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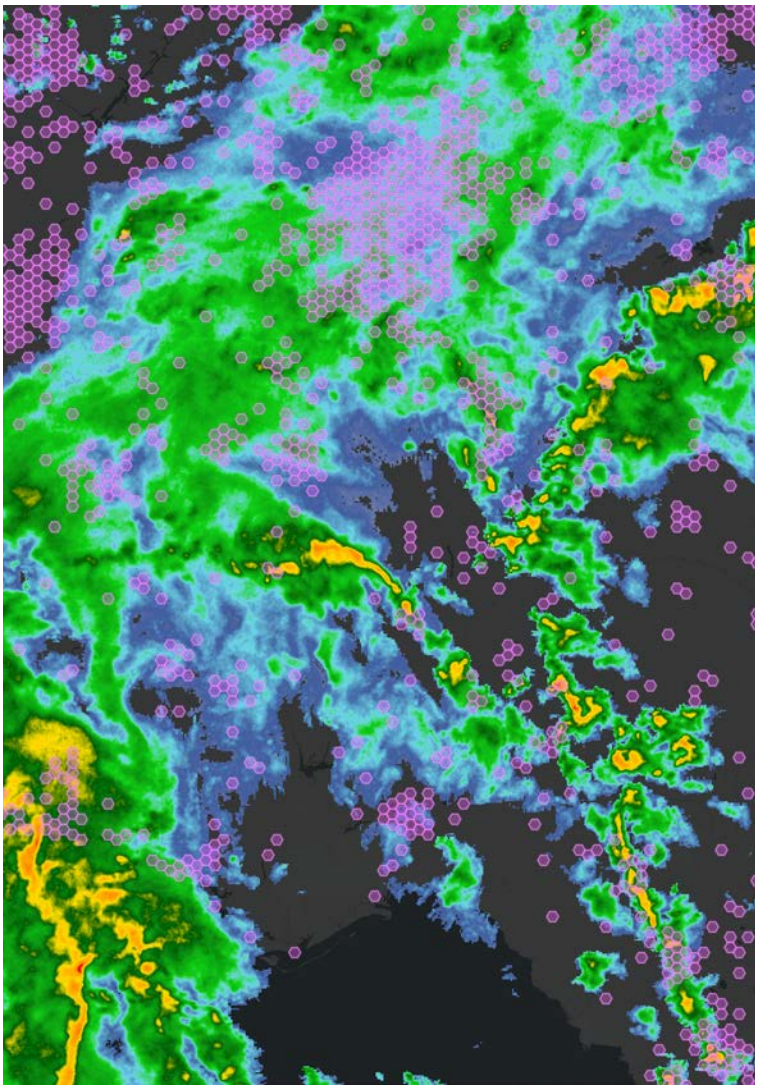
The Climate Checklist

A Five-Factor Framework to Guide Climate Action for Government and Business Leaders

Overview

What was once an impending climate crisis is now our global climate reality. Climate impacts have escalated to the point of endangering communities, triggering new compliance requirements and evoking social urgency.

Executives and government leaders must do more than respond. They must prepare for and predict future climate conditions. This will involve analyzing data, mapping assets, modeling climate impacts, and developing solid strategies for mitigation and adaptation. First, leaders need more clarity around climate risks. They need to know what is likely to happen, who and what will be affected, and when and where. They also need to see the implications—the costs—of action or inaction.



Resilience—the continuity of business and the care of communities—is what's at stake. The good news is that we have the science and technology to deliver greater clarity and support mitigation and adaptation plans.

Climate reports and economic indicators continue to underscore the urgency of action. Combined with pressures like resource scarcity and increased levels of public concern, leaders face an imperative to act. This means prioritizing investments in climate-related initiatives. It means identifying the unique risks faced by a business or community and seeing those risks in the context of people, assets, operations, natural systems, and specific geographic locations. Geography is essential to understanding and tackling climate risks. That is why location intelligence powers holistic planning and problem-solving.

