Change isn't always good

Michael Grove
ASLA, PLA, Sasaki Associates mgrove@sasaki.com

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Abstract
Anthropogenic climate change is one of the most existential threats humanity has faced. Its eventual outcomes, if we do not intervene now, will be catastrophic. Landscape architects are in a unique position to become some of the most influential voices in identifying solutions. There is no silver bullet that will solve the crisis. Multiple strategies require a systems-thinking approach on a variety of fronts and at a diversity of scales. Designing a more resilient future must span the spectrum of ecological, economic, and community-based approaches to tackle big topics like regaining the planet's biodiversity, rethinking the impacts of our current agricultural practices, and engaging political leaders and ordinary citizens to support strategic investments that will reduce risk.

Keywords
Resilience, Habitat Loss, Climate Change, Urban Agriculture, Landscape Architecture.

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The acclaimed Russian author Leo Tolstoy once said that "everyone thinks of changing the world, but no one thinks of changing himself". Even before the dawn of civilization, when our Neanderthal cousins roamed the earth alongside us, humans have been at the top of the food chain. Being the dominant species has allowed the human race to not just to survive, but to thrive. But at what cost? When the industrial revolution demanded that we use Earth's natural resources at unprecedented amounts, we became reckless. For millennia before, our very existence depended on an intentional stewardship of the natural world around us. But our kinship with the Earth was abandoned centuries ago, and now seems nearly forgotten. We *have* changed the world, but not for the better. The fact that technology has improved our life expectancy, and has allowed us to explore further and connect with each other more is not being questioned. But so far, we have observed that technology has proven to be more of a drain on the planet's resources, rather than the panacea that was promised. The world does not need changing—it is we who must change.

Throughout my career as a landscape architect, I have generally been an optimist. The act of design is, by nature, forward-looking. When putting pen to paper, you are laying out your hopes and dreams for the future—blending the reality of present day needs with a grand vision for what might be. As designers, we think of ourselves as stewards, often with a healthy dose of hubris guiding us to believe that human potential can solve anything. I hope it can. But we must address the issues at hand with bold action. Climate change extends far beyond sea level rise and warming temperatures. It is impacting the biodiversity of our planet with frightening consequences, reducing our ability to continue to feed our ever-growing population, and risks sending the global economy into a tailspin.

With that in mind, designing for a more resilient world requires a multi-faceted approach, as inconsistencies and ambiguity arise when we define resilience too broadly. At the very least, we must address resilience as it relates to climate change from an *ecological*, *humanistic*, and *economic* perspective. The following outlines some of the most significant existential threats we are facing, thoughts on how to address resiliency as it relates to these three categories, and tangible examples of projects that are confronting them head-on.

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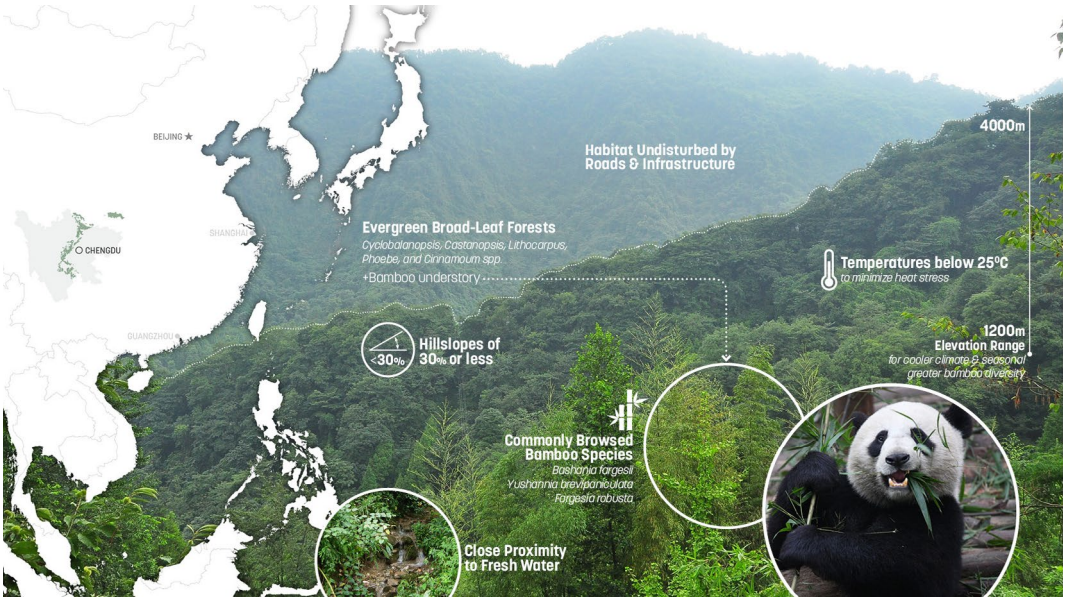
Fig. 1 – Habitat Requirements of the Giant Panda.

