
FROM RESISTANCE
TO RESILIENCE
A New Paradigm of Coastal Cities
BERND GUNDERMANN

Between the first edition of "From Resistance to Resilience" printed in May 2013 and this second edition, over $25b worth of damage has occurred in the US as a result of floods and tornadoes, increasing the awareness of Climate Change and the extreme weather events that it brings.

What began two years ago with my Masters Seminar inspired by New York's MoMA show on "Rising Currents" has now become an accepted new direction: Adaptive Urbanism.

As shelves fill up with books with titles like "The Attacking Ocean" that still argue from the paradigm of separating humanity and nature, we provide advice on aligning with nature to seek a more holistically beneficial solution. In this publication you will find practical tools to address Climate Change issues such as coastal protection from storm surges, reduction of surface run-off as well as measures for water purification. The advantage of these "soft" approaches that can address many aspects simultaneously and a variety of solutions can be used in conjunction to complement each other and the specific environment. Furthermore, a number of case studies exemplify how resilience can be applied to metropolises around the world and how local knowledge can be combined with a natural, global strategy to develop reinvigorated, safer coastal cities.

Whereas New York's US $20B response plan following Hurricane Sandy "A Stronger, More Resilient New York" concentrates on barriers, levees, and concrete bulkheads, my team at S&T is developing (together with Waterfront Auckland) an ecosystem-based strategy - Adaptive Urbanism – which is unprecedented in the world.

Bernd Gundermann
bgundermann@stephensonturner.com

"It's good to see such attractive publications raising awareness of the need to adapt to climate change and sea-level rise in particular."
- Dr Dan Zwartz, Senior Climate Change Analyst, Ministry for the Environment, NZ

"I love it! It's not all loss and gloomy futures."
- Alison Lash, Senior Advisor, Kapiti Coast District Council, NZ

"It's good to see clear thinking and good science linked to tangible strategies for resilience."
- Jez Weston, The Royal Society NZ

"I find it very interesting and applicable to my day to day work."
- Adriana Vega, Urban Development and Climate Change coordinator, Bogota, Colombia

"We appreciate the information provided by you. We are finding it really useful."
- V.Ranga Rao, MInsitry of Earth Sciences, Chennai, India

FROM RESISTANCE TO *RESILIENCE*

CLIMATE CHANGE

THE IMPACTS OF CLIMATE CHANGE

Climate is the most powerful agent that mankind is exposed to. It shapes the surface and living conditions of the planet and affects every scale, from tiniest micro-organisms to the extinction of entire species. A change in climate, such as the one the Earth is currently experiencing, will deeply affect every living entity and the environment which they inhabit.

The recorded effects include:

- Global warming and shifts in local weather conditions
- Rising temperatures which are melting the polar ice shelves and causing thermal expansion of the oceans, leading to Sea-Level Rise (SLR)
- Increase in both frequency and intensity of extreme weather events, such as hurricanes, flooding, rainfall and drought

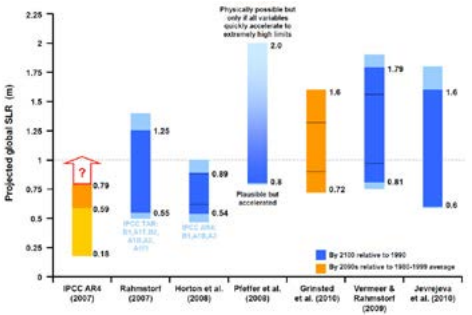


Figure 1. Right Above: SLR predictions by various organizations, compiled by NIWA at the SLR conference in 2012

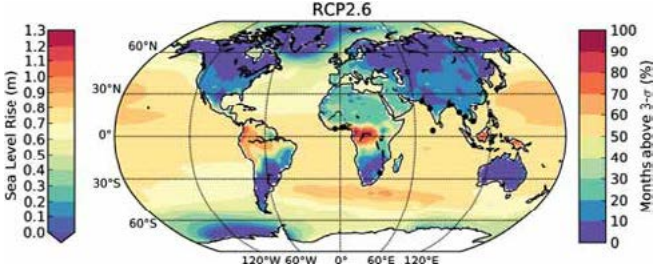


Figure 2. Left: Projected sea-level rise and notrhern hemisphere summer heat events over land in +2°C. SLR projected to be less than 70cm. World Bank Climate Impact Research and Climate Analytics Report 2013.

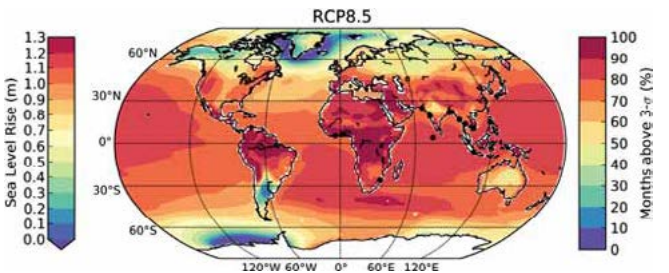


Figure 3. Left: Projected sea-level rise and notrhern hemisphere summer heat events over land in +4°C. SLR projected to be more than 100cm. World Bank Climate Impact Research and Climate Analytics Report 2013.

EFFECTS ON COASTAL ENVIRONMENTS

As mankind prefers to settle in low-lying coastal regions, the majority of humanity will be affected by rising sea-levels. Together with the increasing weather disasters, which drive storm-surges towards coastal cities, higher planes of erosion will put pressure on hard engineered sea-defences, erode beaches and cliffs, and lead to inundations of city-centres and their fragile infrastructure. Hurricane "Sandy" caused approximately $50B of damage in a few days.

In the past, coastal wetlands have been drained and converted for utilisation as sites for developments, leading to a major loss of natural buffers to rising water levels, and leaving low-lying land unprotected to the maritime forces. In New Zealand, over 90% of coastal wetlands have been lost to development. Additionally, the increase in the Earth's temperature has caused the decline of coral reefs which protect many islands in the Indian and Pacific oceans.

Figure 4. The last house on Holland Island, Maryland, where 360 people lived before tides took over. Image taken from washingtonpost.com.

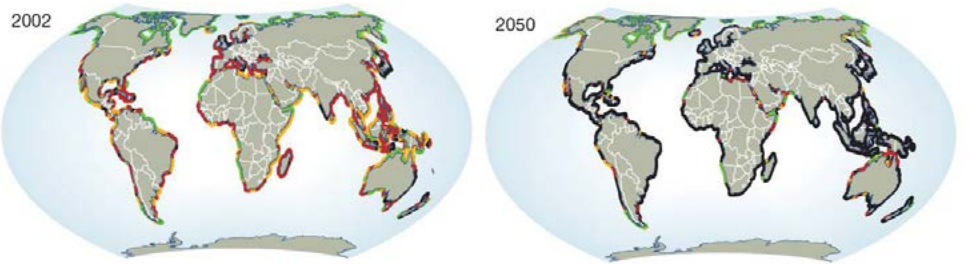


Figure 5. Map showing density of coastal populations. Image taken from http://www.grida.no/publications/rr/in-dead-water/page/1250.aspx

Home to more than 45% of the world's population, 75% of our mega-cities (i.e. populations over 10 million) are located on the coast. Though these areas account for only 20% of the world's surface, it is estimated that by the year 2025, 75% of the world's population (or 6 billion people) will live in coastal areas.

Figure 6. San Joaquin Valley subsidence. Image created by United States Geological Survey.

