both have arguments in their favour. Sea-level rise is clearly a threat, which demands a response. Scientists need to better understand this threat, including the implications of different mixtures of adaptation and mitigation, as well as the need to engage with the coastal and climate policy process so that these scientific perspectives are heard. Importantly, it has been recognised that a combination of mitigation (to reduce the risks of a large rise in sea level) and adaptation (to the inevitable rise) appears to be the most appropriate course of action, as these two policies are more effective when combined than when followed independently, and together they address both immediate and longer term concerns (Nicholls et al., 2007a).

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Table 1. The main natural system effects of relative sea-level rise, including climate and non-climate interacting factors and examples of adaptation to these effects. Some interacting factors (e.g., sediment supply) appear twice as they can be influenced both by climate and non-climate factors. Adaptations are coded: P – Protection; A – Accommodation; R – Retreat. (adapted from Nicholls and Tol, 2006; Nicholls 2010).

NATURAL SYSTEM EFFECT		INTERACTING FACTORS		ADAPTATION RESPONSES
		CLIMATE	NON-CLIMATE	
1. Inundation, flood and storm damage	a. Surge (flooding from the sea)	Wave/storm climate, Erosion, Sediment supply.	Sediment supply, Flood management, Erosion, Land reclamation	Dikes/surge barriers [P], Building codes/floodwise buildings [A], Land use planning/hazard delineation [A/R].
	b. Backwater effect (flooding from rivers)	Run-off.	Catchment management and land use.	
2. Wetland loss (and change)		CO_2 fertilisation of biomass production, Sediment supply, Migration space	Sediment supply, Migration space, Land reclamation (i.e., direct destruction).	Land use planning [A/R], Managed realignment/ forbid hard defences [R], Nourishment/sediment management [P].
3. Erosion (of 'soft' morphology)		Sediment supply, Wave/storm climate.	Sediment supply.	Coast defences [P], Nourishment [P], Building setbacks [R].
4. Saltwater Intrusion	a. Surface Waters	Run-off.	Catchment management (overextreaction), Land use.	Saltwater intrusion barriers [P], Change water abstraction [A/R].
	b. Ground-water	Rainfall.	Land use, Aquifer use (overpumping).	Freshwater injection [P], Change water abstraction [A/R].
5. Rising water tables/ impeded drainage		Rainfall, Run-off.	Land use, Aquifer use, Catchment management.	Upgrade drainage systems [P], Polders [P], Change land use [A], Land use planning/hazard delineation [A/R].

Table 2. Sea-level rise and coastal flooding of people under the IS92a sea-level rise scenarios for low, mid and high climate sensitivities – see text for definitions of People in the Hazard Zone (PHZ) and People at Risk (PAR). The population scenario assumes that population change within the coastal flood plain is double national trends. Defences are upgraded with rising GDP/capita, but do not address sea-level rise (adapted from Nicholls, 2002).

Time (years)	Sea-Level Scenario	People in the Hazard Zone (PHZ)	People at Risk (PAR)
1990	N/A	197	10
2020s	No Rise	399	22
	Low	403	23
	Mid	411	24
	High	423	30
2050s	No Rise	511	27
	Low	525	28
	Mid	550	64
	High	581	176
2080s	No Rise	575	13
	Low	605	17
	Mid	647	133
	High	702	353