Ecological Resilience: Regaining the planet's biodiversity

By the end of the 21st century, the Center for Biological Diversity estimates that more than 50% of the planet's species will be extinct. A recent report by the United Nations calculates that over 1 million distinct species are already at the brink of extinction. What all this means is that the Earth is currently losing animal species at 1,000 to 10,000 times the natural rate. Unlike mass extinctions of the past which can be traced to external disturbances like a giant asteroid striking the planet, our current extinction crisis is almost entirely caused by humans.

Before we get into causality, however, let's begin with some basic definitions. 'Ecology' is generally understood as the study of the relationships of organisms with their environment and each other. It is all-encompassing and has a strong focus on system complexity without biasing or favoring any specific species or elements of the larger ecosystem. In general, an ecosystem is more stable and resilient to disturbance when system complexity increases, such as species richness and landscape heterogeneity. 'Ecological resilience,' on the other hand, refers to the amount of external disturbance that an ecosystem can withstand and recover from, without fundamentally altering its vital processes and structures.

Individual species or components of an ecosystem might undergo dramatic elasticity, although the system as a whole retains its integrity. This ecological resilience might not always be favorable to our current societal preferences. A simple example is our propensity for manicured landscapes. These landscapes require constant weeding and pruning, favoring the few plant species that have aesthetic value for humans at this particular moment in time. This intentional weeding, pruning, and termination of vital insects is an external disturbance to the ecosystem whose inherent resilience exerts its power to bring complexity and chaotic order back to the landscape. Disturbances are ubiquitous in nature, and changes are critical to many vital biogeochemical processes. Most ecosystems can withstand disturbances until a certain threshold is reached, whereby irreversible changes may lead the ecosystem to a fundamentally different state or even collapse. The theory that nature is permanently in balance has been largely discredited in the late 20th century. What becomes difficult to predict with perfect accuracy, however, is exactly how ecosystems will respond to climate change. Shifts in temperature may cause entire plant communities to shift, or result in an unexpected patterns of species migration. Excessive rain or sustained drought might have similar impacts. Currently, we're working in China on the master plan for



the Chengdu Panda Reserve—a 69 square kilometer site with the ultimate goal of releasing bred-in-captivity juvenile pandas back into the wild. Although recently upgraded from endangered to threatened by the International Union for the Conservation of Nature (IUCN), the giant panda remains one of the most vulnerable species on Earth due to habitat loss and fragmentation. With a wild habitat range restricted to the mountains of the Tibetan Plateau, the panda's core habitat lies within a few hundred miles of Chengdu – one of the world's fastest growing cities. This habitat will be vastly impacted by climate change, as pandas are sensitive to fluctuations in temperature and humidity. They also rely on a consistent source of freshwater, and eat only certain species of bamboo which require specific conditions to grow and are affected by a few degrees difference in temperature or changes to soil moisture and pH. This very bamboo is also a critical component in large-scale carbon storage. Well-managed bamboo forests can sequester carbon at nearly 13 tons per hectare per year—a higher rate than many tree species. To protect the panda, we must protect its entire ecosystem—an ecosystem which is already highly vulnerable to climate change.

Currently, there are an estimated 1,864 adult pandas remaining in the wild. While an additional 300 giant pandas live in captivity and supports the gradual recovery of the species, wild populations continue to be negatively impacted by human presence. Founded in 1987, the Chengdu Panda Reserve was originally commissioned as a research center to advance efforts to breed pandas in captivity. Because of the scientific discoveries made at the Reserve, captive giant panda populations have increased, and the Reserve has expanded beyond its initial research mission to include a broader spectrum of ex situ conservation efforts including education and public outreach programs. With over 18 million people expected to visit the Chengdu Panda Reserve each year, the city has a tremendous responsibility to advance its development in a manner that is mindful of protecting the panda's native habitat.