VULNERABILTY OF BUILDING ON RECLAIMED LAND

Many coastal cities around the world are built partly on reclaimed land. Infrastructure that has been introduced after a city has been established tends to be located in reclaimed areas. This is problematic as reclaimed land is highly susceptible to soil liquefaction during earthquakes which can amplify the amount of damage that occurs. In addition, it is prone to subsidence. This is brought about by oxidation, consolidation and withdrawal of moisture. Additional factors include the height of the water table, character of the materials, irrigation and climate.

Worldwide subsidence rates vary between 1-8cm per year, depending on composition, drainage depth and history of reclamation. Land in the Everglades (Florida) has subsided by 1.8 m in only 54 years (1924-1978) and the organic soils of the Sacramento-San Joaquin Delta of California subsided by 1.8 to 2 m in less than 30 years.

IMPLICATIONS OF DEVELOPMENT STAGE

SLR is a global phenomenon, yet responding to it needs regionally specific approaches. This will be determined by the amount of resources available, the level of education and the impact that climate change has on the particular area.

In developed countries where resources are abundant, there is a need to overcome the long-standing conviction that the employment of engineering efforts will trump the natural forces. Other obstacles are legislation and conflicting interests, which can sometimes produce biased information that restricts the knowledge required to trigger adaptation. An example of this has recently occurred in Spain where the Coastal Laws are being reviewed to see the protected areas reduced from 100 meters to just 20. The review has increased the political party's popularity for the upcoming elections.

On the other hand, in many under-developed and developing countries, the lack of education and resources make these communities the most vulnerable and their capacity to adapt is the lowest. However this offers an opportunity to tap into ancient wisdom, from which strategies to identify safe areas for further development can be derived. For example, the most destructive Tsunami ever recorded hit the Andaman Islands in 2004, with surging waves of up to 30m. The indigenous people relied on ancient wisdom and their intrinsic connection to the place, responding to the silence of the usually loud cicadas and headed for the highlands. Their survival instincts surpassed any scientific equipment.

Although the stage of development varies hugely around the world, every country can benefit from each other. Learning different approaches and knowledge from elsewhere is mutually advantageous and allows multi-layered responses to be developed to what is clearly a global issue.

ADVISORY LEVEL & LOCAL INPUT

The scale and complexity of the impacts of Climate Change must be dealt with by developing and pursuing holistic responses, which we believe can only be achieved with the input of all of the stakeholders.

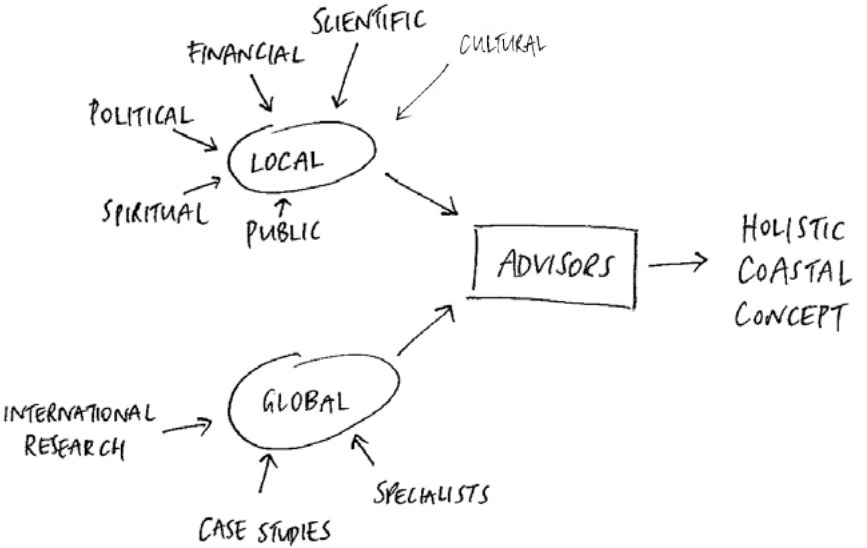
Current information regarding Climate Change provides information on the effects but very little insight as to possible solutions. By increasing awareness of achievable responses the fear of the unknown extent of the impacts of Climate Change will be reduced. Awareness will be obtained through transparency of developments and input of the public.

We recommend the use of Geographic Information Systems (GIS) combined with applications which enable invited parties to view, comment, and mark-up the developing projects three-dimensionally and in real-time. Because resilience begins with people, the communities have to be informed and hence enabled to participate in the development of coastal strategies in a meaningful way. This allows citizens to take ownership of the agreed measures and thus the direction of their future environment.

Our role as advisors is to gain knowledge of the specific area regarding the current situation and existing urban plans and, together with local planning authorities, develop a response strategy that reflects the cities' goals modified due to the potential impact of SLR. This can only be achieved with the knowledge of local scientists and industry experts to achieve an approach that is adjusted to the specific conditions.

Global awareness, local knowledge and tradition are encompassed in our approach, which acknowledges the achievements of hard engineering while connecting to the environment by applying ecosystem-based measures.

PARTICIPATION PROCESS



RESISTANCE

HARD ENGINEERING APPROACHES

Hard engineering is defined as the controlled disruption of natural processes by using man-made structures. They are an artificial boundary that interrupts the natural flow and continuity of the landscape. Their harshness is due to their fixed, static nature that allows no flexibility or adaptation, causing an abrupt transition between the natural and man-made environments.

The implementation of hard engineering solutions into coastal environments causes irreversible ecological damage. Not only do they disrupt sediment movement, and salt- and freshwater ecosystems, but they also lead to increased erosion and soil-salination on the land.

In addition they are an expensive capital investment for a barrier that requires regular maintenance and replacement, and can only protect the land to a certain limit. Hard engineering solutions are not very aesthetically pleasing or a valuable contribution to the urban environment.

Furthermore, if the barriers are breached then the water becomes trapped within the area and cannot drain back to the ocean.

There are many examples around the world where mankind is attempting to control his environment some of which are displayed on the opposite page. This kind of thinking is archaic, outdated and needs to be replaced.

Figure 7. Top Left: Maeslant Barrier, Holland - open. Image taken from http://gcaptain.com/maeslant-barrier/
Figure 8. Bottom Left: Maeslant Barrier, Holland - closed. Imaged created by Aerolin Photo BV
Figure 9. Top Right: Breaching of levee system in New Orleans. Image taken from http://www.terradaily.com/reports/Levees_Cannot_Fully_Eliminate_Risk_Of_Flooding_To_New_Orleans_999.html
Figure 10. Bottom Right: Thames Barrier, London. Image taken from http://architecture.about.com/od/damsresevoirs/ss/floodcontrol_3.htm

IMPLEMENTATION OF HARD ENGINEERING

Despite the numerous disadvantages of hard-engineering techniques, there are situations where they are the only viable solution, such as high density urban environments or locations with valuable architecture or infrastructure. These situations lack the space for soft-engineering encroachment on the land and require a fixed, long-term solution to ensure their survival. Measures can be taken to mitigate the harshness of this type of coastal protection; however their impact on the natural environment is unavoidable.

Figure 11. Sea wall modifications to promote natural growth. Image taken from http://www.conservationmagazine.org/2012/03/how-to-build-a-living-seawall/

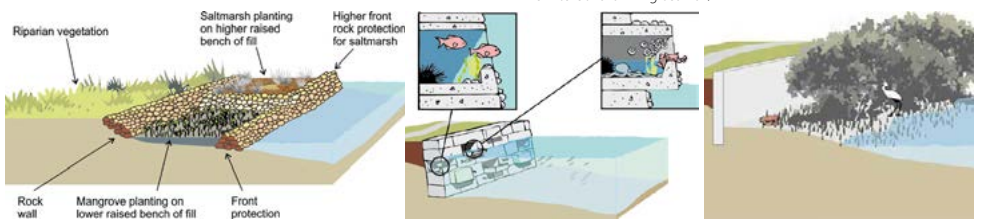


Figure 12. Techniques to soften existing hard-engineering measures from the document: Environmentally Friendly Seawalls issued by the Department of Environment and Climate Change in Sydney

Figure 13. Opposite: Proposed sea wall in Seattle. Image taken from The Elliot Bay Sea Wall Project

PARADIGM SHIFT

For the last 500 years Western thought has followed the thinking of Rene Descartes and his ideology of being the absolute "masters and possesors of nature". The approach was to define the universe as a precise clockwork-like machine, which is non-living and follows strict laws. The result of this mentality came the 'Age of Enlightenment' by which nature was a pyramid and mankind was on the top, emphasizing the superiority that humanity considered to have over the rest of creation.