A modern geographic information system (GIS), delivers location intelligence. It gives decision-makers and stakeholders access to risk analytics and real-time dashboards, striking map visualizations, and predictive simulations. It rolls location-based climate risk data into public-facing websites and compliance reports.

Most businesses and government organizations already employ location intelligence, relying on software and services from Esri, the worldwide leader in GIS technology. As a company known for its heavy focus on research and development, Esri prioritizes engineering technology and solutions and curating authoritative data to support resilience and sustainability initiatives. Recently, Esri was recognized with the highest possible score for climate risk analytics by independent research firm Forrester. The firm's analysis cited Esri® technology for its advanced data processing, visualization, and threat modeling capabilities.

Here, we outline smart approaches to assessing and mitigating climate risks by using GIS technology. And we share proof points—real-world examples of these strategies in action.

Understanding Climate Impacts to Business and Government Operations

Companies and communities need answers. But they also need to ask the right questions. By working together with their GIS teams, executives and government leaders can achieve the following objectives:

Objective: Enhance risk portfolio visibility.

Gain a comprehensive view of complex, local, and globally distributed risks.

- Where are people, assets, and supply chains susceptible to climate hazards?
- What are the specific climate risks and likely impacts?
- Which areas, people, and assets are most vulnerable to those local risks?

Objective: Conduct comprehensive risk assessments.

Understand the specific costs associated with potential climate hazards and provide transparency for the public, regulators, and stakeholders.

- Do the costs associated with our climate risks warrant a mitigation investment?
- What are the financial and operational impacts of our unique climate risks?
- What is the value of the assets that are most vulnerable to local risk?
- What is the likelihood that these hazards will occur?

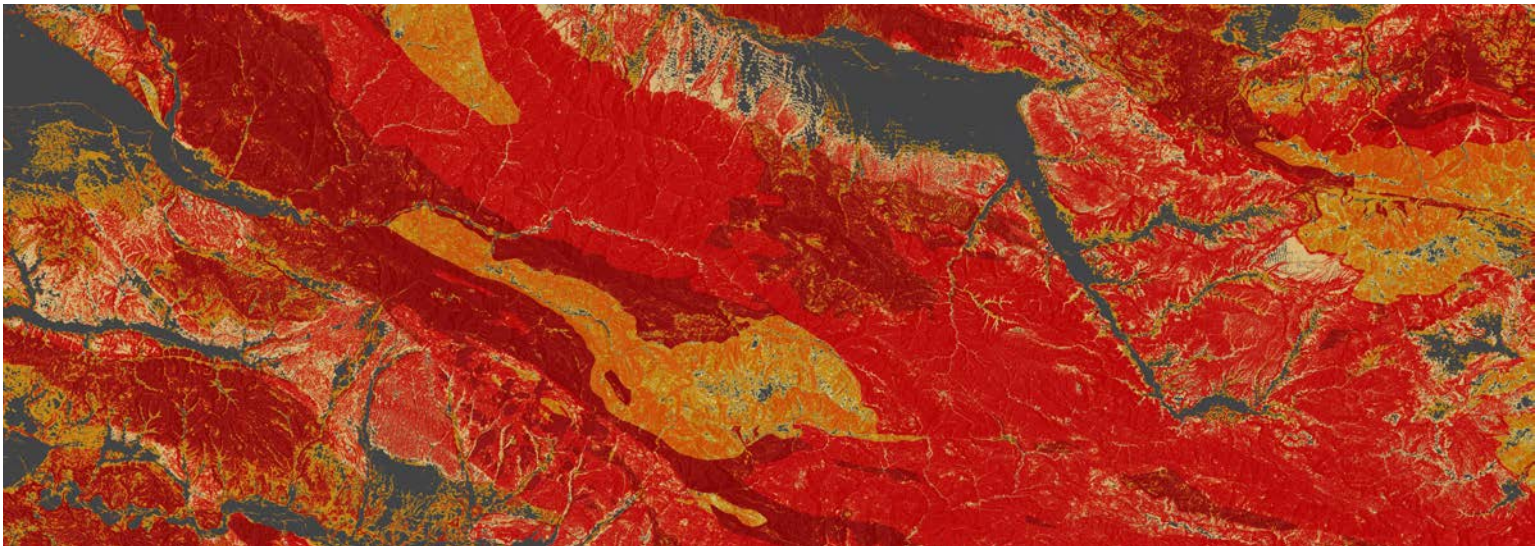
Objective: Develop strategies to minimize disruption.