Overall, three disparate sites comprise the 26 square mile Chengdu Panda Reserve. Organized by their primary functions, as well as by the level of human

interaction and disturbance they allow, each site integrates a complex yet complimentary program that offers the highest standards in captive animal facilities, support facilities including research laboratories and a veterinary hospital, and educational and public outreach facilities. The first of the three sites is the existing Beihu Panda Park, which is located in a suburban area seven miles northeast of Chengdu's city center and currently serves as the main research hub. The second site is located within the 492 square mile Longquanshan Forest Park, providing an opportunity to experience pandas in a much larger native habitat. The third and most remote site is Dujiangyan, which is situated 35 miles northwest of Chengdu in the foothills of the Tibetan Plateau and serves as the site for pre-release training for bred-in-captivity juvenile pandas prior to their release into the wild. All three sites work together to support the Reserve's overarching goals of research, education, public outreach, and environmental stewardship.

From a conservation perspective, the giant panda is considered an 'umbrella species' where the protection of their habitat benefits additional endemic and threatened species. Noted as a global biodiversity hotspot, the temperate mixed conifer and broadleaf forest ecosystem of the giant panda's habitat range is noted for its species richness and diversity, containing over 5,000 plant species, 365 bird species, and 109 mammal species including red pandas, clouded leopards, and golden snub-nosed monkeys. While designed habitats within the Reserve's expansion include areas just outside of the giant panda's habitat range, the design focuses on a restoration approach for the three sites to:

1. create optimal habitat conditions for the giant panda and companion species building off of each site's existing resources and microclimates;

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Fig. 2 – The protection of companion species are an integral component of the Chengdu Panda Reserve.

2. restore the function and diversity region's mixed conifer/broadleaf forests and bamboo-dominated understory on each site;
3. provide visitors with a more in-depth and interactive learning experience emphasizing the conservation of the giant panda as an umbrella species for other mammals, birds, and amphibians which share the region's diverse forest habitat;
4. demonstrate innovative economic and low impact development models to reduce habitat impacts in situ.

To advance this approach, a rigorous site analysis process examined existing topography, drainage patterns, and land cover to provide an understanding of each site's buildable land area, which was based on criteria of preserving/restoring steep slopes, redeveloping existing development sites, and maintaining a sufficient buffer from streams. The analysis also scrutinized each site through a habitat suitability lens, drawing upon criteria noted in peer-reviewed literature of GIS applications evaluating the habitat of giant pandas. A GIS overlay analysis was then developed to identify the most suitable areas for giant panda habitat enclosures and pre-release training. Informed by this comprehensive understanding of habitat requirements, proposed improvements included a range of native tree species and structural compositions, paying close attention to the type and density of bamboo occurring with the restored forests. Across their range, pandas consume about 60 bamboo species, and habitat carrying capacity is based on the seasonal availability of the most nutritious part of various bamboo species throughout the year. While this is typically influenced by elevation and topography, each site's 'panda kitchen' ensures the full nutritional requirements of the giant pandas are met. In addition to planting design, enclosure configurations avoid steep terrain (>30% slopes) that can be difficult for pandas to traverse. Since giant pandas do not hibernate and prefer a cool to moderate climates, enclosure locations maximize the benefits of each sites' microclimate, siting most facilities on cooler, densely vegetated north-facing slopes near natural streams.

Building upon the Reserve's existing facilities, Beihu Panda Park offers an expanded research and education center to accommodate those seeking a more informative experience. Close to downtown and linked to the city by public transit, this urban destination introduces the giant panda to the millions of people who come to Chengdu each year. Here, visitors learn about the daily lives of pandas and their companion species, their shared habitat, and get a glimpse into ongoing research. Based on the habitat suitability analysis, all new giant panda

Fig. 3 – The Chengdu Panda Reserve offers a blend of conservation and species protection alongside ongoing research, public outreach, and pre-release training of juvenile pandas.

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Fig. 4 – Habitat design considered climate change and its impacts to temperature, humidity, and other factors which determine its microclimate.

enclosures are sited on north and east facing slopes to maximize the benefits of the cooler microclimate with access to prevailing northeast winds.

