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Rethink Everything

On October 22, 2012, meteorologists at the National Hurricane Center (NHC), a cement fortress in Miami, Florida, registered Tropical Depression 18 in the southwestern Caribbean Sea. The event was then just a line of thunderstorms moving across the turquoise water, but it represented a serious potential risk. Hurricanes and other weather-related events kill an annual average of hundreds of people and cause hundreds of billions of dollars in damages in the United States alone.

The NHC, which is tasked with predicting the future risk of these low-pressure systems across the United States, jumped into action. It dispatched one of the Air Force's Lockheed Martin Super Hercules aircraft for observation. Despite all the data that streams in from geostationary satellites, as well as other land- and water-based weather stations, flying an 80-ton airplane into a furious windstorm is currently still the best way to gather some information.

In Miami, experts in meteorology, satellite data, and remote sensing poured over the reports and fed it into multiple hurricane forecast models that predicted the event's future direction and destructive potential. Many tropical depressions fizzle out, but the environment surrounding Number 18—including warm waters and local atmospheric conditions—caused it to intensify rapidly with a defined circulating pattern and winds above 38 miles per hour (61 kmh), thus earning it a name: Tropical Storm Sandy. Over the next few hours, Sandy's increasing wind speed and structure quickly took it to hurricane-strength. The NHC issued warnings to Jamaica, Cuba, and other Caribbean islands in its likely path, saving lives and reducing damage, while keeping an eye on potential risk to the United States.

Well before Sandy made landfall in New Jersey on October 29, the NHC had released a continual stream of updates and warnings for areas likely to be impacted, the National Weather Service had issued watches, governors had declared states of emergency—and even mandatory evacuation orders for certain areas. All these advisories were picked up and spread by local police and emergency officials, television, newspapers, and social media. However, even mandatory evacuations are rarely enforced. Once the expert advice about Hurricane Sandy's risks reached residents, it was up to them to decide what to do. Many chose not to heed the warnings; 186 Americans died in the storm.

A later Center for Disease Control and Prevention (CDC) report detailed the fatal consequences of ignoring official advice. The leading cause of death related to Sandy was drowning due to the storm surge and associated flooding, which accounted for nearly half of the fatalities. Of those drowning deaths, over half were people who died in homes located in primary evacuation zones. The result was that, in 2012, more Americans drowned in their own homes than were killed during violent home invasions, sexual assaults, or carjackings.

A decade later, on September 28, 2022, category 4 Hurricane Ian tore into the southwest coast of Florida. Governor Ron DeSantis had declared a state of emergency four days earlier and mandatory evacuation orders covered all or part of 12 counties. Once again, though, many people did not evacuate. Nearly 130 people died in Florida, many of whom, again, drowned near or in their houses located in evacuation zones.

There is a wide range of circumstances that make it harder for certain people to evacuate—some have physical or mental disabilities, some don't have transportation, others simply can't afford to leave. But there are also large numbers of people who remain in the path of storms by choice. Hurricanes are known killers, so what leads those in mandatory evacuation zones to decide against following the expert advice intended to save their lives?

We could ask similar questions about our historic lack of urgency around climate change. The accelerating buildup of greenhouse gases and resultant increase in heat energy trapped in our planet's atmosphere represents a destructive and global threat that causes billions of dollars in damages and directly or indirectly kills thousands of people a year. It is also a phenomenon we have been publicly and repeatedly warned about by scientists since the 1980s. So why have most of us routinely ignored expert advice and downplayed this accelerating threat?

It turns out that our stuttering responses to both specific events like hurricanes and the global phenomenon of climate change are deeply interrelated—both largely determined by human risk perception. Though risk is one of our greatest motivating forces, we also evaluate risk in deeply inconsistent ways that are poorly attenuated to recognizing certain threats. For example, humans tend to react more urgently to near-term, immediate risks—even if the future risks are ultimately much greater. Of course, from an evolutionary standpoint, prioritizing "avoiding hungry tigers" makes a lot of sense. However, the same life-saving perception of immediate risk also introduces a tendency to discount the future. Likewise, we tend to react more urgently to threats with which we've had negative personal experience. Again, deciding not to eat mushrooms of a certain color has distinct evolutionary advantages. But privileging personal experience also tends to reduce the importance of potentially life-saving advice from other people, including those with scientific expertise.

Today, the biggest threats humans face have changed dramatically, but our risk perception is still saddled with evolutionary baggage that gives primacy to risks that are immediate, near-term, and personal. For many people, neither hurricane forecasts nor climate change make that list. However, climate change faces additional obstacles to being perceived as a serious risk. For one, the phenomenon is complex and described most accurately in nuanced scientific terminology—language that doesn't register climate change as a dire threat for many people. Accepting the broad scientific consensus around climate change has also become deeply politicized in the United States, forcing people to "choose sides" rather than dispassionately evaluate risks. The cumulative result of these factors is that, for decades, humans haven't responded appropriately to a potentially existential threat largely because so many of us didn't perceive climate change as carrying meaningful risks.

