Regenerating Ecological Services Using the Public Realm Landscape. A city's largest asset to address climate change is their public realm landscapes (including streets!)

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Abstract

Today, the Greater Bay Area (GBA)is China's behemoth of industry with a population exceeding 42 million. However, the rapidity of growth of these cities comes at a steep price, given the scale of the consequences of climate change poses in the form of sea-level rise. To address climate change so humankind can survive, will demand human intervention. Neither the US nor China is working fast enough to avert Climate Catastrophe. Both produce a combined 53% of the world's CO2 emissions, and China is the largest emitter (28%) in the world, with no policies to stop mining coal.

At some point soon, China will have a reckoning between the benefits of China's expansion of wealth, and the costs of losing its coastal cities which generates 35% of the national GDP. Economically, Guangzhou now has more to lose from climate change than any other city on the planet, according to a World Bank Report. "The challenge facing government officials today is investing in protection before the damage occurs."[1] The clash between the effects of a warming climate, and the human desire for more wealth, will have to be reckoned with.

All coastal cities will experience somewhat the same impacts: submergence and flooding of coastal land, saltwater intrusion into surface waters, destabilization and disruption of infra-structure and groundwater, increased erosion, and overwhelmingly negative social and economic repercussions. These effects will be widespread and will accelerate with time.

1: Which Coast Cities are at Higher Risks of Damaging Floods? New Study Crunches the Numbers, August 2013. https://www.worldbank.org/en/news/feature/2013/08/19/coastal-cities-at-highest-risk-floods

Designers of the built environment have an extremely important and large role to play in reshaping coastal cities so they can adapt, build new cities, and importantly, mitigate the causes of climate change. Landscape architects are more and more involved in large-scale, Nature-Based Solutions (NBS), some of which reach into agricultural and indigenous people's practices or may even combine bioengineering and new technologies. There is even one idea being researched from the field of solar geoengineering that proposes to cool the Earth, thereby reducing most of the impacts we are feeling and will feel in the future, however, it may slow sea level rise but cannot stop it. We will look at case studies and different strategies that may be pertinent to China's important coastal cities. Our remit is not only to halt climate change, but to learn how to live in balance with nature if we are to survive.

Most climate change effects experienced in Guangdong Province are shared. Given that much of the land that these cities sit on is either coastal or situated on the Pearl River Delta area, all cities within this area share a number of climate change effects, such as health issues, due to the smog or viruses, water management, and lastly, and perhaps the worst, the Urban Heat Island Effect. However, the GBA faces another serious issue, which is sea level rise.