Located near Chengdu's new International Airport, the Longquanshan Panda Village provides an abbreviated introduction to the giant panda and regional conservation efforts. Nestled into a low valley and offering scenic beauty and climate comfort, the Panda Village Zoological Park is conveniently positioned as a gateway to Chengdu. Working with the topography of the site, facilities are positioned within the mountain landscape to reduce noise and light impacts from nearby urban areas, situating animal enclosures along shaded northeast-facing slopes.

The most remote of the three sites that comprise the Chengdu Panda Reserve is the Dujiangyan Panda Wilderness. Located in the foothills of the Tibetan plateau and adjacent to the giant panda's natural range, the program focuses on wildlife reintroduction. As one of the gateways into China's newly established Giant Panda National Park, pre-release training acclimates born-in-captivity juvenile pandas prior to final release into the wild. With a significant expansion of animal exhibits planned, the proposed configuration of house/enclosure is organized into three zones – an expanded visitor experience, a research cluster, and wildlife immersion that presents conditions similar to what giant pandas would find in the wild to facilitate pre-release training.

The plan for the Chengdu Panda Reserve by no means strives for perfection, but its goals for habitat protection are ambitious, and hopefully will inspire other regional planning efforts around the world to shape their desired outcomes with a wider lens.

Community Resilience:
Feeding a growing population

Habitat protection doesn't only benefit wild animals. Conservations efforts also provide enormous benefits to humans, most notably for one of our most basic needs—the food we eat. But by the end of the century, our agricultural lands will probably be about half as productive as they are today, with the same land producing half as much food in a world that needs to feed at least 50% more people. And most of those people—an estimate 80% of us—will be living in cities. So how can we invest in food systems that will create more resilient cities in the future? Most investment strategies are based on the principal of diversification— to reduce risk, create a portfolio that includes multiple investments. That said, our current food system does just the opposite. Its success depends on concentrated, large-scale industrial agriculture in only a few places. For example, the vast majority of the fruits, nuts, and vegetables grown in the United States are from California alone. With limited additional capacity available to produce more food for a growing global population, California also suffers from periodic, severe droughts that can impact food availability and pricing across the entire country and beyond. As it stands today, our food system is at risk of failure.

Some have also said that as our world population continues to grow, water may someday become more valuable than gold. Yet our food requires a significant amount of water to produce it. In California, agriculture consumes 80% of the state's available water supply. Just one crop alone, alfalfa hay—consumed primarily by cattle—uses the same amount of water as 12 million households annually. This kind of water-intensive farming and long-distance transport of goods is unsustainable.

To reduce our carbon footprint, we need to grow our food closer to where we live—in cities. Yet for far too long, he have maintained a separation of the urban and rural environments. Cities were cities, and farms were farms. Yet nowhere is our dependence on the natural environment more immediate and more apparent than with our food. Farms themselves are complex, dynamic ecosystems, and farmers are the stewards and the beneficiaries of these

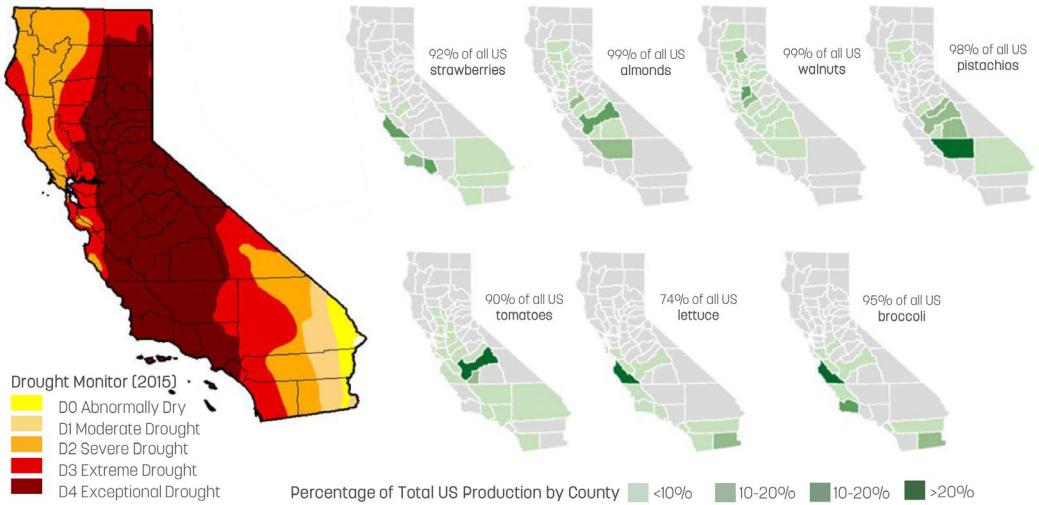

Fig. 5 – Some of the most agriculturally productive areas of California are the most vulnerable to drought and other impacts of climate change.