Making Climate Risk Real

In 2022, the United Nations' Intergovernmental Panel on Climate Change (IPCC), the most authoritative source of scientific data on climate change, issued its sixth assessment. Hoesung Lee, the Chair of the IPCC, described the report as "a dire warning about the consequences of inaction."[1] António Guterres, the United Nations (U.N.) secretary general, added that the assessment represented "an atlas of human suffering and a damning indictment of failed climate leadership."[2]

The only good news was a notable shift in how the report was received. In parts of the private sector, there was an urgency around the issue of climate change that hadn't existed even five years previously. After decades of collective foot dragging—amid increasingly specific and stark warnings from the IPCC—what has changed? Why have organizations finally decided to take climate action seriously?

Once again, the primary driver is risk perception. Decades of resistance to taking climate change seriously is rapidly dissolving as more people believe it poses a near-term, personal, material risk. As investors, shareholders, and business leaders rethink the threats—and opportunities—climate change represents, climate action is finally emerging as a mainstream priority.

Climate-related risk is certainly not hard to find—nor is it new. But while deadly and destructive climate-linked extreme weather used to be viewed more like a black swan event, it is now an annual inevitability. Every year, wildfires, droughts, hurricanes, and other extreme weather will exact a toll—the only questions are exactly how many human lives or billions in dollars. Take, for example, the cumulative financial damage from climate-related events in 2021.Wildfires in the western United States cost roughly $11 billion, a pervasive drought and record-setting Pacific Northwest heatwave cost $9 billion, a historic winter storm cost $25 billion, and Hurricane Ida cost $78 billion. Globally, the losses were even higher—flooding alone hit $90 billion.[3] In short, the massive losses caused by extreme weather were finally making climate risk unignorable.

In the past five or so years, however, a whole new dimension of climate risk has also emerged. Physical risk refers to disruptive, costly events like buildings flooded by hurricanes or supply chains disrupted by wildfires. In contrast, transition risks result from the transition to a lower-carbon economy, and are related to policy and legal actions, technology changes, market responses, and reputational considerations. For example, governments at all levels are introducing and tightening regulatory mechanisms like energy efficiency mandates or requirements on greenhouse gas (GHG) reductions. Companies that don't transition quickly enough risk experiencing severe reputational and brand damage, or being excluded from certain markets. Changing expectations about future profitability within carbon-intense industries can lead to significant loss of asset value. Similarly, changed water conservation policies could negatively impact agricultural companies.

Transition risk also refers to missed opportunities—the new markets and growth that are open to leaders in decarbonization efforts, as well as those organizations that are more progressive with regard to the mainstreaming of resilience and sustainability approaches and technologies. Tesla, for example, is a massive beneficiary of national GHG emission reduction goals. The United States, Europe, China, and other countries offer automakers that can't meet mandated emission reductions the option of buying credits from car companies that have surpassed regulatory goals. Tesla, which primarily sells electric vehicles, has been able to maintain its profitability in the U.S. market largely because it sells so many carbon credits to other carmakers—$1.5 billion worth in 2021.[4]

The third factor driving awareness of climate risk is coming from investors, shareholders, and other company stakeholders. Over the past few years, investor demand for Environmental, Social, and Governance (ESG) reporting—in which companies account for their GHG emissions and climate resilience, and other Environmental, Social, and Governance (ESG) metrics—has soared. ESG assets, like companies that issue annual ESG reports and employ corporate policies to act more responsibly as environmental stewards and community partners, were a relatively niche category 10 years ago. Today, they are on track to reach $53 trillion assets under management (AUM) by 2025, or a third of the global total AUM.[5,6] Though there is no universal framework for ESG declarations nor legal requirement for action, even the process of reporting on GHG emissions has created a whole new driver—as well as a growing industry—for taking climate action seriously.

The meteoric growth of ESG reporting and as a class of investment is also creating a sort of virtuous ecosystem. When companies elect to voluntarily disclose their climate-related financial risks and other ESG criteria, it sends signals to the broader marketplace that these issues are important for organizational decision-makers, employees, customers, and investors of all types.

Increases in ESG reporting also drive more consistent understanding of ESG risks over time. (Although that understanding is still quite inconsistent and messy today—a topic we explore in the second section of the book.) Improving literacy around ESG reporting, in turn, encourages changes in the regulatory landscape to meet investor needs. The European Union (EU) already requires corporate sustainability reporting from a growing number of companies.[7] The U.S. Security and Exchange Commission (SEC) is also expected to require publicly held companies to disclose climate-related information as well as other ESG data.[8] As these disclosures become expected by more consumers and the public, privately held companies are also more likely to voluntarily release information. These reactions, in turn, send additional signals to the marketplace, further accelerating the cycle of normalizing and expanding ESG disclosures.