Although the vanguard of science has long revealed that the human population and universe are deeply interconnected, mainstream-science and commercial industry continue to pursue this separation. The divide has caused complete unawareness of the complexity of the natural environment which has lead to irreversible damage. It is only now that the environmental conditions are impairing our quality of life that we are questioning this hierarchical relationship.

Previous paradigm shifts have manifested to become the cities we inhabit today. We predict that future urban environments that adapt to climate change will be significant different. Straight, clean-cut boundaries between land and water will be replaced with interlocking environments that activate tides as an urban feature. These amphibious cityscapes will be accompanied with new plants and bird life as well as improved air and quality of life.

The impacts of climate change can be interpreted as a 'wake-up call' to evolve from superseded archetypes. By aligning with nature rather than opposing it, we can shift the paradigm to being united and integrated with the natural environment. This shift will minimize hard engineering and replace it with soft, ecosystem-based options and by doing this we will lead the way from resistance to resilience.

RESISTANCE

SUPERIORITY • SEPARATION • DUALISM

RESILIENCE

INTEGRATION • ALIGNMENT • UNION

RESILIENCE

SOFT ENGINEERING ADVANTAGES

FUTURE COASTAL PROTECTION
Soft-engineering provides solutions that are adaptive and responsive, rather than protecting to a fixed, assumed level. This allows the solutions to be more future proof.

ECOLOGICAL REMEDIATION
Engineering that aligns with nature provides the opportunity for native plant growth and increases ecologies through the provision of food sources and habitats.

WATER PURIFICATION
The surrounding bodies of water will be purified using natural methods. Oysters feed off pollutants in the water, processing approximately 60 gallons per day. Planting around the coastline absorb pollutants prior to surface run off water reaching the ocean.

EMISSION REDUCTION
The introduction of planting and other natural approaches leads to an increase in the conversion of carbon dioxide into oxygen. Additionally they replace materials such as concrete and asphalt which are significantly more carbon intensive.

URBAN REINVIGORATION
Removing hard barriers allows cities to become more amphibious and stimulating. It provides connectivity with the water, generates place making opportunities and encourages maritime lifestyles.

ECONOMY
Solutions that minimize hard engineering not only have lower capital costs, but are cheaper long term as they require less maintenance. Savings are increased through the reduced demand on infrastructure.

RETREAT APPROACHES

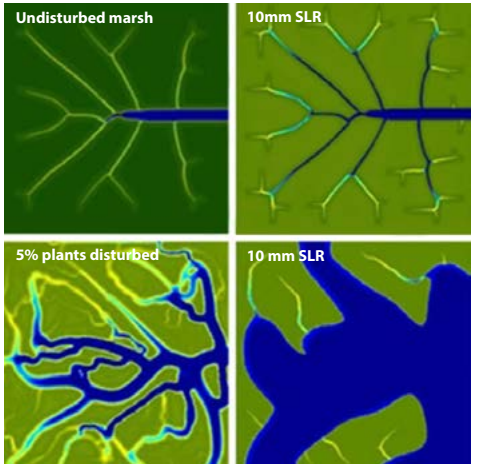


Figure 14. Study undertaken by Duke University modelling the effects of SLR. The images show the effects of 10mm increase in Sea Level to both undisturbed and disturbed marshlands.

Occasionally it is more feasible to retreat from the coast. The sacrifice of villages and relocation of populations allows the land to return to its original form. The cost of protecting these areas is too much so human structures become reverse engineered into marshlands to act as a natural buffer. The following spread shows a variety of methods of retreat resulting in vastly different urban conditions.

Figure 15. Failing sea defences in East Anglia, England. Image taken from www.literarynorfolk.co.uk/norfolk_coast.htm

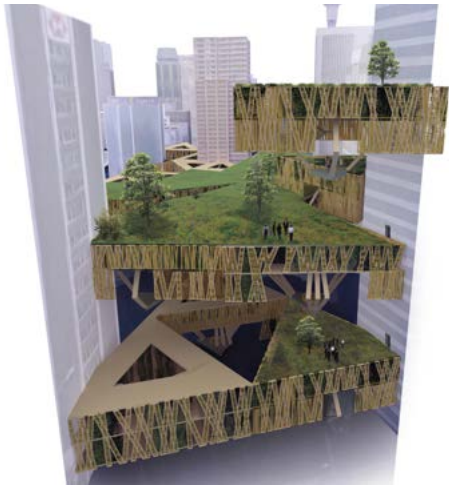


Figure 16. Left: Vertical Retreat: Move upwards into self replicating green balconies that enrich the urban fabric. Image created as part of a Masters Seminar at the University of Auckland by Adrian Kumar.

Figure 17. Above: Scheduled Retreat: Relocation of coastal populations, reverse engineering harmful elements, preservation of landmarks, reestablish coastal ecosystems. Image created as part of a Masters Seminar at the University of Auckland by Thomas Ward.

Figure 18. Above: Floating Retreat: Displaced population can re-inhabit a similar area in a new concept of floating residential communities. Image created as part of a Masters Seminar at the University of Auckland by Jordon Saunders.

Figure 19. Right: Maritime Retreat: Instigation of a new urban fabric/ maritime metropolis that integrates the sea into urban life. Image created as part of a Masters Seminar at the University of Auckland by Esther Mecredy.

HOLISTIC APPROACH

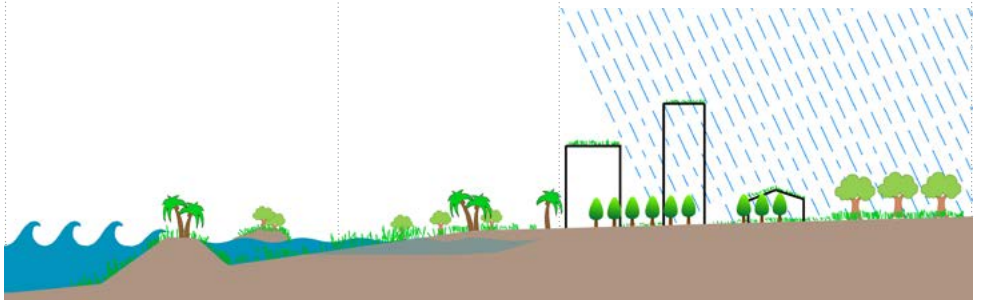
Unfortunately, the effects of SLR are not limited to the coasts. As development within cities has grown dramatically, the amount of permeable surfaces has dropped. In times of inundation, flooding and precipitation, infrastructure will be unable to cope.

We propose increasing the number of green spaces and street plantings, and replacing impermeable surfaces such as asphalt with permeable pavers. Green roofs are a way for buildings to recreate the green space lost by their footprint. Increasing the amount of planting and permeable surfaces within a city will absorb water, reducing stress on infrastructure while also filtering contaminants before they reach the sea.

The measures mentioned above are to help cities to cope with the effects of SLR and Climate Change. In addition, they dimish other side-effects of urban development such as heat islands and greenhouse gas emssions. This demonstrates the interconnected nature of a resilient approach to Climate Change.