Address short-term concerns while ensuring longevity.

- How can we ensure continuity of operations under climate-related constraints?
- What will operations look like in the future if we do/don't make changes?
- How will costs to residents/customers—in either money or time—be impacted?
- How can we report to regulatory bodies to avoid fines or penalties?

Objective: Create actionable climate plans.

- Where are the most vulnerable populations exposed to the greatest climate risks?
- How can we prioritize investments to improve resilience and equity?
- How can we equitably and efficiently build out EV charging networks?
- Where is there potential for solar or wind generation?
- Where would trees or shade canopies provide the most relief from urban heat islands?



Five Steps to Climate Risk Assessment and Action

ArcGIS® technology from Esri provides an end-to-end climate risk and resilience platform, allowing organizations to apply the National Oceanic and Atmospheric Administration's (NOAA) steps to resilience:

1 Understand and Explore Hazards

- Create maps and dashboards to visualize climate hazards, exposure, vulnerability, and potential impacts in relationship to people, assets, and operations.
- Identify climate threats to people and places, biodiversity, and supply routes.
- Customize analyses and visualizations to a specific region or an entire network.

2 Analyze and Assess Vulnerabilities and Risk

- Access and analyze volumes of relevant data including weather and traffic patterns, demographics, imagery from drones and satellites, proprietary information, and sensor inputs.
- Enhance in-house data analytics with maps, apps, and data layers from the foremost collection of global geographic information, the ArcGIS Living Atlas of the World.
- Predict impacts of current and emerging weather events and ongoing global changes.

3 Investigate and Communicate

- Engage stakeholders by collaborating and communicating via shared interactive maps, dashboards, imagery, videos, ArcGIS StoryMaps stories, and visually compelling reports.
- Create shared understanding by socializing easy-to-interpret spatial analysis results and highly visual mitigation plans across the organization, with other agencies, and with the public.

4 Prioritize and Plan

- Iterate various scenarios and analyze possible outcomes to determine the optimal climate action plan for an organization or community.
- Make 3D models and realistic simulations via a location-aware digital twin to see climate impacts on networks and neighborhoods.

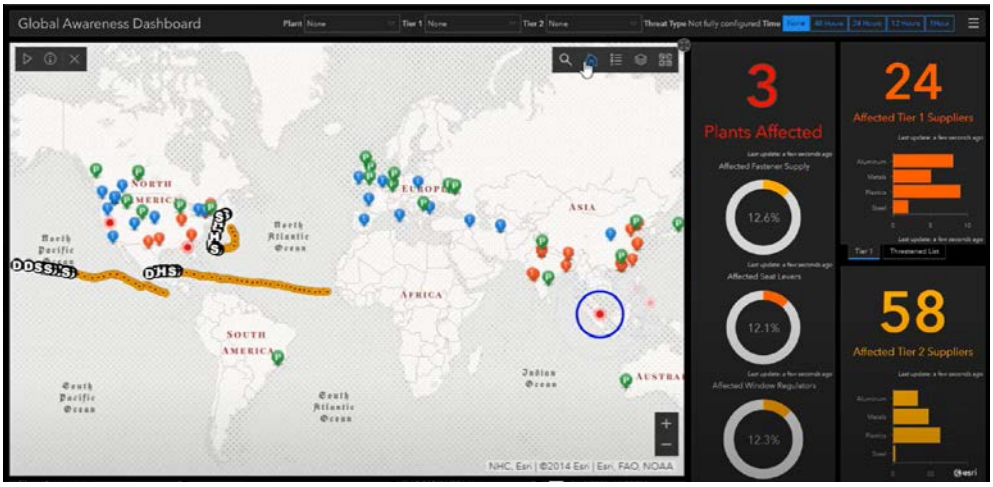
5 Take Action

- Share data, analyses, maps, and strategies by building an online community climate action hub site. Implement and monitor solutions and share progress.
- Continue to access GIS-based decision-support tools including illustrative smart maps for areas of concern, climate risk analytics and predictive analytics, real-time dashboards, historical data, and imagery.
- Create dashboards or compliance reports to show how well your company, city, county, or state is meeting its targeted goals.