The public sector is also moving to limit its exposure to climate risk. Not surprisingly, the areas in the United States that are most at risk of experiencing loss are often among the leaders in building sustainable and resilient infrastructure. For example, Florida and California—on opposite coasts and sides of the political spectrum—are two of the states with the highest climate risk. However, cities, counties, and other stakeholders in both states have invested heavily in sustainable and resilient infrastructure.

Driving toward Zero

One of the most common goals to combat the risk of climate change is what's called "net zero." Net zero effectively means cutting an organization's GHG emissions to as close to zero as possible, with any remaining emissions reabsorbed from the atmosphere—for instance, by forests that naturally store carbon dioxide or by technological means of carbon sequestration.[9] To date, over 70 countries—including the United States, China, and the European Union—have set net zero targets, along with over 1,000 cities, 1,200 companies, and 400 financial institutions.

In practice, though, net zero is often used inconsistently and many organizations definitively count only a fraction of their carbon emissions. We dive deeper into net zero in the second section, along with more detail about what ESG disclosures, sustainability roadmaps, and climate action plans look like and how they are developed. At this point, it's sufficient to know that "decarbonization" and "reducing GHG emissions" both refer to the many processes and technologies used to reach the goal of net zero. The most common timeframe for reaching net zero—and the one supported by the best climate science—is 2050, at the latest.

It's also important to note that reaching net zero is not enough to build a thriving and sustainable future. First, our decarbonization efforts must be grounded in equity—a sustainable future is inherently one in which all people and countries can prosper. Second, we need to reduce the amount of GHG released into the atmosphere in ways that support our planet's diminishing biodiversity and help maintain and rebuild critical ecosystems.

We still aren't moving nearly fast enough to meet the challenge of climate change, but the combination of increasing engagement and focused action from the private and public sectors is promising. It is also being supported by unprecedented government spending on climate action, investments in technology, and building resilient, sustainable infrastructure. The European Union's 2021–2027 budget calls for spending over €2 trillion ($1.9 trillion) to fight climate change and build a more sustainable Europe.[10] In the United States, 2021's Bipartisan Infrastructure Law includes $550 billion to combat climate change and reduce GHG emissions through a variety of initiatives.[11] In 2022, the Inflation Reduction Act included more than $360 billion in additional funding to fight climate change and incentivize sustainability in the United States.

This overdue, but rapidly growing, commitment to combat climate change is inextricably linked to our changing perception of climate risk. As more companies, consumers, leaders, investors, politicians, and citizens come to understand the enormous risks—and rewards—associated with climate change, the faster our transition to a low-carbon economy will be.

System Failure

However, even as climate risk spurs an expanding number of companies and cities to report on their GHG emissions, set net zero goals, and lay out climate action plans, significant challenges to planning and designing infrastructure for a very different future remain stubbornly entrenched. As organizations work toward a more sustainable, resilient, and equitable future, there are a number of recurring, systemic obstacles to these goals.

For example, the necessity and commitment to decarbonize our economy often runs head-on into perverse incentives to *not* build sustainably and resiliently. The traditional economics of the insurance industry, for example, are one such stumbling block in efforts to design resilience into buildings. Following hurricanes that devastate beachfront properties, many homeowners build right back on ground zero. Sometimes they take measures like elevating their houses on stilts, but, whether they built back better, they very often built back bigger and more expensively. Were these homeowners, who had recently experienced a major material, personal loss, all pretending that the last storm was a one-off? Perhaps, but in many cases, they built back the way they did because their homeowner's insurance and/or government-subsidized flood protection programs paid to replace what was damaged—in whole or in large part—not what would be smarter for a future that includes accelerating sea level rise and more intense storms.

This is even more curious because insurance companies are large organizations staffed with smart people who have all the data on climate change. They understand the science and the vulnerabilities of assets around the world very well; mapping climate risk is even a product line. So why aren't insurers world leaders in building resiliency, at least for the assets they cover?

Part of the reason is that insurers operate in a unique industry. Just about every bank requires a homeowner to have insurance before it will sign off on a mortgage. So, homeowners with mortgages have no choice but to buy insurance, while those who do not have a mortgage can afford and often choose to purchase insurance as a hedge on risk. What's more, insurers can tightly define the risks they cover and for how much, which can be adjusted based on likely climate risk. For example, a policy might cover 70% of the cost of repairing flood damage, but only 50% of wind damage repairs to the same house.