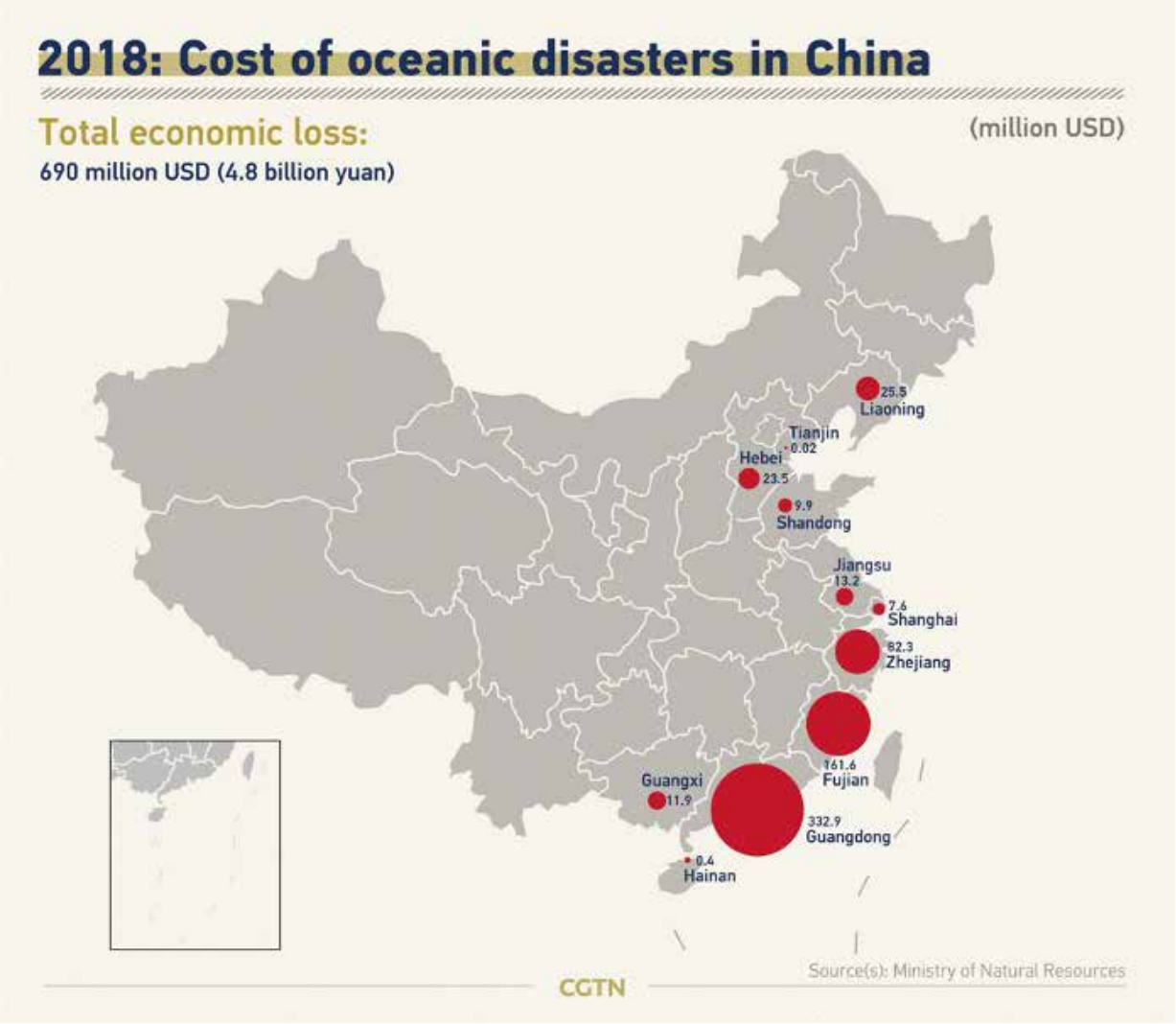

Fig 1: Sea Level Rise

Every city within the GBA will be facing more floods and tidal surges, worsened by a mix of increasingly severe storms, and land subsidence, as the earth compresses under the sheer weight of these cities, and amplifying the impact of rising waters. The destruction of Shenzhen's wetlands in recent decades is perhaps one of the area's biggest climate challenges.

These red dots represent the cities that are going to be affected in China by sea level rise. The size of the dots represents economic loss from climate change, and you can see that the GBA will have larger economic losses due to sea level rise than any other city in China.

The image below shows the percentage of the population that will suffer due to sea level rise, and Shanghai will suffer the most given that 76% of its population will be affected, the highest percentage of people in any city in the world.

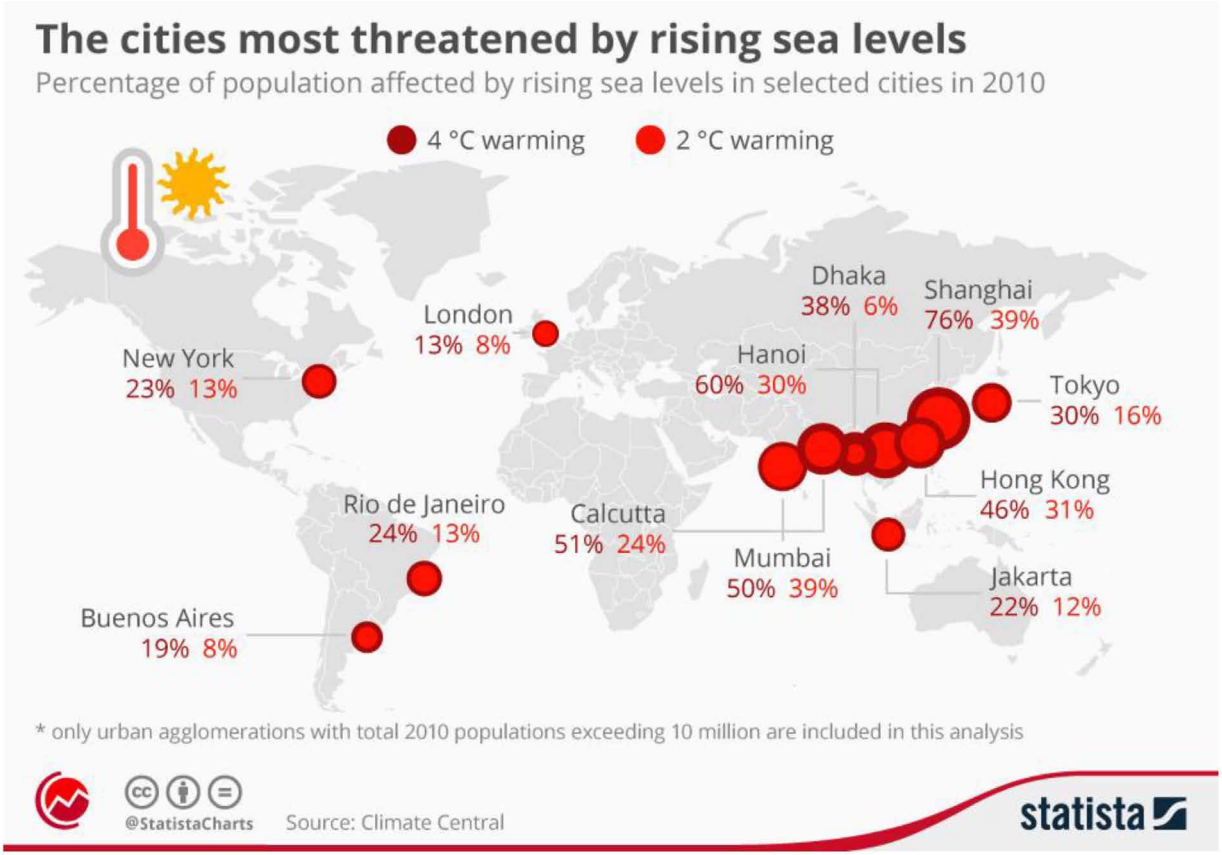

Fig 2: Cities Threatened by Sea Level Rise

Hong Kong, which covers the GBA region, shows 46% of its population will suffer, statistics on GDP losses show that Guangzhou will have the highest GDP losses in China.

