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Field Notes:

Extreme Weather and Community Resilience

THE SYRIAN EXPERIENCE FROM 2006 THROUGH 2016 ILLUSTRATES HOW CHANGING CLIMATE CAN WORSEN THE EXTREMES OF WEATHER AND UNDERMINE CRITICAL INFRASTRUCTURE.

Steven Steinhour September 26, 2016

The disruption of America's critical infrastructures due to climate-amplified extreme weather damage or rising sea levels could be among the earliest climate change shocks we experience.

The peril of ignoring climate-amplified weather extremes is readily evident in Syria. Prior to 2006, the government promoted the national expansion of agriculture, but failed to expand the infrastructure for delivery of irrigation water. By 2006 a decades-long trend toward drought was intensified by climatic drying. The interaction between the resulting extreme drought and the demand for water from the older, inadequate water delivery infrastructure resulted, by 2008, in collapse of the nation's farming sector. Over a million rural Syrians moved to cities where they found few jobs, poor housing, and virtually no social services. Syria's government, already struggling with political and economic challenges responded to the ensuing civil demonstrations with force. By 2011, civil war had forced an outmigration that, by July 2015 found over 4 million Syrians stranded in Turkey and other nearby nations. That year, more than 350,000 Syrians applied for asylum in the European Union; others entered illegally. The 2015 million-plus flood of refugees, including Syrians, into the EU undermined its goal of free movement, and contributed to the English referendum to leave the EU.

Syrian societal upheaval was not caused directly or solely by climate change. It was triggered by the convergence of a decades-long trend of climatic heating, three years of extremely dry weather, and human failure to modernize and adapt water delivery infrastructure to the increasingly hot, dry atmosphere of the 21st century.

Discussions about climate change tend to focus on the direct impacts of atmospheric heating: too much heat, too little rain, too much rain at once or at the wrong time or lasting too long. The Syrian experience flags a new type of ever-present, and now increasing, risk. Atmospheric heating, weather extremes or rising sea levels can, indirectly, undermine the effectiveness of critical infrastructure that we have failed to upgrade and adapt to emerging climatic conditions. In a large nation with a diverse economy and multi-level disaster response services, such as the U.S., indirect climate damage to infrastructure is likely to be confined to an urban area, a state or region. But even a localized failure can significantly affect other regions if it results in economic damage with national implications or an unexpected, abrupt mass migration of people. The post-Hurricane Katrina relocation of New Orleans' residents is an example of such ripple effects.

We are surrounded by systems of infrastructure that may be our Achilles' heel as the atmosphere heats.

Infrastructures are the physical structures and logistical schemes designed to meet our needs in daily life while concurrently adapting to shifting conditions of climate, weather, economies and population. To clarify the idea of systems of infrastructure, think of the number of faucets in your house. Pipes carry water to each of them, and all of those pipes are connected to the city's water distribution pipes, which, in turn, are connected to the city's water purification facility. All of those pipes and that facility are infrastructure: physical structures built in-place to provide benefits to the community. Every house on your street and throughout the city is connected to that water purification facility in the same way as your house. Every one of those pipes is directly or indirectly connected together into a community-wide "system" of built-in infrastructure for the delivery of water to residents' homes.

The examples of built-in and interconnected systems of infrastructures continue with our streets, storm drains, sanitary sewers, and electrical service. At a larger scale there are systems of flood-control levees and dams that keep floodwaters within rivers. At an even larger scale, roads, freeways, bridges, subways, tunnels, sea ports and airports comprise a built-in system of transportation infrastructure. We depend on them to be there and to work properly, but we rarely think about them—unless they fail. And then we realize they are critical to our lives, our communities and the economy.

Adaptation for some systems is a regular, ongoing process. For example, agricultural practices and products are constantly being modified, and even relocated, to adapt to climate and weather—just ask any farmer. Farmers' uncertainty is not about whether climate and weather will change, but how quickly and how extremely.