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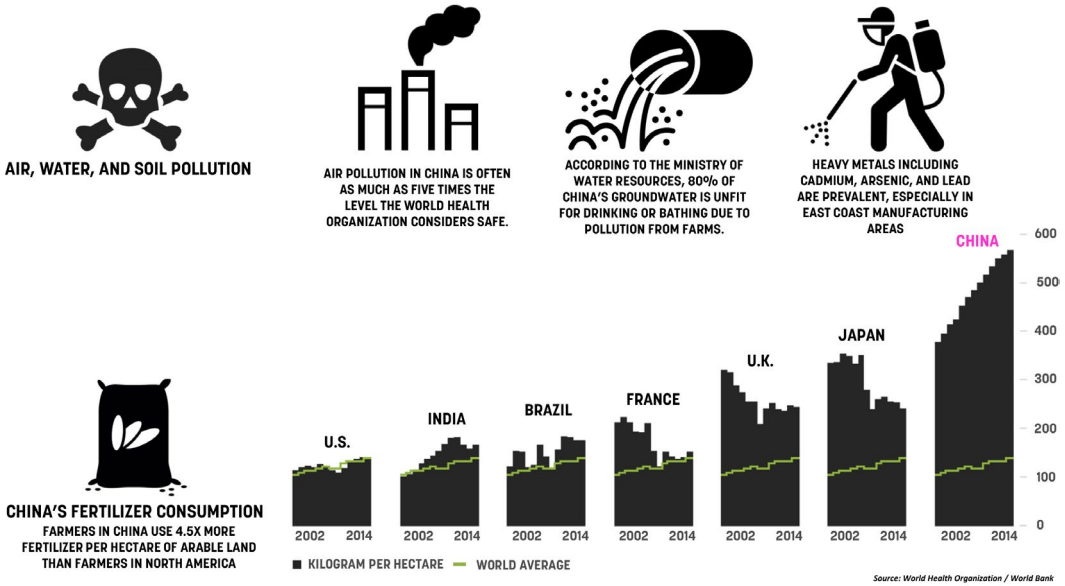
Fig. 6 – Fertilizer consumption is increasing around the world, with some of the highest rates occurring in China.

ecosystems. Historically, farms were managed as zero-waste cycles. Between the livestock and the produce, all forms of waste were processed and utilized as inputs. In healthy ecosystems, waste is a misnomer and maximum efficiency is the modus operandi. Vegetable waste feeds the livestock, livestock waste feeds the soil, and the soil produces the vegetables. But within this neat cycle are millions of unseen and underappreciated players with critical functional roles –-agrobiodiversity.

The traditional farm was a characteristically messy landscape with a mix of crops, pastures, fencerows, and woodlands that built a balanced ecology through the resilience inherent in these diverse systems. Modern industrial farms, on the contrary, have resulted in ever-more simplified landscapes with fewer and fewer living components. The heterogeneity of the messy farm gave way to massive fields of single-species crops and isolated confined animal feeding operations. The traditional small farm was also teeming with biodiversity–especially insects. Pest species were present, but so was an abundance of beneficial insects that fed on these pests, and were the pollinators necessary for fruits and vegetables to grow. Over 100,000 different species including bees, birds, bats, wasps, flies, butterflies, moths, ants, beetles, and other bugs all contribute pollination services worldwide. Today, many industrial farms rely exclusively on only one species–the honeybee–which is highly susceptible to disease outbreak and hive collapse. Similarly, countless species of beneficial insects once kept pest populations in check, but depended on adjacent non-crop habitats like hedgerows, woodlots, and meadows for their life-cycles. Our reliance on chemical pesticides has eliminated most of these species from modern farms.