The issue of time also looms large. Policies expire and require renewal every 12 months, so insurers can regularly adjust the premiums they charge. As a result, there is little incentive for insurers to share risk assessments—in the form of risk-adjusted premiums—with consumers beyond one year out. Many states do regulate premium increases, but insurance companies always have the option of getting out of a market altogether. Ultimately, the business of insurance underwriting is to sell risk transfer, not to educate consumers—at least not yet.

These dynamics are playing out dramatically in Florida, a state with very high climate risk. The insurance market had been in turmoil for years, with insurers regularly exiting the state or liquidating—six companies became insolvent in 2020, even before Hurricane Ian hit the state. Floridians' premiums have also been rising at a much faster rate than other Americans. In 2022, premiums increased roughly 33% in Florida versus 9% for the United States as a whole.[12] To date, however, all this turmoil and financial pain has done very little to design for and properly adapt to climate change. The economics of this sector provide little incentive to invest in long-term resilience and to truly adapt to the climate that will prevail several decades from now.

A system that encouraged people to rebuild where and how they did before is frustrating not just from a problem-solving, engineering perspective, but a basic financial one. In the United States, Federal Emergency Management Agency (FEMA) statistics show that every dollar spent on pre-disaster hazard mitigation returns $6 the next time a similar storm comes to town.[13] You'd think that a 6-to-1 return on investment would encourage a wholesale rethinking of resilience spending, but only about 10% of FEMA's government post-disaster resources are spent on reducing the impact of extreme weather before disaster strikes again. Resilience requires modern codes and economic incentives to be better aligned with proactively building, or rebuilding, for a different future.

Full Costs

The economics of the traditional construction business is also not conducive to rapid innovation. Historically, the industry has operated on very low margins and decisions have been made on the basis of lowest upfront capital costs—not on innovations that could add long-term value. This model has long discouraged investment in—as well as uptake of—newer, more resilient and sustainable technologies and processes.

Confronting climate change means rethinking this capital cost-driven approach to planning, design, and procurement across every sector. Upfront cost considerations should be part of any decision. But the costs and benefits of integrating innovative materials, processes, and techniques needs to be viewed across the whole life cycle of a product. This includes everything from the product's initial funding and planning studies through to design, manufacture, and end of life, usually either reuse, recycling, or landfilling. While these full life cycle costs are important for evaluating consumer goods like a laptop or an EV, the extremely long useful lives of buildings and other infrastructure elements that make up the world's built environment amplifies the importance of full life cycle assessments and accounting, and more broadly the concept of circularity.

Investing in sustainability and resilience at the planning and design stage of a school, apartment, or pretty much any type of building, will provide multiple rewards, which could include lower GHG emissions, construction waste, and build time. Picking a better location and designing in resilience and sustainability will produce other benefits too. Owners and landlords' assets will retain their value longer. Occupants will breathe cleaner indoor air or pay less for heating and cooling. But building more sustainably and resiliently requires life cycle cost accounting and a circularity mindset instead of focusing primarily on the upfront capital cost of construction.

So, given all of these advantages, why aren't more buildings designed with these resilience and sustainability goals front and center? In many cases, it's because the assets don't have a consistent owner across the life cycle of the asset. For example, the owner of the initial design and construction budget is different from the owner of the asset's ongoing operation, and each owner brings their own budgets, priorities, and goals to the decision-making process. While the real estate and construction industry is much more likely to invest in greener, more climate-resilient buildings today, this lack of continuity in ownership is a drag on rapid adoption.

Solutions Everywhere

Designing one-purpose solutions that don't consider the whole impact of infrastructure projects and programs can also have unintended negative consequences. In contrast, holistic solutions that deliver multiple co-benefits are more likely to be widely embraced—even by people who aren't particularly interested in reducing GHG emissions. Low-emission transportation options, including cycling lanes, pedestrian-friendly urban design, and electrified transit, will reduce carbon emissions, while also reducing inequality by providing mobility to lower-income and non-licensed drivers, improving health by cleaning toxins out of the air, and reducing cardiovascular disease by encouraging cycling and walking. Green roofs provide multiple benefits, such as mitigating flooding, cooling the areas around them, providing aesthetic benefits, and can be combined with solar to accelerate decarbonization.

Multiple benefits solutions also offer an answer to the human tendency to discount the future. Convincing people to give up something now—flying, consuming meat, using air conditioning—in exchange for a future payoff is a losing argument. However, offering a program or project that directly benefits people in a community right now, while also mitigating future climate change risk, has a much better chance of success. Instead of sacrificing today to mitigate a future risk, multi-benefit climate action is an opportunity to improve the world today.