Understanding that the natural environment as well as many external factors continually influence our built environment, our approach also seeks to incorporate a temporal aspect. We wish to avoid static 'grand plans', and move towards more flexible, adaptive responses that are constantly adjusted to the ever-changing conditions. This allows our approach to be considered as a process rather than a solution.

IN THE WATER	AROUND THE COAST	ON THE LAND
PROBLEM:		
• SLR • Storm Surges	• Inundation • Erosion	• Increased surface water run-off • Contamination of water



SOLUTION:		
• Archipelagos • Oyster Reefs • Pile Flelds • Oyster Filtration	• Wetlands • Water Basins	• Inland Planting • Permeable Paving • Green Roofs • Densified Urban Environments

IN THE WATER: ARCHIPELAGOS

Figure 20. Creating an Ecological Urban Habitat. Studio Gang. Proposal for Chicago's lakefront. http://www.studiogang.net/work/2007/northerlyisland

Figure 21. Competition entry for Tulsa Riverfront, USA by West8. http://www.west8.nl/projects/parks/tulsa_riverfront/

In a similar fashion to sea walls, archipelagos protect the coast from storm surges. However they differ in that they are a natural buffer, providing habitats to boost ecosystems as well as creating invigorating, natural spaces within dense urban environments. In addition they are more long-lasting than sea walls as they are self-sustaining, growing and adapting to the conditions. For example, the growth of trees and plant life will create a stronger defence than a crumbling sea wall.

IN THE WATER: OYSTER REEFS & PILE FIELDS

Figure 22. Living shoreline breakwaters in Alabama . http://ecosystemslab.disl.org/projects.htm

Figure 23. Pier 1 Brooklyn Bridge Park. Michael Van Valkenburgh Associates Inc. Proposal for reinvigoration of industrial areas surrounding Brooklyn Bridge. http://www.mvvainc.com/project.php?id=91&c=parks

Another replacement for sea walls are oyster reefs, protecting the coast in the same way except they replace the resource intensive materials with recycled natural materials. This promotes future growth and provides habitats and food sources to assist ecosystems and increase biodiversity.

Pile fields are a low cost, easy to install means of coastal protection. The piles interrupt wave paths and break up wave energy. Simultaneously the piles act as a resting ground for birdlife.

IN THE WATER: OYSTER FILTRATION

Figure 24. Oyster-tecture. Kate Orff, SCAPE. Proposal for New York as part of the Rising Currents Projects and Exhibition. Rising Currents, MoMA, 2011,

The oyster, a bivalve (two-shelled) filter feeder, inhales sea water, extracts nutrients and exhales the filtered water. They are the most efficient natural method of water purification, filtering around 50 gallons of water per day, and requiring no additional chemicals or food for growth.

Other benefits of oyster cultivation are that they:

- Attenuate wave energy
- Reduce Erosion/Stabilise the shoreline
- Create habitats augmenting marine populations
- Increase biodiversity to boost coastal ecosystems
- Diversify the landscape
- Decrease greenhouse gas concentrations
- Reduce toxic nitrates

Establishing a healthy oyster-bed will require the introduction of additional plant life such as marsh grasses to provide the phytoplankton and oxygen that oysters consume. Implementing both oysters and plantlife simultaneously will ensure that the eco-system remains balanced and other species are not deprived in any way.

Oysters can be incorporated into existing urban environments without any disturbance. Methods of growth could include oysters:

- suspended beneath existing piers
- attached to boardwalks
- floating from piers
- growing in low-lying baskets beneath marine areas

Figure 25. Pacific Oysters in New Zealand . http://aquaculture.org.nz/industry/pacific-oysters/

AROUND THE COAST: NATURAL WETLANDS

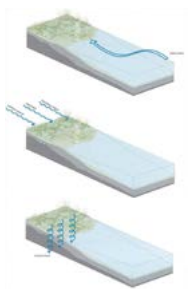


Figure 26. Above: Natural Wetlands at Nick's Head Station. Image taken from http://architecturenow.us1.list-manage.com/track/click?u=610116aa23b00d06b2daf717e&id=2865442086&e=b357aed1e1

Figure 27. Left: Diagram showing the interaction between water and wetlands created by Princeton University.

The reintroduction or restoration of wetlands are vital to the mitigation of impacts recently caused by human activity due to their many beneficial impacts on ecosystems, humanity and the natural environment.

Some of the benefits include:

- Vital part of the ecosystem providing habitats and nutrients for many species
- Land buffer, soil stabilizer, erosion control
- Purification of water
- Co_2 to Oxygen converter
- Inexpensive to construct and maintain
- Tolerant of varying water levels
- Natural water storage with slow release systems

& CONSTRUCTED WETLANDS

Implementing wetlands around the coastline is an inevitable move towards resilience for the future as well as remediation of damage done in the past. There are many examples where natural wetlands have been reinstated to exploit their many advantages. However due to the large footprint that they require, these can only occur in suburban or rural areas rather than dense, urban environments. Within cities, it is crucial to avoid significant encroachment onto the land, where valuable infrastructure and architecture is already in place. Here a more compact approach is necessary.

Constructed wetlands are artificial wetlands that are created as a habitat for wildlife and a biofilter to remove sediments and pollutants but in an way that increases efficiency and reduces their spatial requirements. This advancement combines all the benefits of natural wetlands with increased productivity as well as the opportunity for human inhabitation within the area.

We believe that the challenge and opportunity lies in the introduction of constructed wetlands into a tidal environment. This requires further research and consultation with experts as these systems are highly engineered, controlled environments. This development would be hugely valuable as urban wetlands are a vital component of resilient cities.

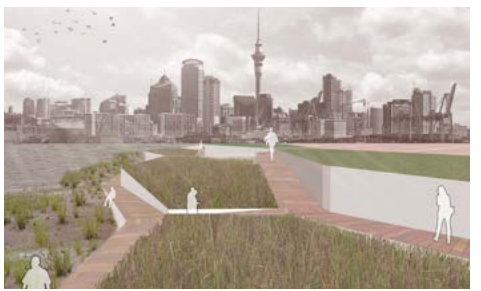
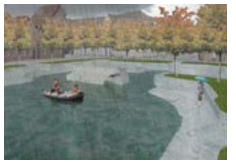


Figure 28. Constructed wetlands in an urban setting. Image created as part of a Masters Seminar at the University of Auckland by Gabrielle Free.

AROUND THE COAST: WATER BASINS



Coastal waterbasins provide overflow areas for storm surges or increased run-off. They create an integrated relationship between land and water that promotes amphibious, water-based urban environments. Furthermore, they demonstrate the effects of SLR thereby raising public awareness.

Figure 29. Above;: Water Plaza in Rotterdam taken from weadapt.org
Figure 30. Left: Tying into the CIty to Create a New Cultural Anchor. Studio Gang. Proposal for a Waterfront Development in Taiwan. http://www.studiogang.net/work/2010/kpop_urbandesign

ON THE LAND: INLAND PLANTING

Inner city planting allows pollutants to be filtered before reaching drainage systems that flow to the sea. It absorbs water and slowly release it, reducing run off and lessening stress on infrastructure. Along natural water paths, planting stablises the soil, limiting erosion.