Farms have also increased fertilizer applications significantly in the past 40 years, especially in China. As industrialized farms shift towards monocul-



tures, a host of new problems have arisen that impact not only the ecosystem, but our entire society. The runoff of farm nutrients is the primary contributor to eutrophication in rivers and lakes around the world. Pesticide application not only eliminates populations of beneficial insects, it contaminates groundwater, kills fish and amphibians, and wreaks havoc on the balance of any ecosystem. Bumblebees, for example, have declined by over 25% across most of the northern temperate world. The loss of genetic diversity in food crops through the ongoing extinction of heirloom and uncommon varieties threatens the very future of our food supply as climate change and emerging diseases make common varieties more and more vulnerable in an uncertain future.

Yet, in cities around the world, small-scale, environmentally and community focused farms are experiencing a renaissance. Small farms are emerging not merely as sources of food, but also serve as educational landscapes where urban children learn about food and nature. They are part of our green infrastructure as well, providing ecosystem services rather than exporting pollutants. They bring communities together around the elemental joy of the pastoral landscape. With few exceptions, this has been happening organically, through the efforts of passionate individuals. Design and planning, however, can strengthen this movement. As urban centers continue to expand, so will the challenges and opportunities for urban agriculture.

Now more than ever, as we imagine innovative functional roles of farm landscapes within and around cities, we must seek to rebuild the complex landscape structures to support a robust agro-ecological system. As designers, we must strive to integrate sound science into the creative process and explore the spatial synergy between our natural lands, recreational lands, and our productive agricultural lands all at the interface of the burgeoning modern city. How can a stormwater basin serve as a source population for beneficial insect predators? How can the landscape of a public park intentionally rebuild pollinator populations adjacent to a community vegetable garden? How can we leverage diverse yet intentional native plant palettes to con-

Fig. 8 – The traditional Shanghainese diet consists of up to 56% leafy greens, many of which are the ideal crops for vertical farming.

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Fig. 9 – At Sunqiao, scientific research is intentionally integrated with public outreach and education around the impacts of agriculture on land use and climate change.

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Fig. 7 – The Sunqiao Urban Agriculture District in Shanghai seeks to shift the conversation for how cities source their food.

tribute mutual benefits with local farms? Can we design adjacent uses for maximum integration of beneficial biodiversity back into urban and peri-urban landscapes? Can we imagine an ecosystem that is both city and farm, buzzing with all kinds of life?

In Shanghai, we are designing the Sunqiao Urban Agriculture District which is focused on closed-loop indoor farming. Here, researchers will embark on solutions to feed an ever-urbanizing planet. Located between the international airport and the city center, Sunqiao illustrates that, like the city's soaring skyscrapers, its farms are also going vertical. After 20 years of conventional agricultural production on the site, Shanghai is expanding the role of Sunqiao in its foodshed. The plan for this unique agriculture-focused innovation district focuses on the integration of vertical farming systems in conjunction with research and public outreach.

Shanghai is the ideal context for vertical farming. Like many global cities, land prices are high, which makes building up rather than out the economically prudent choice. Even more significant is the Shanghainese diet, which consists of up to 56% leafy greens including spinach, lettuce, and kale. Leafy greens are an excellent choice for hydroponic and aquaponics growing systems. They thrive in the simplest of setups, and don't need a lot of extra attention. They grow quickly and weigh little, both of which make them an economical and efficient option.

To fully understand the motivation to build a project like Sunqiao requires an acute awareness of the Chinese agricultural context. Although many in the Western world think of the 'Made in China' economy as being driven by manufacturing, China is actually the world's largest producer and consumer of agricultural products. In fact, the agricultural sector represents approximately 13% of China's total Gross Domestic Product. Agriculture in China is also responsible for feeding 20% of the world's population and employing 22% of Chinese citizens. Sunqiao not only can feed the country's urbanizing population, but will fuel its economy. New industries that benefit from access to agriculture– biotech, textiles, etc. –are thriving. With land prices making traditional horizontal farming an endeavor with little room for profit, Sunqiao illustrates how the Chinese government's strategy of preserving land for agricultural purposes can also provide a higher and better use. This approach actively supports a more sustainable local food network while increasing quality of life in the city through a community program of restaurants, markets, and pick-your-own experiences. As cities continue to expand, we must continue to challenge the dichotomy between what is urban and what is rural.