This approach might even help people suffering from eco-paralysis, or an inability to process the worst potential climate change scenarios. One clinical therapy encourages patients to focus on one small thing that makes a difference. People with a passionate commitment to climate action might have more long-term success—and better mental health—building local support for an EV hub than advocating for a long-shot global phase out of fossil fuels within three years.

By delivering multiple benefits as soon as they are completed, additional stakeholders will come on board because they appreciate the short-term advantages of sustainable infrastructure—even if they aren't convinced of the need to act on climate change. In the United States, for example, the last three presidential administrations were a rollercoaster in terms of the politics and communication around climate change. Nonetheless, the sustainability and resiliency efforts were bundled and remained essentially unchanged while the overarching "strategy" changed from energy to mission resiliency to carbon. However, teams that design and deliver infrastructure projects as win-win-win solutions need to be highly connected and have deep expertise across the entire life cycle of a project. These are values and capacities that are consistent with a Future Ready mindset and at the core of WSP's Climate, Resilience, and Sustainability practice.

Planning for an Uncertain Future

In February 2008, a group of water engineers published an article in *Science* magazine entitled "Stationarity Is Dead: Whither Water Management?" "Stationarity" refers to the limited range of variability within a natural system and is used to create a statistical average around which engineers can plan. For example, water engineers use statistical averages like local rainfall to plan dams or stormwater pipes or municipal drinking water systems. By 2008, however, the authors believed these averages were hopelessly outmoded. The risks to water supplies, waterworks, and floodplains could no longer be calculated as they had been for decades, or even centuries. Stationarity was dead, they concluded, and hydroclimatic change had killed it.

The article has since had impacts far beyond the "Policy Forum" section of *Science*, in part, because the engineers' predictions have repeatedly been borne out. In 2015, 2016, and 2017, for example, the Houston area experienced three consecutive 1-in-500-year rain events, each creating devastating flooding. The events couldn't be written off as a trio of rare historic anomalies—in 2019, another 24–36 inches (61–91 cm) of rain fell in a three-day period between Houston and Beaumont, Texas. When an area gets four deluges of that size in five years, they are no longer 1-in-500-year events. However, the events didn't mean that Houston should be designing for epic flooding every four out of five years either. So, what did it mean? For water management engineers, it meant that the existing codes and flood maps were not as reliable as they once were.

The summer of 2022 also saw dramatic variations from historic means in water resources across the United States. A persistent western drought dropped Lake Mead, the largest reservoir in the United

States, to its lowest level since it was filled in the 1930s. Soon thereafter, the nearby Las Vegas strip was inundated by flash flooding, St. Louis set a new 24-hour record for rainfall, and both eastern Kentucky and Death Valley, California, experienced 1-in-1,000-year flood events.

However, the reason that the water engineers' 2008 article has gained currency outside of hydrology circles is because the phenomenon is not limited to any one field. In a hotter world, stationarity is losing its meaning everywhere. Wildfires in the western United States and Australia, for example, haven't just reached historic sizes, they have begun acting in fundamentally different ways. There are fewer fires per season, but, aided by heat waves and parched landscapes, fires are burning hotter and faster. As a result, even compared to fires of similar size, recent fires cost up to twice as much to fight per acre. They are also, in some cases, creating their own weather, like pyrocumulonimbus clouds and "fire tornadoes."[14] Many veteran firefighters and researchers report that the behavior of fires in the past few years is virtually unrecognizable from what was once normal.

This departure from stationarity creates a real challenge for designers, planners, and engineers on any infrastructure project. Structural engineers, for example, work off building codes that tell them how thick the reinforced concrete in an apartment building needs to be to withstand the sheering impact of wind or how high a bridge must be to resist floodwaters. But if the speed of wind or height of floods are no longer readily predictable over a long period of time, the codes aren't as useful. Engineers are more likely to run the risk of either under-designing or over-designing infrastructure—as well as misjudging or not anticipating the impacts of failure or some other aspect of the potential future.

Adding to these complications is that infrastructure is often expected to last for decades, and even as much as 100 years in the case of high-cost, high-criticality infrastructure like long bridges and deep tunnels. As planning projects further into the future, the variabilities, contingencies, and unknowns increase. Engineers or urban planners in 1930 could use the storm records of the previous 100 years to plan for, say, 1980 with relative confidence. Today, an engineer wouldn't have nearly the same amount of confidence about predicting the climate in the 2070s because of how rapidly climate and weather is changing, in a way that makes storm records from the past essentially useless as a predictor of the future. In other words, we're moving from an era of high-confidence decision-making to one of low confidence. That doesn't mean we don't make decisions, or that we accept that we're likely to make bad ones. It means the future requires operating in a more nimble and adaptive fashion.