ON THE LAND: PERMEABLE PAVING

Permeable paving is a 100% recyclable, total replacement for asphalt. It has high load bearing capacity, able to support large vehicles while also slowing transport to make a more pedestrian friendly environment. Most importantly it reduces run off surface water, lessening stress on infrastructure. In addition it:

- filters the water
- eliminates pollutants
- reinforces the ground
- promotes tree growth
- can be replaced and repaired more quickly than asphalt
- is more aesthetically pleasing

Figure 31. Above;: Permeable pavement in Vancouver. World Changing: A user's guide for the 21st century. Alex Steffen. New York. 2011. p174
Figure 32. Structure of permeable paving. http://www.boddingtons.com.au

ON THE LAND: GREEN ROOFS

Green roofs work in a similar way to permeable paving by filtering water, promoting natural growth and delaying the run-off water, taking pressure off drainage and sewage systems. In addition they replace the space lost by the footprint of the building with an invigorating, natural space for urban activity.

Figure 33. Above: Conference Center by Vancouver waterfront. worldcitiesnetwork.org
Figure 34. Left: Proposed urban landscape for Melbourne City. Melbourne. vic.gov.au

‘SMART CITY’ TECHNOLOGY

The concept of a ‘Smart’ City is a knowledge-based city that develops extraordinary capabilities to be self-aware of its functionality and provide real time information to its citizens. This was defined by T M Vinod Kumar, in Geographic Information Systems for Smart Cities by Copal Publishing, New Delhi in 2013. The increased communication provides users with an improved quality of life through the ease of mobility, accessibility of public services and interaction with the natural environment. This has flow-on effects of energy and resource conservation. The resulting communities become more energetic and vibrant, aiding the urban economy, despite economic downturns or environmental pressures.

Records of recovery from recent weather disasters in the United States have demonstrated that well-informed and connected communities recover much better than others (*http://www.theatlanticcities.com/neighborhoods/2013/01/resilience-about-relationships-not-just-infrastructure/4305/*). By providing coastal communities with better communication networks and information access they can take ownership of the protection of their people and environment.

Currently e-governance, is technology driven governance which provides convenient, efficient and transparent exchanges of information between the government, various businesses and its citizens. ‘Smart City’ technology aims to develop this concept though the employment of Geographic Information Systems (GIS) and social media to increase the interconnectedness of the community.

The quick development of communication-technology will lead to cellphone applications that provide valuable real-time information in the case of a critical situation. What is the current water-level and the forecast? What roads are open and lead to safe areas? Which is the closest hospital with spare capacity? Crucial questions like this can be answered instantly via smart phones. Adaptive signage can manage traffic fluently and direct to recovery areas.

Instant information allows the communited to be well connected and respond instantly, avoiding unnecessary risks and strengthening self-responsiveness to create Smart Cities of the future.

CASE STUDIES

HAMBURG, GERMANY

Hamburg is located 140km upstream of the North Sea at the river Elbe. The river-mouth and the shape of German Bight are open to the north-west, which is the prevailing wind direction. In the event of a storm surge the water is funnelled into the tightly dyked Elbe Valley, amplifying its force as it reaches the metropolitan area of Hamburg and its 3.5 million residents.

The German port cities, together with those in the Netherlands, are considered well-prepared to meet the challenge of SLR. Their proactive adaptation plans focus primarily on the risk of flooding due to the vulnerability of the surrounding areas. However, looking at the bigger picture, we can see that since the melting of the glaciers during the ice age 20,000 years ago, the North Sea has been advancing southwards. Climate Change has the potential to accelerate this advancement beyond the current estimates which the vast urban developments in Hamburg are based on.

The basic approach of Hamburg's Coastal defence Master Plans is resistance: holding the line by reinforcing the dykes. The master plan for the period 2013-2035 will define new and increased dyke lines, an approach only capable of protection until the end of this century. After that the predicted increase in sea level will breach the dykes and flood the city.

Further environmental interventions such as increased dredging of the river, need to be reviewed in the dynamic context of climate change. It is an ongoing environmental challenge requiring new thinking and lifestyles rather than a temporary inconvenience to be solved with current solutions. Cities last much longer than their master plans, and response options should be explored that address longer time spans and higher sea-levels.

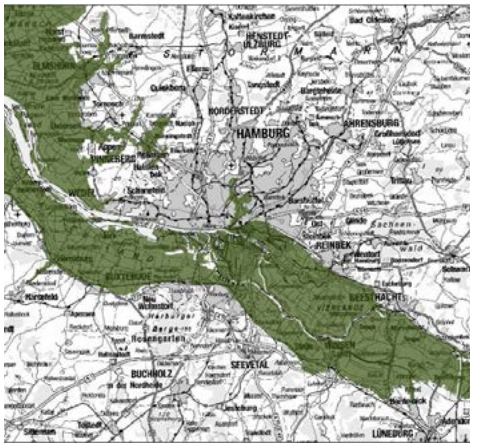


Figure 35. Area to be protected from flooding by 2100 assumed to be 1.1m higher than 1962. Image taken from http://www.kuestenschutzbedarf.de/nordsee.html

Figure 36. It is likely that Climate Change will continue the regression of the North Sea after the Ice Age. Map from National Geographic Article 'Searching for Doggerland' Image taken from http://ngm.nationalgeographic.com/2012/12/doggerland/spinney-text

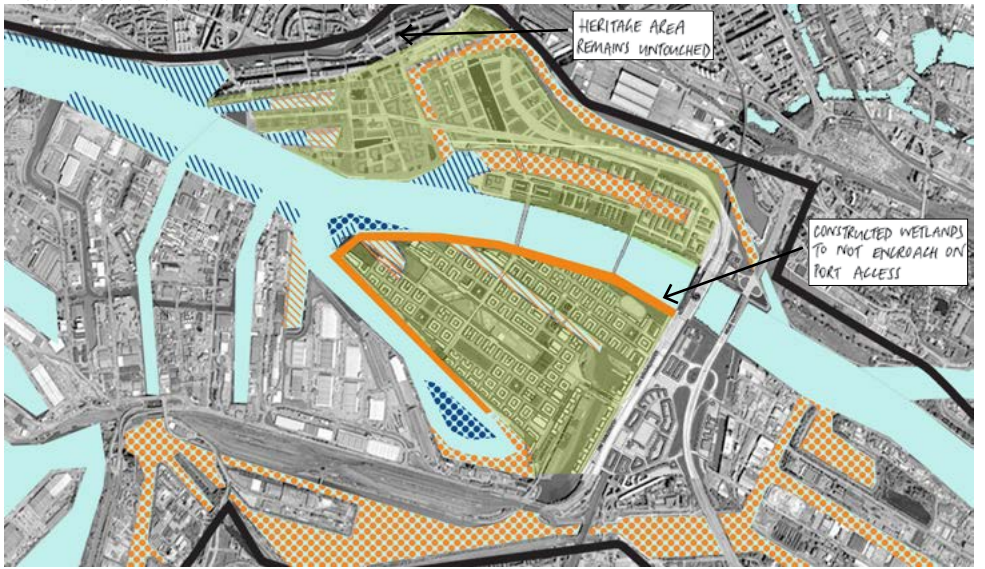
MAP OF GREATER HAMBURG

- Current Water Levels
- Extent of SLR
- Affected Areas
- Surrounding Urban Fabric
- Existing Dykes

MAP OF HAMBURG INDICATING IMPACT OF 2m SEA-LEVEL RISE

KEY:	WATER FILTRATION	CONSTRUCTED APPROACHES	NATURAL APPROACHES
WATER	Oyster Filters	Oyster Reefs Pile Fields	Archipelagos
COAST	Constructed Wetlands	Water Basins	Natural Wetlands
LAND	Permeable Paving, Green Roofs & Native Planting		

PROPOSED RESPONSE TO SEA-LEVEL RISE



MUMBAI, INDIA

Today 25% of Mumbai is already at or below sea-level. The mega-city is ranked sixth of the most exposed metropolises in the world with 14.4 million inhabitants and $1.6 trillion of assets being at risk. Due to its geographic location on a peninsula, Mumbai is threatened on all sides from SLR, storm surges and high storm-water run-off in the monsoon seasons.