Economic Resilience:
Strategic investments to reduce risk

Although the food we eat is likely to cost more due to climate change, the damage caused by higher intensity storms will be the most expensive consequence. By the end of the century, the United Nations predicts that the earth is going to be 4.3 degrees warmer than it is today if we don't change course. 4.3 degrees of warming translates to about $600 trillion in damage from climate impacts. We must accept that climate-induced catastrophes will be a fixture of our future. That said, the discourse around resilience is primarily an anthropocentric one. While most of the pressing challenges we face in the Anthropocene are ecological, there will also be dramatic impacts on socio-economic inequality. In planning and design, the discourse around resilience embodies a strong anthropocentric element. Most resilience-focused designs preempt plausible future disturbances, especially catastrophic disasters in the most densely populated urban areas. While ecologists view change as a dynamic process, the anthropocentric mindset of resilience-minded design solutions understandably safeguards the present system and maximizes its durability in the face of uncertainties—even though the present system may be flawed.

Despite the growing consensus that many coastal areas or floodplains are not suitable for urban settlement and will be increasingly vulnerable and costly amid a rapidly changing climate, it is unrealistic and inhumane to expect cities and settlements to retreat completely. In response to this, we have seen a rise in collective resiliency efforts, such as Rebuild by Design after Superstorm Sandy, Resilient by Design in the San Francisco bay area, and our work mapping sea level rise in Boston.

In Boston, sea levels are projected to rise two feet (60 centimeters) by mid-century, and six feet (180 centimeters) by 2100. This new tide line will transform the coastal landscape of the city and increase the probability of a major storm devastating the metropolitan region. Advocating for a long-term resiliency strategy, the design team led the city in pre-

WE NEED TO DESIGN FOR RISING SEAS AT MULTIPLE SCALES.

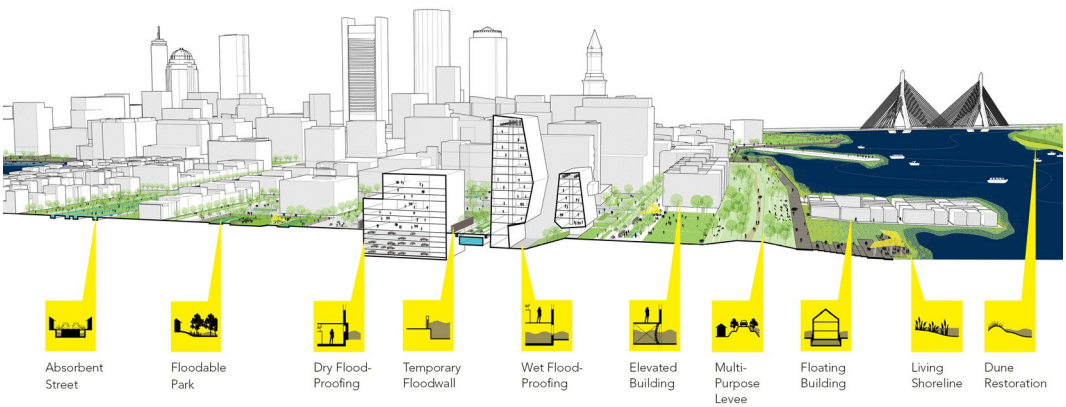

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Fig. 10 – Cities around the world, including Boston, are beginning to map the impact of sea level rise and other symptoms of climate change as they make long-term planning decisions.

Fig. 11 – A composition of strategies, rather than any one 'silver bullet' solution, must be implemented to mitigate the impacts of climate change.

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Makoko #2, Lagos, Nigeria 2016.
photo(s) © Edward Burtynsky, courtesy Admira Photography, Milan / Nicholas Metivier Gallery, Toronto.
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paredness planning at the building, city, and regional scale. Designers also collaborated with experts in engineering, academia, advocacy, and policy making to harness sea level rise expertise and push design thinking further. The study illustrated Boston's vulnerabilities and demonstrated design strategies to address them, catalyzing a conversation among, city officials, real estate leaders, and academics about a specific call to action: to develop a resiliency plan for the city called 'Climate Ready Boston', which was unveiled in 2018.

As designers, we need to focus on having a deeper understanding of ecology and embrace our responsibility to promote resilient strategies in order to find a balance between the ecological processes and societal wellbeing. In spite of the world we are leaving to our children and our grandchildren to fix, I am still optimistic. If there ever were a time in history for the design professions to step up, it is *now*. Everything we do must focus on slowing climate change while contributing to the betterment of society. It is our obligation as designers to provide a meaningful and lasting benefit to the planet, and to humanity.