One possibility would be to design buildings and infrastructure that are more adjustable and flexible over their lifespan. For example, a British station in Antarctica was designed to "step out" of the massive snow drifts—4 feet (1.2 m) falls annually—that regularly bury and crush buildings. The units are each fitted with 13-foot (4-m) hydraulic legs that sit on skis, allowing the units to be relocated outside of existing snow drifts and extend their useful lives.[15] A similarly transformative approach to more conventional, fixed infrastructure might include designing ground floors of buildings as collateral damage—areas with low-value functions that could be quickly repaired post flood. In some cases, buildings could also be designed to be permeable to high winds, thus avoiding the risks of major structural damage or failure.

Megatrends and Being Future Ready

Designing infrastructure that meets today's codes as well as the challenges of tomorrow's world requires rethinking many of our assumptions. First, we need to get comfortable with the idea that there is no *one* answer. In a previous era, engineers might have consulted the current building codes, technologies, materials, conditions, and equipment and made the "single best current choice." This best choice often looked very much like the previous best choices in any given infrastructure agency jurisdiction. Then the engineers would walk away to their next project, which was also likely to look like earlier versions of the "best choice." There are multiple reasons why this mindset was so prevalent, but, even decades ago, it also received a fair bit of justifiable criticism. Now, in an era without meaningful stationarity, this thinking isn't an option. Going forward, we to need to plan infrastructure around flexibility—testing future scenarios during the design process and then developing a design that is adaptable mid-stream. Every solution should be developed on a forward-looking, flexible, case-by-case basis.

Future Ready is WSP's broad and adaptable forecasting framework for evaluating projects and programs, ranging from highways to stormwater management systems to wetland restoration, designed for our era of uncertainty and dynamic change. The framework is divided into four megatrend categories: climate, society, technology, and resources. Within each category are multiple subtrends, like flooding, urbanization, connected vehicles, and water scarcity, with insights and analysis on each. Viewing projects and programs through these four lenses ensures that a plan or design incorporates a range of innovation, goals, political realities, and human needs from the very beginning, creating an integrative, stronger understanding of the future.

Future Ready Megatrend 1: Climate

The climate lens focuses on how a project, infrastructure, or community will hold up against heat waves, drought, flooding, extreme weather, sea level rise, as well as other major climatic trends.

Of course, not every megatrend will be relevant for every project, so the climate lens is adapted to local needs and challenges. For example, Portland, Maine, sits on one of the fastest-warming bodies of salt water on earth, driving an expected sea level rise of 10–17 inches (25–43 cm) between 2000 and 2030. Future projects need to be designed around the likelihood of increasing sunny-day flooding in the city's center. Meanwhile, Portland, Oregon—which sits at the same latitude as its East Coast namesake—faces a different climate future that needs different solutions. Deadly triple-digit heat waves and drought have already become a regular feature of summers there, increasing demand for air conditioning, public cooling centers, water fountains—as well as multiple days of dangerous air quality due to wildfires. In other words, the two Portlands not only need different solutions from each other, but they may need different solutions from what worked in the same city just a few decades ago.

Future Ready Megatrend 2: Society

The society lens refers to human interactions with our built environment and each other. How we move around our cities, design our neighborhoods, and plan our infrastructure in the future should be informed by trends like growing diversity, aging, urbanization, and a changing workforce.

For example, cities with aging populations need to account for a larger number of people with health, vision, and mobility challenges. Cities in Japan, the country with the oldest population in the world, have installed sidewalks that melt snow and all-weather walkways to reduce weather-related injuries.[16,17]

In a future in which, say, 50% of work is done remotely, urban transportation systems might plan around more moderate rush hours. Mid-size cities and towns with more affordable housing and lower costs of living might expect an influx of remote workers from larger job-rich urban areas.

The society lens also integrates awareness of historic inequalities in infrastructure from the beginning of the planning process. In the United States, many roads, highways, airports, and waste facilities were built and developed in a way that degraded the health and well-being of minority and low-income areas. Knowingly or not, this infrastructure exacerbated economic inequality and diminished quality of life, including limiting access to healthcare, cool spaces, healthy food, public transportation, and job centers. Incorporating social equity issues and early community engagement into planning can avoid outcomes that literally divide and further disadvantage already-overburdened communities. Underappreciating or misunderstanding local concerns can undermine or degrade efforts to build infrastructure that improves sustainability and resilience.

Future Ready Megatrend 3: Technology

The technology lens tracks beneficial innovations in infrastructure like nanomaterials, multimodal transport, phase change materials, or virtual reality. Understanding today's cutting-edge materials and processes is essential to developing the best, most Future Ready solutions. However, because technological development is so rapid, new innovations that are not realistic options or don't even exist now could be incorporated into the design of programs with long-term goals.