Real-World Resilience

Climate Risk Assessment and Mitigation in Action

The window for success against climate change is narrow, but we can still change for the better. We have the tools. We have the science. We have the justification: the social, environmental, and economic benefits of climate mitigation and adaptation far surpass the costs.



A global risk dashboard using GIS technology can visualize distributed asset locations and near real-time risk factors, giving leaders critical data to inform decision-making.

Critical risk events prove disastrous and even lethal to communities. They can destroy infrastructure, disrupt supply chains, delay operations, damage reputations, and take lives. Many businesses and governments around the globe are combining the power of GIS technology with the five-factor framework to climate risk assessment and action. They are increasing awareness, communicating effectively, developing strategic plans, and taking decisive action.

Which Locations Are Most at Risk?

To support climate action goals across the US, the White House debuted its Climate Mapping for Resilience and Adaptation (CMRA) Portal. The innovative tool—developed with the National Oceanic and Atmospheric Administration, the Department of Interior, the US Global Change Research Program, and Esri technology—offers scientific data in a visual and easy-to-understand format to help leaders understand and explore current and projected climate conditions at state and local levels.

Proof Point:
Understand and Explore Hazards

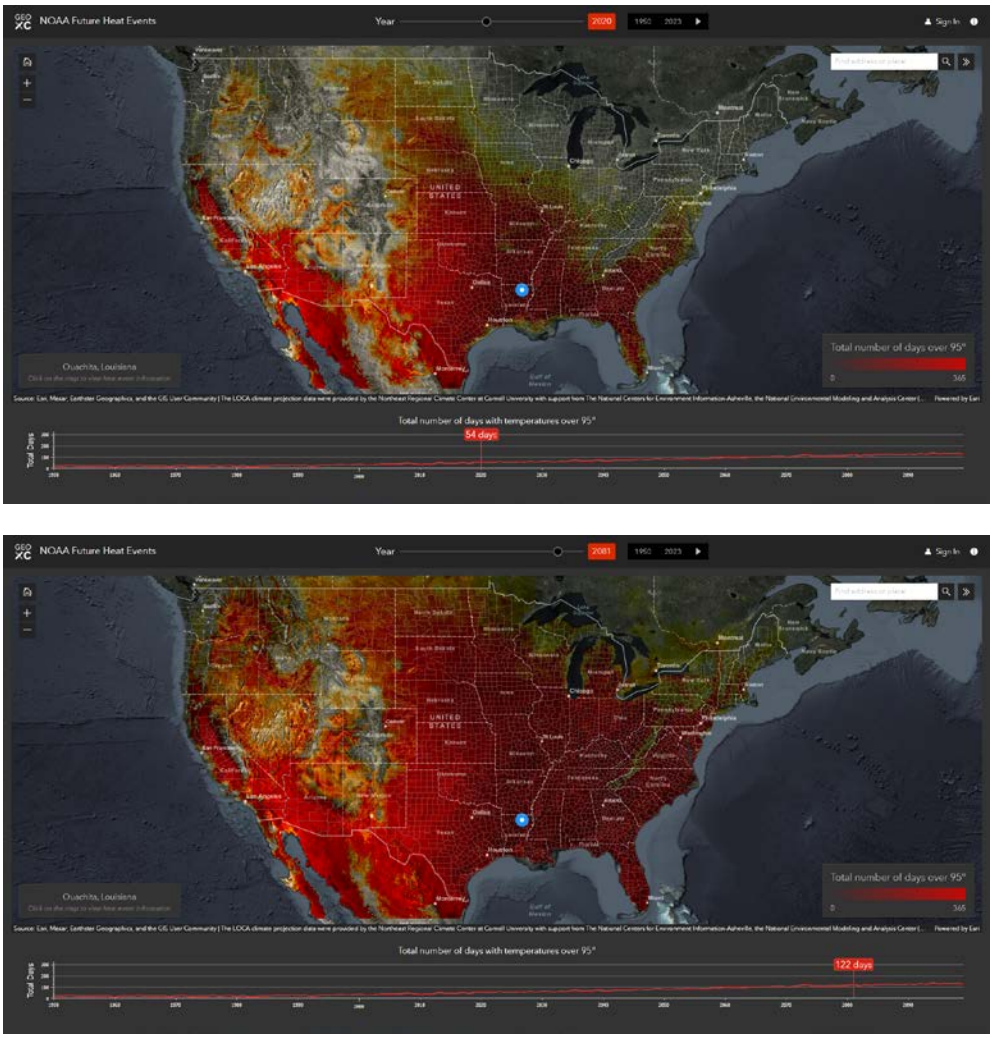
The CMRA portal guides cities, counties, states, tribes, and private organizations in determining where and how they need to act. Users can type in an address or select a point on a map to reveal climate projections through 2099 related to extreme heat, drought, inland flooding, coastal flooding, and wildfire.