The Coastal Zone Management (CZM), in place since 2011, protects and preserves coastal areas (38% of the city) through development restrictions. As a result of the growing population and powerful property market, these areas are under pressure to increase utilization of the ground area, undermining the CZM. Recent developments such as the Dharavi project continue to encroach on the Mithi River and the surrounding mangroves.

As a result the urban poor have been displaced by property development to the Mumbai's salt pans. The settlements in this area are the most vulnerable to the effects of SLR due to the low-lying nature of the foreland. Furthermore, these settlements put pressure on the surrounding mangrove belts, the most effective protection from storm surges.

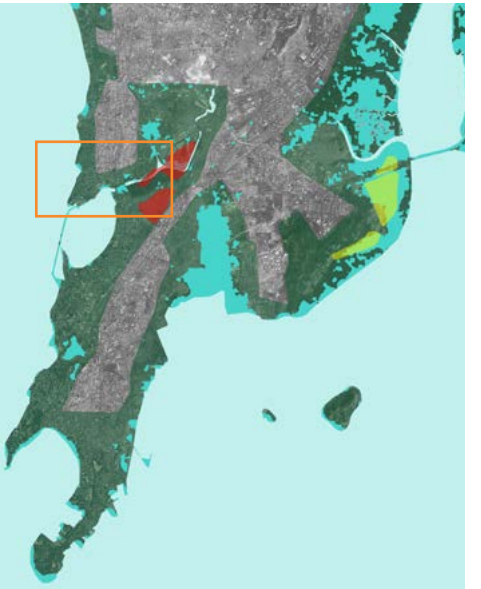
It is clear that Mumbai is experiencing many geographic and social complexities outlined above, and thus requires a transparent, holistic approach. Mumbai will aim for complete awareness of any development: from initial interdisciplinary assessments to measures being implemented. Applying Smart City strategies with long-term concepts that integrate ecological and social values as well as economical goals will help to ensure Mumbai's successful growth for the next centuries.

Figure 37. Image taken from Centre for Science and Environment, New Delhi

- Current Water Levels
- Extent of SLR
- Affected Areas
- Surrounding Urban Fabric
- New Developments
- New Settlements on Salt-Pans

CASE STUDIES

MAP OF GREATER MUMBAI

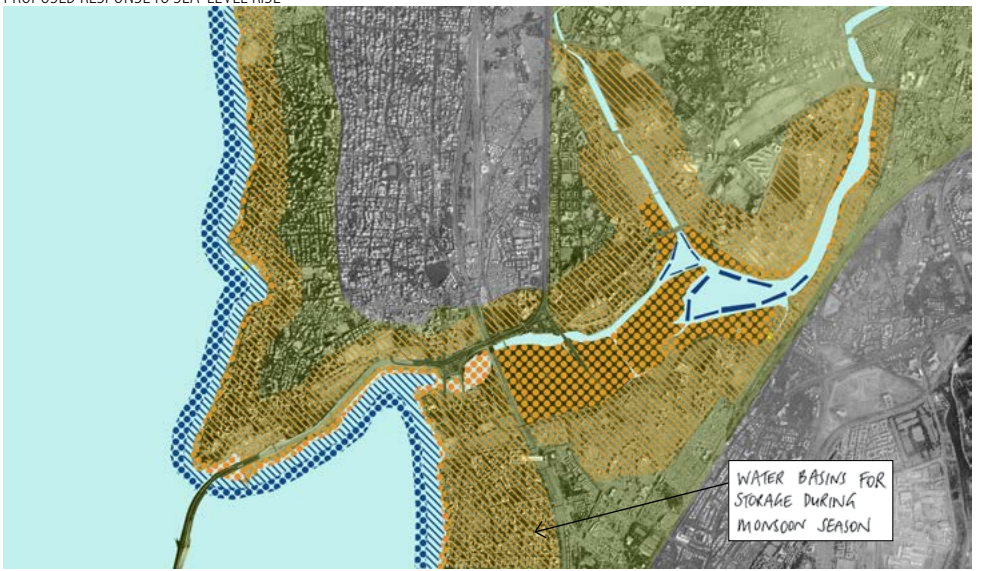


MAP OF MUMBAI INDICATING IMPACT OF 2m SEA-LEVEL RISE

- Current Water Levels
- Extent of SLR
- Affected Areas
- Surrounding Urban Fabric

KEY:	WATER FILTRATION	CONSTRUCTED APPROACHES	NATURAL APPROACHES
WATER	Oyster Filters	Oyster Reefs Pile Fields	Archipelagos
COAST	Constructed Wetlands	Water Basins	Natural Wetlands
LAND	Permeable Paving, Green Roofs & Native Planting		

PROPOSED RESPONSE TO SEA-LEVEL RISE



GOLD COAST, AUSTRALIA

The Gold Coast represents Australian's coastal culture and beach lifestyle. It can be divided into the narrow sandbar along the shore with the iconic high-rise buildings and the hinterland where the Nerang River previously meandered through expansive wetlands that were eventually transformed into an array of artificial islands and canals for holiday homes.

The powerful East Australian current severely erodes the sandy beaches, requiring them to be regularly replenished. The effects of SLR will create additional threat to the low-lying land that puts the 600,000 inhabitants and investment worth $300 billion at risk.

In 2018 the Gold Coast will be hosting the XXI Commonwealth Games, providing the opportunity to create a resilient coast based on geo-engineering and the ecosystem-based approach of Adaptive Urbanism.

Offshore an array of archipelagos would create estuaries for kayaking or paddle-boarding as well as blocking storm-surge to counter loss of sediment by erosion. The water precincts could be conceptualised as an eco-themed resort, comprising raised islands with constructed wetland embankments. In the long term, these future subtropical ecosystems could connect to Gold Coast's world heritage listed rainforests. The upcoming games has the potential to be the catalyst for a conversion to a sustainable eco-resort.