This image shows economic losses where China leads the pack showing that losses exceed between 100-300 billion US dollars. It says among the ten costliest disasters, 7 were reported in China, mainly due to floods, but also due to cold waves and drought.

This image shows a Map of the rising South China Sea, and the over-stressed Pearl River network lies just a meter or so below the city that is poised to drown after decades of progress. Notoriously, China, today, is crippled by air pollution linked to local emissions from coal-fired plants, steel factories and cars. This map is from a website called Climate Central. It's a fantas-

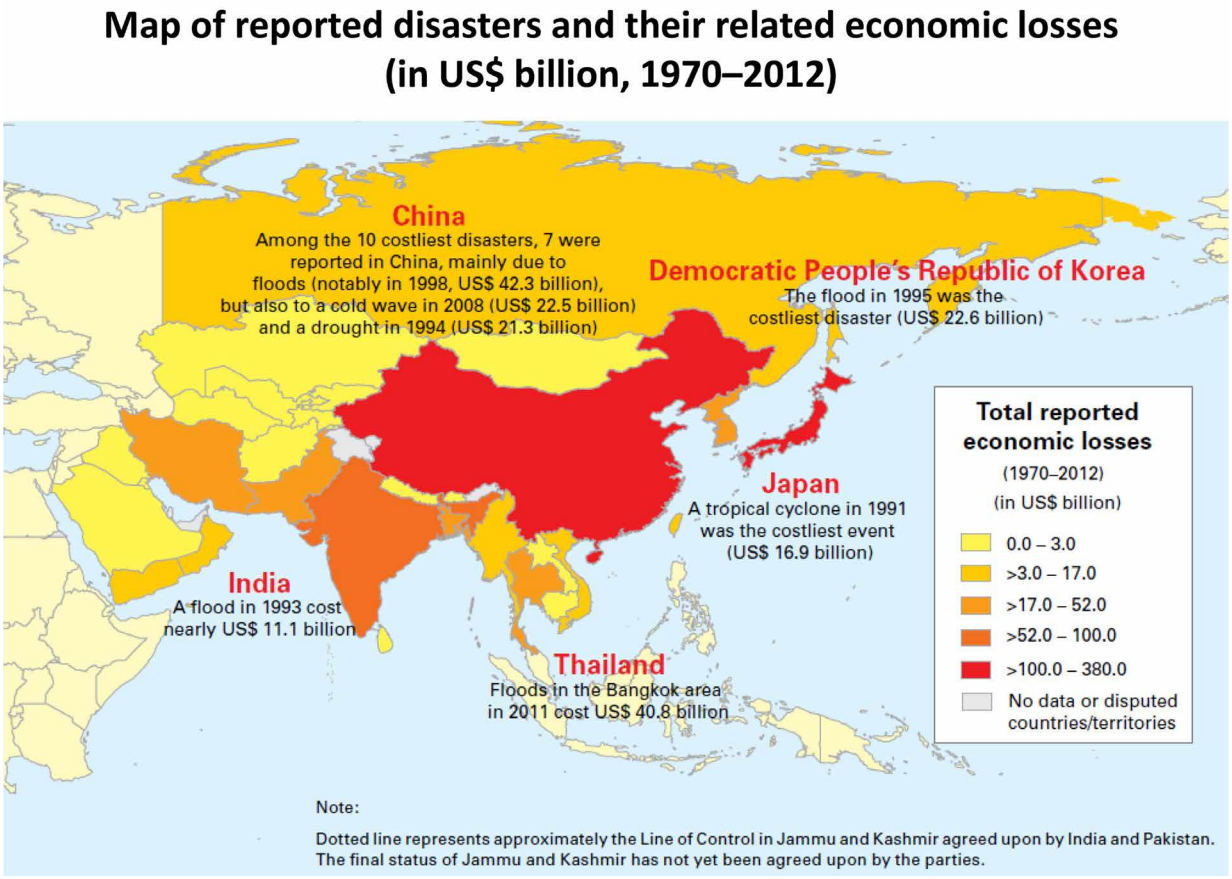

Fig 3: Maps of economic losses due to Sea Level

tic interactive site that you can play with to see what sea level rise looks like in the years 2050 and 2100. In 2050, the red indicates land under water. So, what we are seeing shows that the GBA will be under water by 2050.

HONG KONG

Starting with the city of Hong Kong, it was difficult to find much information about climate change impacts other than about cyclones that will be stronger and more frequent. Storm surges will also be a very serious issue. Hong Kong will do a bit better in the region due to its being on top of rock, although sea level rise will be an issue later on. It will be the storm surges that will hit the first and the hardest.

However, the real culprit for Hong Kong will be precipitation from storms and the amount of storm water that will gather within the streets of Hong Kong, causing increasing floods, as well as lack of food and water.