The larger built-systems are not so readily or frequently adapted, leaving them vulnerable to gradual deterioration or failure due to climate impacts exceeding their design. Significant harm can come from infrastructure failures of our coastal cities and ports; dams and other flood control systems; transportation and energy networks; integrated communication networks that support financial and economic sectors; and freshwater delivery and sanitation systems. Each of these systems can be indirectly damaged by changing climate. In 2012 Superstorm Sandy destroyed part of the U.S. Eastern-states' electrical system; more than 8.5 million people lost electrical power for weeks to months.

All of those systems are potentially vulnerable because most were designed and built during the last century to operate under conditions of relatively benign climate and weather. Climate and weather conditions have changed so fundamentally over the last 20 or more years that past weather patterns are largely irrelevant for infrastructure decision-making today. The emergent extreme weather of the 21st century appears to be more chaotic and unpredictable, with greater intensity and duration, and, unfortunately, shorter return intervals. Sea levels are inexorably rising due to the physics of heat.

Since the year 2000, Americans have faced the stark realities of Katrina, the 2011 Texas drought, the 2012 corn crop failure, Western wildfires, Superstorm Sandy, and the August 2016 Baton Rouge flooding. Looking ahead we can measure similar projected increases in damaging weather extremes and sea level rise against the familiar 20th century patterns of climate-related damage. That comparison argues strongly for urgent review and adaptation of those infrastructures whose failures, under the climate stresses of extreme weather and sea level rise, pose the greatest risks of physical, economic and human loss.

The impacts of climate, extreme weather and sea level rise on specific infrastructures vary widely in type and degree of damage, with great regional differences. Here are some 21st century examples of existing hazards. Adaptive solutions to each will be site-specific.

SEA LEVEL-RISE IMPACTS ON COASTAL CITY INFRASTRUCTURE


Photo courtesy: rsmas.miami.edu


Photo courtesy: phys.org

The South Florida coast is already experiencing sunny-day, king-tide flooding and greater hurricane-driven, storm-surge flooding. In 2010 the Southeast Florida counties of Miami-Dade, Broward, Monroe and Palm Beach entered into a climate compact to plan for sea level rise between 2.5 and 6.24 feet by 2100. About 4,500 square miles of South Florida are within 4.5 feet of the 1992 sea level. If sea level were to rise 6 feet by 2100, an estimated 1.6 million South Floridians could be at risk of inundation by the ocean and potentially forced to migrate. Miami is built at an average height of 6 feet above mean sea level; Miami Beach is at an average of 4 feet. While some areas in each city are over 6 feet above mean sea level, both cities slope down to current sea level beaches, increasing vulnerability to storm surge.

By 2100 portions of the existing Miami/Miami Beach urban area are likely to be permanently underwater due to the combination of rising coastal sea level and subsurface intrusion of saltwater through the porous limestone bedrock. Higher sea level and the gradual submergence of Miami Beach means that Miami, itself, may be directly exposed to oceanic storm surges from hurricanes that could flood even farther inland among the buildings of Miami.

Miami Beach is developing engineering approaches—such as seawalls, raised roads and sidewalks, reverse-flow valves on major flood drains, and huge drainage pumps—to protect existing and future high-rise development near the ocean. The first $100 million is a down payment on projects that may total $400-500 million over the next five years in an attempt to secure another 40 to 50 years of urban defense against sea level rise. However, research on the flow of salty ocean water through the porous limestone bedrock underlying these cities and other areas of South Florida indicates such flow may be a serious challenge for engineering solutions. Communities along the coast are already experiencing intermittent saltwater intrusion into the freshwater aquifers they depend on for drinking water.

Long-term and repeated exposure to saltwater flooding can damage many surface and undergrounded urban infrastructure systems including transportation; electrical power distribution and communication systems; and freshwater, stormwater and sewage distribution systems. Frequent salt water flooding and corrosion of structural materials may also increase the costs of operation and maintenance of commercial and residential buildings.