CASE STUDIES

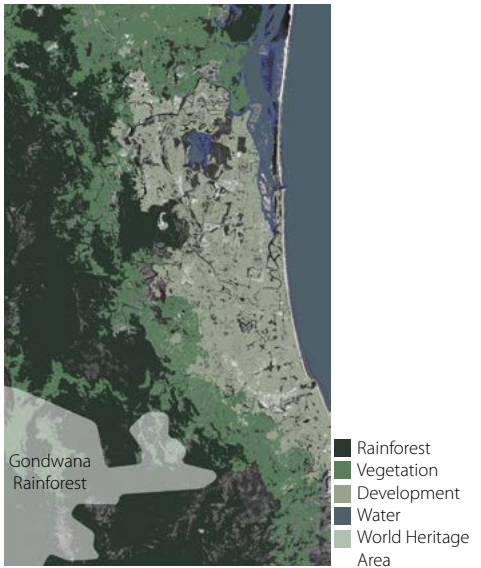


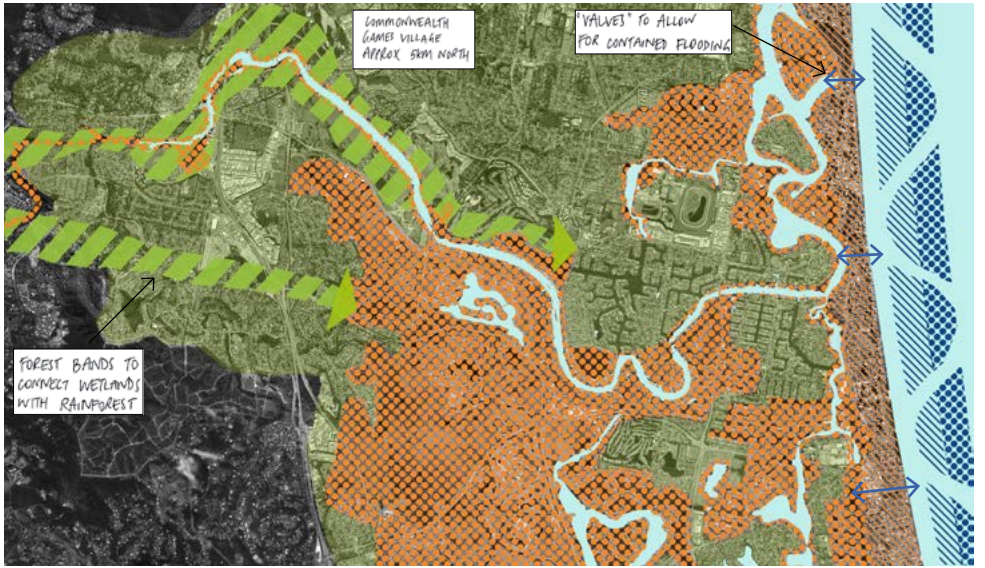
Figure 38. Land Use Diagram

MAP OF GOLD COAST INDICATING IMPACT OF 1.1m SEA-LEVEL RISE

- Current Water Levels
- Extent of SLR
- Affected Areas
- Surrounding Urban Fabric

KEY:	WATER FILTRATION	CONSTRUCTED APPROACHES	NATURAL APPROACHES
WATER	Oyster Filters	Oyster Reefs Pile Fields	Archipelagos
COAST	Constructed Wetlands	Water Basins	Natural Wetlands
LAND	Permeable Paving, Green Roofs & Native Planting		

PROPOSED RESPONSE TO SEA-LEVEL RISE



PERTH & FREMANTLE, AUSTRALIA

During the summer of 2012/13, Perth experienced a controversy over which were the most significant contributors to SLR. The debate identified at least three contributors:

- The actual SLR measured by the tidal gauge in Fremantle due to the thermal expansion of the ocean water in accordance with the 4th assessment report of the IPCC.
- The extreme inter-annual variability between 1993 and the present driven by El Nino
- The subsidence of Fremantle and Perth of c 4.6mm/yr due to groundwater extraction.

This debate may have scientific merit but for the cities, the contributors are less significant than the future impacts. However the argument does reveal the interconnectivity of the natural environment as well as the inability of scientific enquiry to gain total understanding.

Besides the steps already undertaken by the adaptation plans, we propose a high-level planning approach focussed on aligning with the sea and Swan River; designing permeable thresh-holds of land and water; softening embankments in Kings Park, and preparing retreat from eroding sandy beaches. Implementing these measures won't make the oceans stop rising but they will provide awareness and resilience to the recently exposed, complex environmental processes.

CASE STUDIES

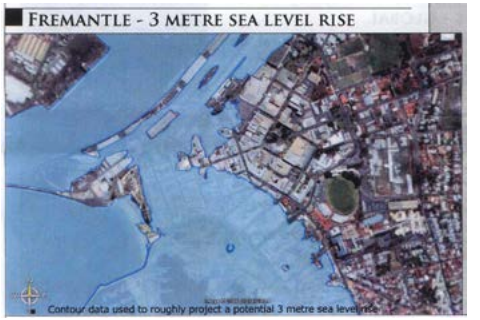


Figure 39. Image showing 3m rise in sea-level created by Dave Robertson and published in Fremantle Herald in 2006

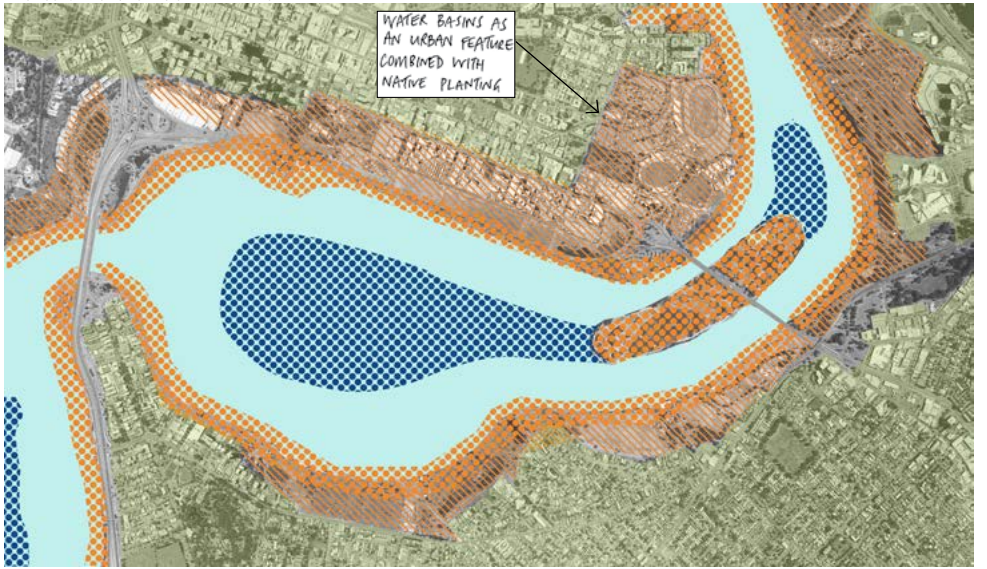
MAP OF FREEMANTLE INDICATING IMPACT OF 1.1m SEA-LEVEL RISE

MAP OF PERTH INDICATING IMPACT OF 2m SEA-LEVEL RISE

- Current Water Levels
- Extent of SLR
- Affected Areas
- Surrounding Urban Fabric

KEY:	WATER FILTRATION	CONSTRUCTED APPROACHES	NATURAL APPROACHES
WATER	Oyster Filters	Oyster Reefs Pile Fields	Archipelagos
COAST	Constructed Wetlands	Water Basins	Natural Wetlands
LAND	Permeable Paving, Green Roofs & Native Planting		

PROPOSED RESPONSE TO SEA-LEVEL RISE



AUCKLAND, NEW ZEALAND

Auckland is striving to become the world's most liveable city, and thus Waterfront Auckland, the City Council's organisation responsible for the coast, has sought advice from us regarding sustainability and resilience for future developments. Auckland will subsequently become the first city to apply the principles of Adaptive Urbanism to create a resilient coastal environment.

Fortunately, Auckland city is blessed with a very protected location. It opens East to the South Pacific Ocean but due to the Coromandel Peninsula and large number of islands in the Hauraki Gulf, it is quite enclosed. This reduces the threat of storm surges on the city and thus it requires less intervention than other, more exposed cities.

To the West of the City centre, around the Harbour Bridge and Westhaven Marina, approaches will be applied to soften the shoreline, purify the water, and make the waters-edge more accessible. In the long-term the entire shore will be adapted to become more resilient. Our role as advisors is to link local scientists, engineers and planners in order to develop solutions that align naturally with the given environment. In addition to this, there will be consultation with local tribes to ensure that the spiritual importance of the sacred land is considered and integrated within all developments.

Our task is an opportunity for public information and education as well. Along the timber boardwalks that replace the existing paved footpath, visitors will find informative features about the problems and how they are being addressed. It is envisaged that further steps for interactive online tools will be developed.

Auckland has identified that resilience is vital to withstanding the effects of Climate Change, and is thus implementing many principles into this extensive urban development project. Auckland has recognized that in the 21st century, all urban transformations must occur in a cohesively sustainable manner.