For example, in Washington, DC, the number of days with temperatures exceeding 95 degrees Fahrenheit will grow from nearly 19 days per year in the early part of the century to as many as 64 days by the last years of the century. For analysts, this data flows into straightforward hazard reports that can be incorporated into strategies for future projects, a climate action plan, or support for a funding proposal.

The maps highlight any area designated as a disadvantaged community—based on an environmental justice score—making it eligible for prioritized funding. The aim is for equity to be top of mind when government leaders design and implement resilience measures.

> "There is no more important service that the federal government can provide right now than completely up-to-date information on the climate impacts, on a geographic basis, that are hitting our communities, causing the loss of lives and loss of livelihoods."

David J. Hayes
Special Assistant to President Biden for Climate Policy



NOAA Future Heat Events maps show the total number of days over 95° F by county, to guide action for strategic climate adaptation and mitigation measures. The top map shows historic climate data for 2020 (54 days over 95° F), and the bottom map shows 2080 projections (122 days days over 95° F) for Ouachita, Louisiana.

While climate action strategies have become commonplace in some metropolitan areas, including Boston, Miami, and Los Angeles, a data-driven approach may have been out of reach for others. The CMRA Portal aims to fill knowledge gaps—helping communities and organizations identify climate threats so they can prioritize resilience-building actions. The portal also links to federal funding resources, federal climate policies, and proven solutions from other communities.

Read the full story in *Esri Blog*.

Mapping Climate Intervention Priorities

Around the world, cities are increasingly taking proactive approaches to climate change, using big data and mapping technology to gain a deeper understanding. This is how the European city of Prague is tackling climate-related extreme heat.

"There are more droughts, less precipitation, and more tropical temperatures than ever before," said Jiří Čtyroký, director of spatial information at the Prague Institute of Planning and Development (IPR Prague). "It makes the city streets and public spaces less livable and more stressful for people."

Prague is particularly vulnerable to extreme heat. Compared to other European cities, it has more paved spaces, built-up areas, and industrial infrastructure—the kind of spaces that can create what are called heat islands. But Prague also contains a significant amount of green space and vegetation, the kind of areas that can offer respite.

Čtyroký and other officials from IPR Prague are studying present-day climate impacts while devising ways to meet the climate-related challenges of the future. They use GIS technology to view and analyze the city in both its street-level granularity and its bird's-eye view totality.

Sensors throughout the city measure variables like temperature fluctuation, solar radiation, and humidity. IPR Prague integrates sensor data with health and demographic information. The team can see, for instance, where there are high populations of seniors and young children—two populations at increased risk from high temperatures.

The effort grew out of requests from Prague officials for IPR Prague to devise a way to rate the viability of future projects. "We were asked to develop an aggregated map that showed the best areas to expend effort and money," Čtyroký said. "That was the beginning of our vulnerability index."