HEAT AND DROUGHT IMPACTS ON AGRICULTURAL INFRASTRUCTURE

Photo courtesy: cnn.com

In 2012 nearly 80 percent of the U.S. Corn Belt suffered extreme heat and drought during which production of field corn and sorghum dropped by more than 25 percent. The Federal Crop Insurance Program paid out $17.3 billion for crop failures that year. The effects of corn and sorghum crop failures cascaded further within agricultural industries by reducing supplies of cattle feed. Early spring temperatures were so high that heat prevented pollination of much of the corn crop. Continuing high temperatures and lack of rain dried out the plants and soil so much that entire fields of planted corn, running to the horizon, died and were eventually plowed under. The farm equipment, storage silos, farm labor, and the customized water and chemical needs of the crops for each step of the growing season – from plowing to planting, fertilization, weed reduction and harvest—comprise an infrastructure developed over many years in this region. But even such preparation was undermined in 2012 by the extreme drought that, in places, equaled the severity of the 1930s Dust Bowl.

Increasing repetition of such heat and drought conditions may force relocation of corn, sorghum and, possibly, soy farming to areas farther north where cooler temperatures during the critical pollination period and adequate rainfall are more likely. If adverse conditions such as poorer soil or inadequate moisture or too-short growing days prove to exist farther north, those crops critical to the U.S. agricultural industry may be reduced with implications for both the U.S. economy and food security.

OCEANIC STORM SURGE IMPACTS ON COASTAL CITY


Photo courtesy: telegraph.co.uk

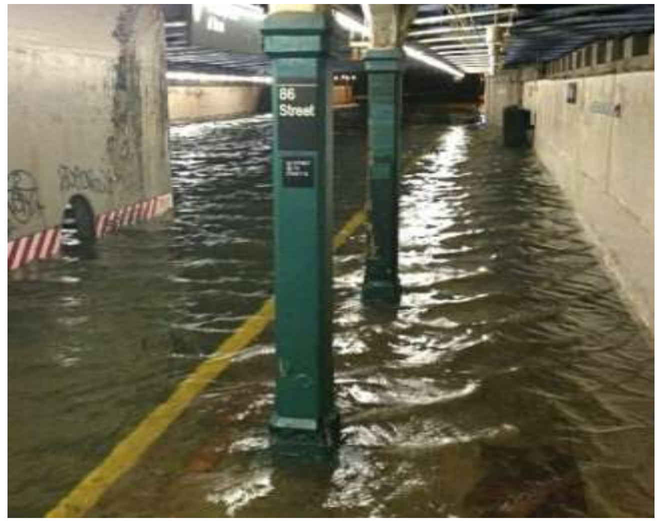

Photo courtesy: inhabit.com

In late-October 2012, New York City and an extensive region from Florida to New England was hit by [Superstorm Sandy](), causing an estimated $50 billion in damages. More than 8.5 million people lost electrical power, some for weeks and others for months, as power plants, transmission and distribution infrastructure recovered from the damage. Approximately 650,000 homes were destroyed or damaged by waves and storm surge cresting up to 9 feet. In New York state 305,000 residences were lost or damaged. NYC, alone, suffered an estimated $19 billion in loss or damage to residences, businesses, and infrastructure. Of that, $4.5 billion of city agency facilities and $2.5 billion in New York transit agency facilities were destroyed. The City's subway system and tunnels flooded with the worst, most-extensive damage to those systems in its 109-year history.

WILDFIRE IMPACTS ON FORESTRY AGENCIES' INFRASTRUCTURE AND URBAN DEVELOPMENT


Photo courtesy: npr.org


Photo courtesy: cbsnews.com

As of September this year, part way through the 2016 national fire season, there have been more than 39,000 wildfires covering 4.4 million acres of mostly Western forests.