One possible solution I suggest, to deal with storm water management for Hong Kong, is based on "terraforming" (shaping) the mountains sitting behind Hong Kong. These paddie-formed terraces can hold and absorb the storm water, a real threat to the city, while at the same time catch and store precious rain-water for drinking (which Hong Kong will need). As

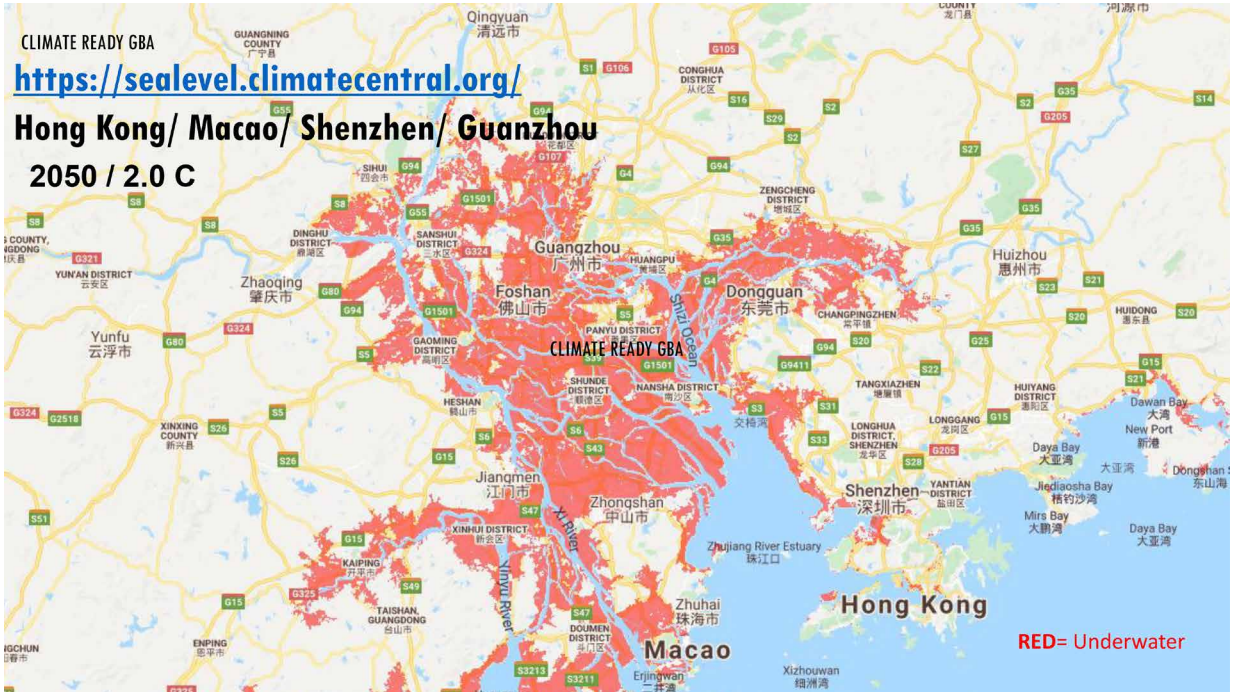

Fig 4: Map of the GBA area Sea Level rise in 2050

well, these 'paddies' could support agriculture in order to grow your own food (which will also be needed) as Hong Kong will have to be more self-sufficient in the future, especially food. By 2050, countries are not going to be sharing food, as our countries must feed our own populations. A recent article says that in the future, the United States will have to find land 2.5 times the size of California to be able to feed us.

This is something that we must consider as a reality and plan for, in terms of urban design, and how we must redesign our cities for the near future. The food crisis is happening due to the spiraling heat. The environmental stress on agriculture and the people who work in the fields means that there will be less food in China. So, think seriously about terraforming the mountains.

GUANZHOU

Rushing to catch up after decades of stagnation, China has built a gargantuan collection of cities the size of countries, with barely a pause to consider their toll on the environment. This was not a topic thought about when amazing growth and transformation started for China, however, even though climate change is now, taking large tolls on the country, it does not seem that climate change and its impacts are being considered even now. Today the region of Guanzhou is a titan of industry with a population exceeding 15.3 million, but while prosperity reshaped the social and cultural geography of the delta, it has also opened up numerous

Fig 5: Hong Kong mountains shaped into paddies, control storm water/ provides water/ Martha Schwartz

vulnerabilities to the impacts of climate change. Here as elsewhere, the breakneck development comes up against the growing threat of climate change.

There are many reasons we are at this point. Most of these problems come from how we have dismissed natural ecological processes, we covered the land, cut down trees and removed grasses and groundcovers that held in moisture and held-down the soils, lessening fires and heat, and polluted the air and rivers due to the lack of oversight, and lack of care or effort to protect the soils and waters which are fundamental to our health.

Rains have already brutalized many cities throughout southern China. Flooding has been a plague for centuries in China's Pearl River Delta, and is happening to some extent because canals and waterways that had once helped drain the cities naturally are gone. Like Guangzhou, many cities, natural streams and rivers have been filled and then paved over with concrete as a whole. Impervious surfaces are the cause for flooding which is a huge and destructive issue for most cities, but the removal of these impervious surfaces and implementing pervious surfaces, and the opening up the streams and soils, could be a big solution to what cities will be facing due to climate change. Whatever the costs will be, it will be less than the destruction that flooding will bring, and the loss of housing, industry and economy.

SHENZHEN

Nearby, Shenzhen, which is another booming

Fig 6: Rains have brutalized cities throughout southern China

metropolis, is ranked 10th in terms of financial risk due to climate change on the World Bank list, which measures risks as a percentage of gross domestic product.

Climate change not only poses a menace to those who live and work there, causing severe impacts on the immense concentration of wealth and investment. It is also a threat to the world, like us here in the US, who have grown dependent on everything produced in Shenzhen's factories. In order to grow this incredibly productive corner of the world, China has unveiled a very comprehensive policy, which is very interesting.

This policy suggests reforms that would be implemented in Shenzhen. It is a framework agreement that further defines Qianhai, as a key Hong Kong - Guangdong Cooperation Zone. Qianhai will play, or is playing now, a leading role in changing China's development process and is now working on promoting a relationship between Shenzhen and Hong Kong. Cen-

Fig 7: ShenZhen

turies of industries are being connected with the thought that this cooperation will build even a more robust economy in China.