A common interim deadline for net zero targets, 2030, is rapidly approaching, but, inevitably, so are technologies that will upturn markets and make previously unviable tools realistic, if not superior, options. Between 2008 and 2016, lithium-ion battery costs dropped from $1,236 per kilowatt hour to $271 per kilowatt hour, or 220%. Lithium-ion may very well prove to be a transition chemistry for batteries—they have environmental issues that still need to be solved and resource scarcity could lead their prices to rise again. Nonetheless, their improved performance has dramatically and quickly improved the prospects for decarbonizing personal mobility. Electric vehicles have reached cost parity with internal combustion engines in terms of total cost of ownership in many countries, including the United States. The dramatic change in EV viability over a few years is just one example of why any long-term design, program or plan needs to consider options that aren't yet available.

Future Ready Megatrend 4: Resources

Finally, the resources lens tracks areas like materials and energy with a focus on how we can produce what we need in ways that encourage the development of no-waste circular economies, decarbonization, and sustainable water management.

For example, on-demand manufacturing can reduce or eliminate the need to maintain large amounts of stock. Biomaterials or reusable modular units will change end-of-life buildings from waste to assets. The increased efficiency and lower costs of solar panels and battery storage will encourage the development of micro-grids decoupled from the centralized energy systems.

At the same time, the growing need for battery storage to support EV as well as utility infrastructure will require significant consumption of precious metals such as cobalt and lithium as well as create capacity constraints on supply chains. Additional concern over the associated embodied carbon of these resources' extraction has driven searches for alternatives. Among these novel approaches is exploring lithium extraction from Salton Sea in southern California—the 600°F (315.6°C) brine bubbling in the desert is one of the world's richest sources of lithium.

There is also continued innovation in battery chemistry, and greater understanding that there doesn't need to be a one-size-fits-all solution. For example, iron flow batteries, which are relatively low cost and have much lower negative environmental impact than lithium-ion and most other comparable batteries, are gaining traction at utility-scale energy storage. The relatively short term that they can hold charge—8 to 12 hours—is not an issue as the batteries are storing renewable power overnight, when usage is low, while minimizing the need for carbon-intense diesel plants.

Future Ready in Action

Researching and tracking these megatrends is critical to develop an adaptable Future Ready planning process, but they are ultimately only important in terms of how they manifest themselves in a specific, local case. Once the relevant megatrends are identified, they are leveraged in a scenario planning that integrates the key inputs of climate, society, technology, and resources to create coherent visions of the future. The following is a relatively simple example of what Future Ready might look like in action.

The town of Sleepy Hollow, New York, has faced challenges from multiple long-term megatrends. Several decades ago, it took an economic hit when a local General Motors (GM) assembly plant was shuttered, taking away manufacturing jobs and leaving behind a vacant, sealed, brownfield area. In 2012, it was damaged by Superstorm Sandy's high winds. The town, which sits on the eastern shore of a tidal portion of the Hudson River, faces ongoing climate change threats including flooding and sea level rise. Like many other cities in the United States, Sleepy Hollow also has to contend with challenges, including population growth, lack of housing, lonelier and sedentary lifestyles, and obesity.

The Sleepy Hollow Local Development Corporation (SHLDC) worked with WSP and other partners to design Future Ready solutions that integrated sustainability and resilience while proving community benefits. Comprehensive hydrologic, hydraulic, and coastal analysis of the project area determined that future flooding could inundate the nearby Metro North railway tracks as well as threaten the local Department of Public Works (DPW) headquarters. Green infrastructure was designed to improve storm water treatment and increase flood resistance. To promote resilience in extreme scenarios, the greenspace and porous parking lot were also designed to flood in order to protect critical facilities like the DPW building. The area around the GM assembly plant was converted into a civic focal point featuring athletic fields, an amphitheater, walking trails, and a skate park—providing community building space and exercise opportunities. Development of condominiums and apartments will provide additional housing for citizens in the growing area, as well as serving as a hub for economic development that reclaims the area's historic waterfront.

Rethinking Everything

In addition to rethinking obstacles to a just, sustainable, and resilient transition—like perverse economic incentives and overvaluing capital costs—designing for a dynamic future means reconsidering our current practices as well as searching different places for better solutions. Contemporary engineering practices created the cultural, architectural, and technological marvels that have made the modern world possible. However, there was a high cost to many of these achievements—including the unprecedented build-up of greenhouse gases in the atmosphere that are fueling climate change. Reevaluating design processes that have been largely sidelined in contemporary engineering can suggest novel solutions.

Take, for example, non-Western or indigenous building technologies. Chinese traditional houses feature roofs angled to let in more sun during winter than summer, courtyards with sophisticated air circulation, and water catchment and runoff areas. These traditional practices have helped inspire "new" trends in sustainable and resilient design like daylighting, passive heating and cooling, and zero-carbon water management. Although some of these techniques would have to be modified for changing local climatic conditions, new inspiration can be found in the past millennia of human innovation in infrastructure that utilized unique materials, techniques, and technologies.