The infrastructures of fire suppression include full-time federal and state forestry agencies, equipment, staffing, staging areas, water supplies, training and specialized techniques to battle different types of fire. The total number of wildfires this year is not exceptional, but the steady increase in the size of landscapes over which wildfires are now being fought threatens the agencies' other efforts aimed at preventing many of the fires before they start. Fighting wildfires after they develop severely distorts fire-agency budgets toward the immediate crises of responsive firefighting. Funding is diverted from proactive, pre-fire vegetation clearance and timber thinning, particularly in urban/wildfire interface zones where structures are at risk, to minimize wildfires before they gain a foothold.

The total loss of homes, businesses and municipal facilities in burned-over rural and urban-edge areas imposes harsh conditions on residents as essential services and resources collapse. When wildfires sweep through communities, which are frequently small towns, the infrastructures of streets, roads, electrical and water distribution provided by local government and utilities may require nearly complete replacement. All of this superimposes additional reconstruction burdens on residents, who are not only restoring their own homes and workplaces, but are also paying the taxes that will finance replacement of local infrastructure.

IMPACTS OF EXTREME RAINFALL ON URBAN AND RURAL INFRASTRUCTURE


Flooding to eaves of houses/ Photo nola.com


Opening soaked walls to prevent mold/ abcnews.com


Soaked furnishings create debris fields
Photo credit Reddington.com


Emergency evacuee facility
Photo en.wikipedia.org

Baton Rouge, LA, and its surrounding 20 parishes—home to more than 280,000 people—are only now beginning recovery from a massive rainstorm system that stalled for days over this 10-river watershed. This worst U.S. natural disaster since Superstorm Sandy in 2012 has killed 13 people. The flooding is estimated to have damaged as many as 60,000 homes and over 3,300 businesses that had employed more than 27,000 workers from the area. Losses are preliminarily estimated in the billions of dollars.

Floodwaters swirled sewage, spilled fuel and hazardous chemicals into residences and commercial and public structures. The public infrastructure damage has ravaged all aspects of transportation, water, sewage and electrical systems, and facilities for public services. Recovery of housing and commercial facilities will take months, if not years, of settling insurance claims and financing the construction recovery. Municipal and parish governmental physical infrastructure and tax revenues may not recover for several years. The Red Cross has estimated the costs of emergency disaster response services and supplies, alone, may reach $30 million.

Even aggressive adaptation of infrastructures will fail if global atmospheric temperatures continue to rise.

Infrastructure adaptations to climate-amplified extreme weather and sea level rise, tailored to each situation, are possible—for a time. They may buy decades, possibly even a century or more in specific cases, during which we can stop, and then reverse, global greenhouse gas emissions. Replacement of major infrastructure adaptations will be costly; adaptive upgrades less so. Of potential national concern, there may be both hardships and potential mass relocations of people and, possibly, even communities if gradual adaptation is not, or cannot be, implemented.

There will be no happy return to normal before then, because the emerging normals for climate, weather and sea level are not static. They are driven by the physical realities of the natural systems of atmosphere and oceans that are currently absorbing the heat trapped by greenhouse gases. Those systems are so vast, and change so slowly, that they will release the heat they have absorbed only over extremely long time periods—possibly centuries for heat absorbed by the oceans. Heat-driven climate change, and its offspring of extreme weather and sea level rise, increasingly disrupts our lives. The erratic changes in temperatures, precipitation and coastal flooding will incrementally—and with unrelenting pressure—damage and undermine the effectiveness of many critical infrastructures upon which our daily lives depend.

We have a choice. The sooner we reduce atmospheric greenhouse gas levels, the sooner we can commence the centuries of work necessary to return to 19th and early-20th Century conditions of temperature, weather and sea level—conditions under which we thrived. The longer we wait, the higher the cost in terms of adapting critical infrastructures to the emerging realities of climate. Failure to adapt in time risks a catastrophic decline in the conditions of human society, not only in the U.S., but around the globe. In the language of politics, the race is ours to lose.

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How to Get Involved
RRI would like to hear from you. If you have questions, comments, or concerns, please contact us at:

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