This diagram shows the aspiration of connectedness, which will create a vast node of commerce at a scale that we haven't even yet seen on earth.

However, this other image is a curiosity, as its shows black dots in the Qianhai Bay area which are the locations for the various centers which will be built to house these programs. centers include the Business Centre, a Bonded Port Zone, a Qianhai Port, a Comprehensive Development Zone, a Coastal Recreational Zone, Housing along the Bay, and the Shenzhen Heliport. The strange thing is that according to this Climate Visualization created by the very qualified site, 'CLIMATE CENTRAL,' all of these new centers are going to be below water by 2050. How did this happen?

Fig 8a: Shenzhen Commerce Diagram(1)

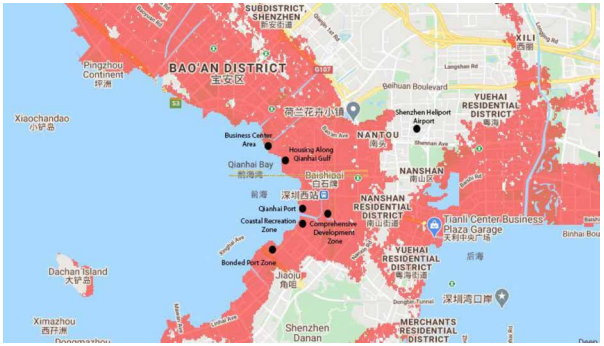

Fig 8b: Shenzhen Commerce Diagram(2)

Unfortunately for this initiative, about 70% of mangrove forests along this coast in Shenzhen have been destroyed and their disappearance is accelerating. An article says that 2100 acres have been paved over between 1979 and 1985, and 6700 more acres during the next decade, and thousands and thousands more. I guarantee that Shenzhen will be paying a lot more money as the ocean moves in and ravages the newly built economic enters. The reality is that the problem isn't just about the loss of mangroves. It

is also due to the landfills upon which the buildings will sit. When you landfill an area, it is notoriously vulnerable to rising water because it destabilizes the earth and the buildings sink.

Again, my question is, why are huge investments being built in a flood zone that is flooding now? Whose reality this is? Who has created this heroic vision without understanding the reality of climate change, as this very area will soon belong to the ocean. It is difficult to understand how so much investment in infrastructure and growth is being done, carelessly, and especially in areas that have been mapped by scientists who have proven that this area will be highly affected by sea level rise in the near future. Again, the mangroves could have helped to hold back the water. The destruction of the mangrove forest was a horrible mistake basically caused by ignorance of, or ignoring the importance of natural systems and their benefits in protecting coastal sites in the face of climate change.

Without having a very clear view of what the IPCC (The International Panel on Climate Change) and what the scientists are saying (On the World Wide Web), it is a terrible mistake to invest so much in areas that are now, only temporary. These important and bold "Visions" could be created in areas that are much safer and would last much longer. Without the any understanding of the benefits that nature provides for us and without any knowledge about climate change and the impacts that will reshape our cities, China will befall many catastrophes that could have been averted. My question is whether leadership in China is aware of what is happening to our climate? Do they understand the seriousness of these repercussions? And how does this impact the other major cities in China? What is China to do if there is no guidance and oversight to begin with, and how will city leadership learn how to integrate adaptive measures to protect their cities?

The world acknowledges the astonishing transformations that China has accomplished in an incredibly short period of time, however it is time to be wise as we enter a new era, with the earth's systems having been destabilized to the point where potentially that there is no turning back. How is it possible to risk humanity while looking for more riches or power? What is it that we (humanity) really care about? These are things we all must think about.

Right now, if we were not able to stop climate change tomorrow, Global Warming will continue to spiral for decades. Very soon we will not have the ability to turn this around. The Earth will move on in her own way, but now it is urgent that we to stopping emissions before we can no longer 'turn the ship around'. We also must repair and regenerating the earth, and adapt our cities so they can provide shelter for humanity who will be living on a hotter Earth. We must use adaptation methods that can prepare the urban landscape to make our cities "Climate Ready".

The major lesson we have learned, is that we, collectively, have ignored the value that nature provides for us. We have degraded our lands, air, water and food and now we shall pay a

tremendous cost. In developing our cities and economies, we have devalued all of these gifts we nature provided for us. And the land beneath our cities is the most, valuable part of our city that can be used to protect us as the climate impacts become more severe. Up until now, we only valued the urban landscape by what we could build on it. But now we are learning that was a big mistake. Scientists and economists are starting to create metrics called "Ecological Benefits" that is now monetizing the benefits afforded by nature.

It is of real importance to understand that the Urban Landscape is critical to creating a safe future for a city and its citizens. Of course, to appreciate these benefits, one must also understand the risks and impending catastrophe we are facing.

JAKARTA

The reason why the urban landscape is so important, is that it is the largest,contiguous, infra-structure a city has that can be re-designed, re-envisioned, re-built and re-engineered to protect the city. The land is the great canvas for a city to adapt to climate change. Adaptation along with Nature Based Solutions will enable cities to cope with the impacts of climate change. This was the basis for these islands' development and design.

Our company worked on a project a number of years ago located in Jakarta called Pluitt Island.