Americans are also not fully utilizing the modern processes and technologies in use outside of the United States. China, Japan, and multiple European countries, among others, have a lot of innovation to share, from smarter urban design to low-carbon cooling systems, but the U.S.'s continued usage of inches, pounds, and other nonmetric units hampers this technology transfer. Officially, only three countries in the world don't use the metric system: Liberia, Myanmar, and the United States. So, if a new innovation is developed in Japan, it can relatively quickly be adopted in Europe—or virtually anywhere else in the world—as both regions use the metric system. However, retooling is required to enter the U.S. market, significantly delaying some innovative technologies' entry.

The long use life of buildings in Europe and many other regions versus shorter lifespans in the United States, suggests rethinking their full value. Buildings should be thought of as valuable assets with large amounts of embodied carbon (a concept addressed in greater detail later in the book), not disposable products.

In some cases, the most valuable rethinking of infrastructure overlaps with rethinking societal expectations. For example, heating and cooling buildings are major sources of GHG emissions, both from natural gas or oil furnaces as well as the fossil fuels used to create electricity for heating and air conditioning. However, the amount of GHG emitted is largely determined by how much heating or cooling occupants use, decisions which vary dramatically around the world. In tropical Singapore, for example, higher indoor temperatures or humidity—even in office buildings—is more acceptable than in Europe or the United States. In other regions, including warmer parts of the United States and the Middle East, "over air conditioning" often brings interior temperatures far below outdoor temperatures throughout the year. There is no doubt that air conditioning—or other lower-emission cooling systems—will be important resiliency measures in a hotter world. However, determining internal temperatures based on factors like health and productivity instead of cultural expectations will ultimately create a more sustainable and resilient infrastructure.

Avoiding False Choices

The mission of the authors and their colleagues in this fight is guided by the conviction that delimiting innovation and accepting either/or choices betrays a dangerous lack of imagination. Rethinking everything about how we have built for centuries, and even where we should build, means rejecting the supposedly immutable trade-offs that still plague all sorts of planning and design decisions.

For example, new infrastructure doesn't have to result in detrimental environmental impact. Incorporating nature-positive infrastructure, such as using public spaces for stormwater management, biodiversity, and flood and heat resilience, can have win/win/win effects. Even the hard infrastructure projects most associated with environmental costs can have very high sustainability ratings. A recent expansion project at New York's LaGuardia Airport, for which WSP provided a range of environmental and engineering services, received an ENVISION Platinum rating from the Institute for Sustainable Infrastructure for its high levels of sustainability, resilience, and community engagement.

We don't have to build back in the same location or not at all, and we shouldn't passively accept the logic of other either/or decisions. We don't have to pick between resilience and sustainability, or economic growth and biodiversity, or lower costs and lower carbon, or more jobs and a just, sustainable economy. We can choose from, and need, all of the above to meet the challenge of climate change in a just, sustainable, and resilient way.

Part I of this book covers "The What" by detailing some of the types of risks, challenges, infrastructure solutions, and other opportunities developed and implemented across the United States and around the world. Ranging across the built environment, transportation, energy, water, and waste management sectors, as well as taking a deep dive into New York City's ongoing transformation, the chapters are not exhaustive on any one topic. Instead, they include examples of how a wide variety of specific risks and challenges are being assessed and mitigated using innovative planning, sustainable, resilient, and innovative techniques, cutting-edge technologies, and the Future Ready framework. Part II is "The How," a practical guide that explores and explains some of the primary frameworks, strategies, target setting, and individual solutions for organizations to start, evaluate, or accelerate their own sustainability journeys.

Since WSP partners with a large number of organizations in the private sector as well as the public sector, the book shares our expertise broadly. After all, building a sustainable and resilient world that is ready to meet the present and future challenges of climate change requires the combined efforts of large corporations, mid-sized businesses, rapidly expanding startups, megacities, counties, and towns. While some of the specific challenges and solutions will be more relevant to certain organizations than others, we intend for the whole book to be engaging, informative, and inspiring for all readers.

This is a critical, but exciting, time for anyone working in the infrastructure sector. The green transition to a more sustainable, resilient world is a massive opportunity, but it is not optional. The proliferation of ESG disclosures and investment strategies, net zero targets, and climate action plans show us what we need to do. The emergence of climate risk has heightened awareness of why we need to do it. Our challenge is to figure out how to pick the right things to do, as well as how to do those things right. The next decade or two will be a major inflection point for the Earth, driven by both risk and virtually endless opportunities.

Notes

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