CASE STUDIES

Figure 40. Aerial photograph of Auckland City provided by Waterfront Auckland

Figure 41. Images produced for Waterfront Auckland advisory discussion

AUCKLAND, NEW ZEALAND

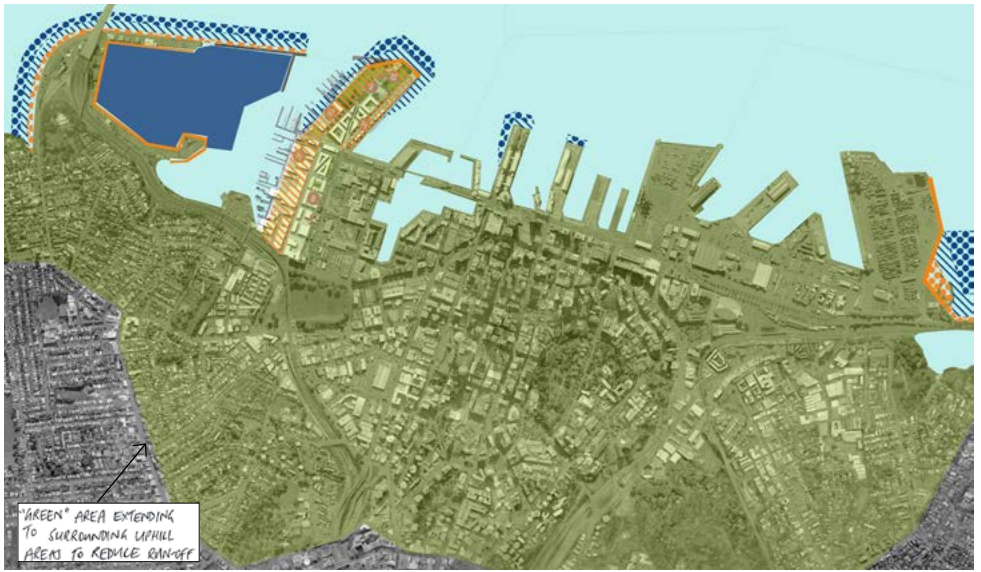
MAP OF AUCKLAND INDICATING IMPACT OF 2m SEA-LEVEL RISE

- Current Water Levels
- Extent of SLR
- Affected Areas
- Surrounding Urban Fabric

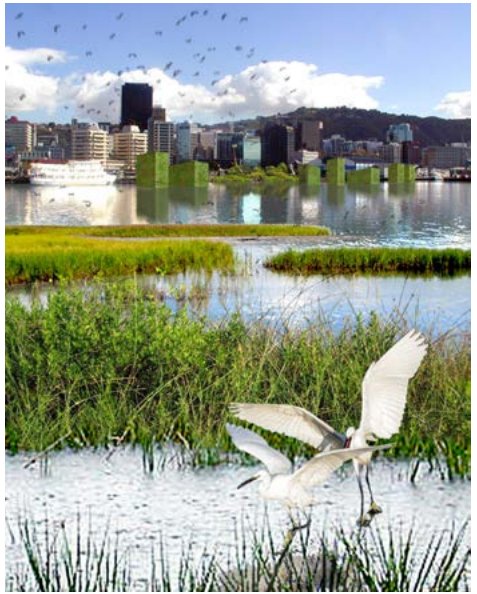
KEY:	WATER FILTRATION		CONSTRUCTED APPROACHES		NATURAL APPROACHES	
WATER		Oyster Filters		Oyster Reefs Pile Fields		Archipelagos
COAST		Constructed Wetlands		Water Basins		Natural Wetlands
LAND		Permeable Paving, Green Roofs & Native Planting				

CASE STUDIES

PROPOSED RESPONSE TO SEA-LEVEL RISE



CONCLUSION



In 2012, our first booklet initiated a discussion that has created the first opportunities to instigate change. *From Resistance to Resilience* develops these ideas into applicable solutions allowing the theory to be put into practice. We have initiated this through advising Waterfront Auckland, the council's organisation responsible for Auckland's coast, to put resilience into practice.

Currently there are several parallel streams of efforts that deal with Climate Change. Firstly, there are more than 20,000 UN-delegates, arranging Climate Change Conferences around the world, and preparing additional tons of papers filled with data that highlight the problem with increasing resolution. However no government has undertaken serious efforts to stop Climate Change. Additionally, the efforts of the United Nations concentrate, without success, solely on the reduction of Greenhouse Gas emissions. This is despite acknowledging that Climate Change has already been triggered and there is significant time lag between cause and effect. Without global agreement on climate control, governments are reluctant to take action.

However, we believe that action needs to be taken immediately. Our booklet illustrates our approach of:

- connecting people working on practical solutions around the world
- strengthening local efforts to both raise awareness and to increase resilience
- avoiding generic solutions developed by impersonal computer systems and algorithms
- establishing many hotspots of action on a local level
- achieving tangible, realistic results that are embedded into local environments and communities

Developing a holistic strategy that aligns with nature will allow urban environments to become thriving, amphibious metropolises instead of barricaded cities. Viewing climate change as an opportunity for urban reinvigoration, the measures and case studies in this booklet provide valuable information on how our cities can become resilient for the future.

ACKNOWLEDGEMENTS

GABRIELLE FREE
Research Assistant,
Editor & Graphic Design

Gabrielle is an architectural graduate with a keen interest in the complexities of urban sustainability worldwide.

ANDREA MUNROE
Editor

Andrea has over 5 years experience producing professional copy and is a key member of S&T's marketing team.

CATHERINE HUGO
Graphic Design

Catherine has more than 13 years in graphic design and marketing experience in advertising, publishing and architecture in both the States and New Zealand. She is S&T's marketing manager.

STEPHENSON&TURNER
Publisher

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ABOUT THE AUTHOR: BERND GUNDERMANN

Before becoming an architect, Bernd studied Geosciences and was actively engaged in the preservation of coastal estuaries. Since then he has more than 30 years international experience as an architect and designer, responsible for over 350,000m² of building space. Bernd was Lead Master Planner and Architect for the Hanseatic Trade Centre in Hamburg, converting 15 Hectares of former port into a mixed use development, which led to the largest port-conversion project in Europe, Hamburg's Harbour City with 2.3million m2 GFA.

Bernd is currently a Professional Teaching Fellow and Masters Thesis Supervisor at the University of Auckland. His research on coastal responses to Climate Change will be published in a text book in India this year which will be adopted into the curriculum for smart planning in many universities throughout India. He is an Expert Reviewer for the 5th Assessment Report for the Inter-governmental Panel for Climate Change, the guest speaker for the Commonwealth Human Ecology Council Annual Lecture, and has been invited to speak at the Dynamic Cities conference in Perth later this year.

Bernd has produced two booklets on Sea-Level Rise and Coastal Response; Adaptive Urbanism and From Resistance to Resilience. They demonstrate his philosophy of aligning urban interventions with the natural environment; designing away from the current, predominantly static mode to a new paradigm of adaptive resilience.

CREDITS

A recent US study states that a rise of 1.6 feet (49cm) by 2070 puts 150million people and $35trillion in assets at risk in just 20 of the world's most vulnerable and fastest growing cities. Furthermore, by 2050 in India an additional 420 million people will live in urban areas, many of them along the coast, which is threatened by hurricanes and monsoons. The erection of tens of thousands of kilometres of concrete sea walls will only increase Greenhouse gas emission and worsen the problem.

The impacts of climate change can be interpreted as a 'wake-up call' to evolve from superseded archetypes. By aligning with nature rather than opposing it, we can shift the paradigm to being united and integrated with the natural environment, protecting lives and assets. This shift will minimize hard engineering and implement soft, ecosystem-based options and by doing this we will lead the way From Resistance To Resilience.

STEPHENSON &TURNER