Above (see fig 10) is a master plan for a city of 70,000 people on an island off the coast of Jakarta. It's a new city built on two man-made islands, designed by the Dutch firm Royal Haskoning, a company that knows how to build dams and other infrastructure that controls the ocean. This is an interesting solution: they knew that the land was subsiding, so they suggested to build islands that are already in the water like fake islands, like a ship going into the wind, instead of with the wind.

The design and process were complex, given that this island would also subside, like the mainland where Jakarta was already sinking. But the structures of the buildings were built so that they would hold steady. The landscape had to be designed so, that as it subsided, it was adaptable enough to change as the relationship between the building and the land changed slowly over time.

We learned about mangroves, and how they provide a natural buffer from the sea, shielding the coastline, reducing the impact of waves and rising water, and filtered out the salt that can infiltrate freshwater reserves. As well, they are the incubator for fisheries as they protect fish eggs and allow them to grow and provide food for us and other ocean animals, and importantly, a fishing economy.

However, Jakarta had destroyed all the mangroves that shielded the city and built Hi-rise buildings along the coast. The idea was that this sea-side development would create a lot of financial value, which it probably did… for a short while.

We designed the new island so it would be able

Fig 9: Pluitt Island, Jakarta protected by Mangrove Forests /Martha Schwartz Partners.

to weather climate change and sea-level rise by creating a 'wall' of mangrove islands.

Our goal for the new islands was to re-establish a large, Mangrove Forest in the new marina.

To make sure the new islands would be well protected from storms and sea level rise, we planted Mangroves within the rocky slopes up to the islands' edges. Docks were able to float up and down that led boaters access up to ground level.

We created a series of 'Mangrove Islands", as the water is not very deep, and planted them with Mangroves.

What you see here is the second island with a

boat marina. The marina, full of islands, act to protect the mainland against floods and ocean waves. The marina is like a cul-de-sac within the 'sea' of small islands. Planted with mangroves and trees, these islands were there to rebuild the fishing industry and protect the mainland and the islands. It's also a floating public park where people can walk out on the water on boardwalks, or dock small boats, and visit the mangroves.

But Jakarta is now sinking due to sea level rise, saltwater intrusion, land subsidence, and is now dealing with mass migration to another site. Leaving a healthy layer of mangroves along the shoreline would have avoided this catastrophe.

It turns out that the money they thought they'd make in developing these waterfront properties would turn out to be a pittance compared to the cost of moving to a new city (which they are doing), or having to rebuild Jakarta. It is now a flooding city left to the rest of the people cannot afford to move elsewhere. These areas, along with a series of islands that the developers have built, will be what is left of Jakarta.

Fig 10: Pluitt Island, Jakarta/Mangrove Islands Park protecst waterfront/Martha Schwartz Partners.

NANAO

NANAO WATERFRONT PROJECT, CHINA

This is a project located in NanAo, is very close to Hong Kong. Out remit was to design the coastal waters of the Dapeng Bay and the coastal area of Xichong Nan'ao Bay so it could withstand rising sea level and deal with the typhoons that regularly swept through this area, bringing much destruction to the coast.

The client wished to make a resort on the beach, a very beautiful environment that's been suffering due to typhoons and eroding beaches. We understood that the future of Na'Nao was severely threatened and that it needed protection from the storms as they are becoming more severe and coming more often.

We devised a series of five different levels of defense which are a series of different methods that will protect the shore as well as the forest and city in back of it.

The methods of protection include sea barriers, artificial reefs made of floating breakwater islands and eco-piles; then the coastal dyke, made out of mounds that are up from the beach and protect the forest at the back; then the eco-park, a large zone of vegetation which includes wetlands and woodlands and absorbs water; then an inland dyke made of re-enforced sand dunes; and retention ponds, that actually help to slow down and store the water coming down from the mountain - we had two sources of wa-

Fig 11: MSP Natural Solution to Sea Level Rise and Typhoons Project

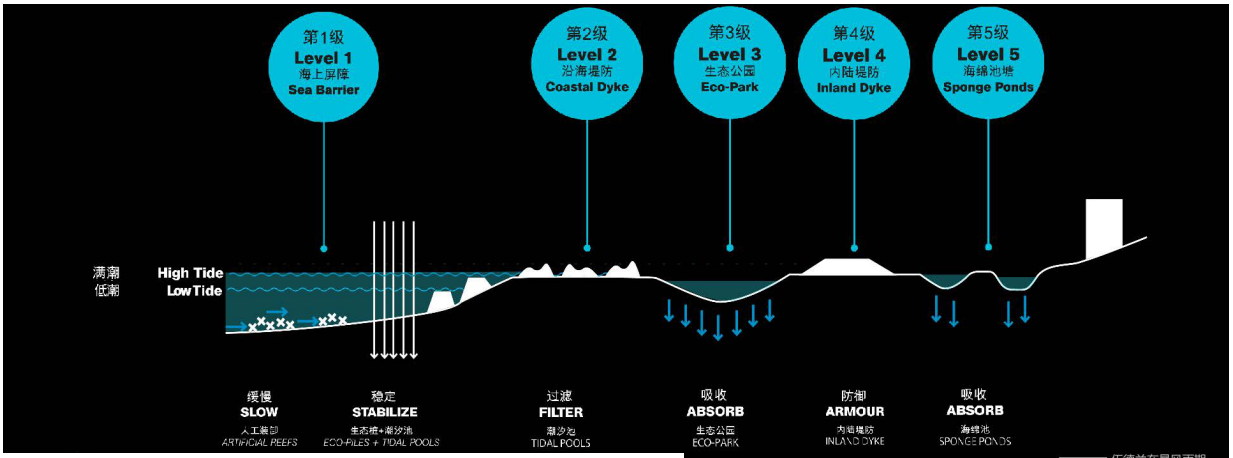

Fig 12: Levels of Defense

ter to deal with.

There are many ways that nature and natural processes can help us to win the war against Climate Change. They are now known within the Climate Change discourse as Nature Based Solutions (NBS). But the point is that the more we integrate NBS to build green infrastructure that also incorporate new technology, materials, and methods, the stronger we can create resiliency and adapt to our new climate.

THE LINEAR URBAN FORESTS

This is a design studio I ran at the Harvard Graduate School of Design (HGSD), called "SEQUESTROPOLIS", based on Rob Adams' work in Melbourne, Australia. It's about urban afforestation and is based on the insertion of ecosystems into cities, which is a radical idea. Forests are very different that street trees, as "street trees" create beauty in cities, but that's about all. Forests create so many more benefits; absorb air

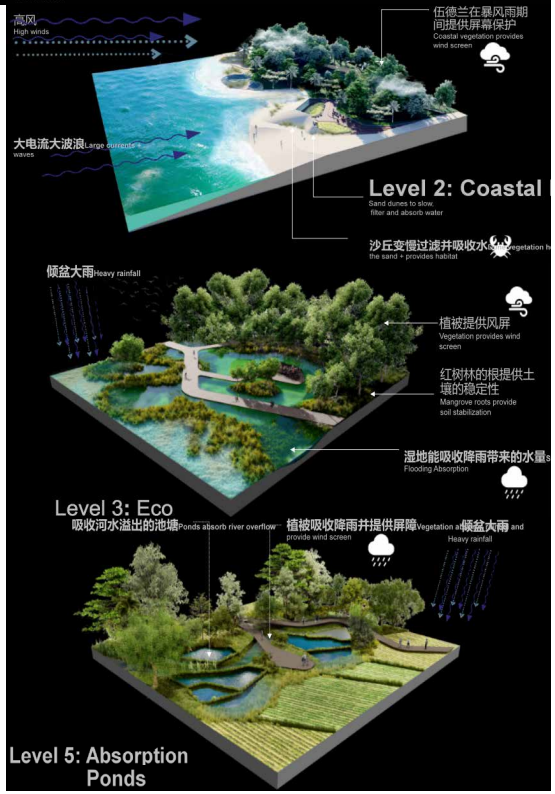

Fig 13: Coastal Dyke/ Eco Parks/ Absorption Ponds Levels of Defense

pollution/ stabilize soils/ cool cities & help to reduce energy (reduce the need for air conditioning, support biodiversity/ create economic value/ support mental health/ create quality of life and beauty). The idea of linear forest is that, this forest can run throughout the entire city, creating "environmental benefits" at a scale that matters, as well as addressing climate inequity.

However, if we contemplate the Urban Right-of-Way, the land that cities own, and view it as a space that we can engineer, shape, and use it as urban green- infra-structure, we can use this important space to implement adaptation in order to survive the impacts of climate change.

This transition to use cities' streets so we can use the land to protect the city, starts with the fact that within a decade, we are going to be driving automated electric vehicles, which will need far less space in our city streets.

The metrics show that we could recover 30%-50% of the land of the public right-of-way in cities. The idea of the Linear Urban Forest (LUF) is that as we no longer drive in privately owned cars, and have Transport As A Service (TaAS) using AV/EV Uber-type public transit.

This will give cities an incredible opportunity to use street areas that run throughout the city as a way of bringing forests throughout, in order to cool down our cities and avoid Urban Heat Island Effect. The Linear Urban Forest will

Fig 14: Benefits of the Urban Forest

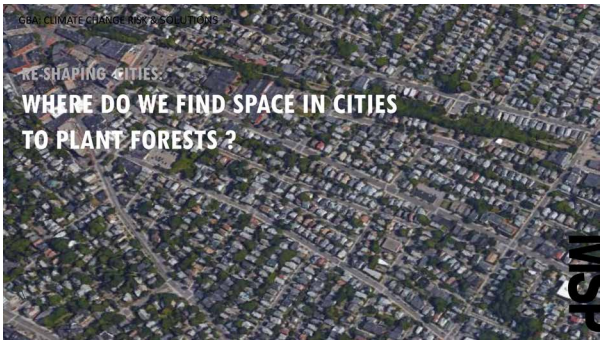

Fig 15: Where do we find the room for forests in a city?

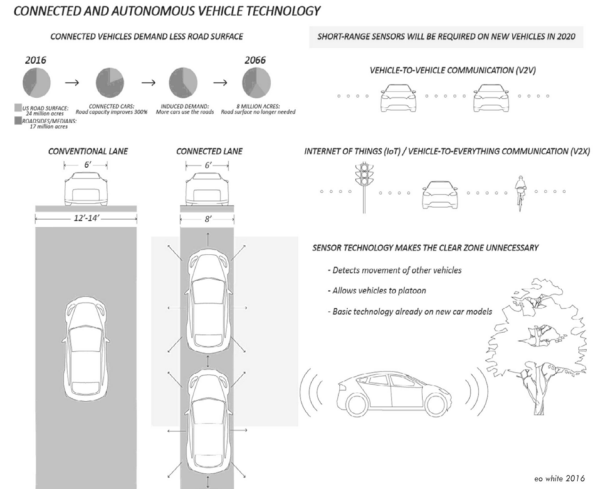

Fig 16: Future Mobility is the key to re-shaping our cities

provide benefits such as to absorb storm water, grow food, collect drinking water, create clean air, restore biodiversity, cut down need for energy because there's little need for air conditioning, stop spread of vector-borne diseases, make our cities beautiful and create climate equity. These forests could create the a "Protective Wall" against Climate Change for most cities as impacts grow more severe as the planet warms.

The trench in which the Linear Forest is planted will also contain Storm Water Management devices that can both detain and retain water, so the forests can be irrigated during drought events and capture storm water during extreme precipitation events.

The Linear Urban Forest will also help to mitigate emissions by absorbing carbon dioxide and pollution. We are also going to take out all the impervious paved surfaces and replace this with permeable surfaces and open up more land so it can help with stormwater management issue tremendously.

This is an example of a student's work. It shows the cross-section of one of the streets he designed. All streets were redesigned to integrate the Linear Urban Forest along with enough space for the EV/AVs, sidewalks and bike lanes, drops-off points, and noise barriers.

Students created metrics on the benefits of the Linear Urban Forest using an application called i-tree which is developed by the U.S. Forest Service.

The class determined that in the 108 sq. km. areas we worked on, and a population of 900,000 people, we were able to save 206 million dollars a year just in energy savings, due to the ability of the trees to cool down the city.

This is an example of creativity in problem solving that we will need now and in the future, as we cannot depend on business as usual any more. We are no longer living in the holocene. We are now living on a new planet – welcome to the holocene! We need new ways of thinking

Fig 17: Linear Urban Forests and Storm Water Devices create a balanced urban climate.

about how cities and nature can be integrated so we can adapt to and live on a 'new' planet.

ADAPTATION IS FOR NOW--- EMISSIONS- CUTS WILL BE FELT LATER

This sound very strange. But it is true. The effects of the reduction of CO2 emission will be felt over time, as even if we were to stop CO2 emission the Earth will continue to warm up due to the fact that our natural processes move slowly, as the effects of Global Warming are being experienced now, affecting millions of people while we are 'only' at 1.2°C. Given our situation, we will likely blow past the 2°C :Tipping Point, likely before 2050, as the Globe is heating up more quickly than predicted. Every small increment in heat creates logarithmically more severe impacts. But even at 1.5°C life on Earth will be catastrophic. We must work to protect our cities and citizens now.

Adaptation and working with Nature Based Solutions, are the ways forward to make our cities

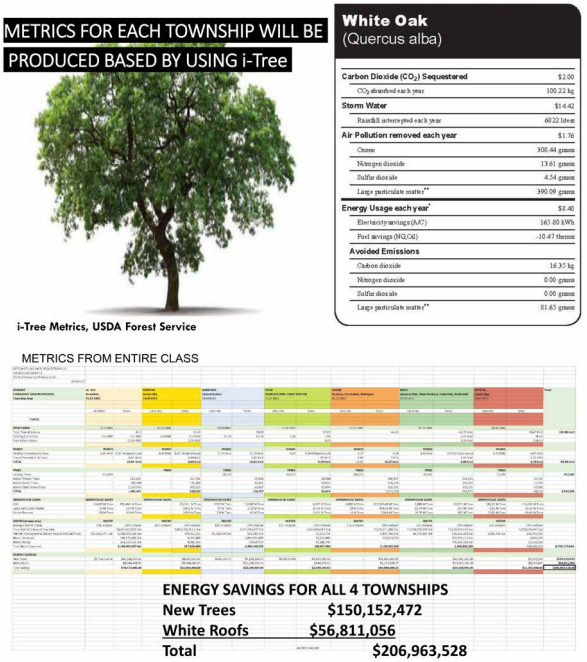

Fig 18: Metrics show that 4 Townships in Boston save $209,000,000 / year on energy due to cooling of the Linear Urban Forest.

Fig 19: Climate ADAPT: An excellent document for learning aboutAdaptive Measures and Nature Based solutions to protect your city.

"Climate Ready". Our urban landscape is the most important and useful component of a city that can be planned, re-designed, and re-engineered so to protect and sustain a city.

"CLIMATE ADAPT" is a compendium of Nature Based Solutions that can address issues in cities. It is an excellent document, prepared by an organization in Europe called Grow Green. They have actually looked at green cities, climate, and water. It's funded by the European Union Horizon 2020, and focuses on grey and green solutions to climate change. I highly suggest that you self-educate and advocate to leadership these ideas.

It has information needed to understand how to plan and design the Urban Landscape to protect our cities. There are two pages that are lists of 60 nature-based solutions. Along with this, we are going to have to regenerate our natural system if we want them to survive, which means that we have to participate in the regeneration of nature. We will use technology integrated with ecological systems to build green infrastructure.

We will use new ideas and science, such as geoengineering to cool the Earth, bioengineering to make plants more reflective, and we must use every idea we can think of to rebuild our cities so we can live in balance with nature.

3 MAJOR STEPS

In order to address now and the decades ahead of us, we must prepare ourselves for a 2°C world through three major steps.

1.Reduction of CO2 Emissions

2.Bring dodwn Atmospheric CO2 (through Carbon Dioxide Removal)

3. Prepare your cites through adaptation using Nature Based Solutions & Green Infrastructure