Čtyroký highlighted Old Town—Prague's original city center, which dates back to when it was a medieval walled city—on the map. "It's one of the worst spots in terms of climate," he said. "It's a densely built-up quarter, and there's no wind—just the cobblestone, stone, and asphalt surfaces." This area could benefit from increased green spaces and tree cover.

A 3D, interactive map of Prague shows models of the city's microclimates to analyze the effect of mitigation strategies before investment and guide strategic climate action.

The plan is to update the index every few years to see how the situation has changed. "It won't be a static thing—and hopefully it will be improving," Čtyroký said.

The next phase of Prague's climate strategy will involve using GIS to construct intricate 3D models of the city's microclimates and analyzing the likely effects of adaptation strategies before the city invests time and money. These models will also provide a way to communicate these plans with other government agencies and the public.

Read the full story on *Esri Blog*.

Groundbreaking Climate Analysis

Leaders at AT&T—the world's largest telecom company by market cap—have already set a precedent for this level of climate modeling. Through a public-private collaboration with the US Department of Energy's Argonne National Laboratory, AT&T is making it possible to understand both climate risk and business adaptation.

Drawing on the data-gathering and supercomputing power of the leading national lab and the visual and analytic capabilities of GIS technology, AT&T developed a climate analysis tool capable of identifying the areas of the company's network that are most at risk in the US Southeast.

"It's not just AT&T—I'm seeing this more and more in all kinds of industries where companies are saying, 'If this is the reality, then let's prepare for it, let's deal with it,'" said Antoine Diffloth, director of data insights in the Chief Data Office at AT&T.

As one of the world's largest companies, with revenues of $181.2 billion and over 247,000 employees, AT&T has a vast infrastructure network and thousands of pieces of equipment exposed to climate risk. Repair and recovery from a series of severe weather events between 2016 and 2018, for example, cost AT&T over $800 million.

"One of the things we quickly realized was that if we're going to talk about climate change, probably the best thing we could do is give folks a visual representation of that," said Shannon Carroll, director of global environmental sustainability at AT&T. "You have to think about the end user. You could give them a bunch of datasets, but how useful is that really?"

To capture climate data in a visually engaging way, AT&T turned to the GIS technology it was already using to map the locations of the company's infrastructure assets. The smart map was a natural fit both to communicate with stakeholders and to shape decisions around adaptation and resilience. By working with Argonne, AT&T had access to timely data tailored to the company's locations of interest and climate risk priorities.

"AT&T's problem was very complex and very, very specific," said Thomas Wall, program lead for engineering and applied resilience at Argonne. "It was also at a systems-level scale that is much larger and more detailed than most of what I've seen for these types of projects."

The telecom giant was particularly interested in flood risk and high-intensity winds—the two threats deemed most

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significant to electrical and battery-powered equipment aboveground and underground.

Argonne built on its physics-based regional climate modeling system, taking global climate predictions and applying them to a local level. While most climate modeling of this kind works on 12-kilometer blocks, Argonne was able to enhance the focus down to hyperlocal, 200-meter blocks—the most detailed level of climate modeling available that covers the four southeastern states of focus. AT&T then layered the climate forecasts and information on maps of the company's network assets.

"What's really important here is the quality of the data," Carroll said. "It's never perfect, but if we know with a 95 percent confidence interval that between now and the next 30 years, a specific grid cell will have a maximum flooding of 15 feet, that's really good information to have." Utilizing smart maps, AT&T can determine which assets are in each grid cell and how susceptible they are to flooding.

With knowledge of those risks, a planning team might decide to move the construction of a cell tower 200 meters south to an area less prone to floods or wind, or to the other side of a highway. The team could shore up existing facilities, knowing that one building may only need to be reinforced by sandbags, while at another location, batteries need to be elevated above maximum flooding levels. "The more granular you can get, the better decisions you can make," Diffloth said.

Proof Point:
Analyze and Assess Vulnerabilities and Risk

From the beginning, the AT&T teams working on the climate risk analysis tool decided they were going to make the data available to everyone. They publicized access through press releases and social media channels, encouraging people and groups to download it.

Read the full story in *WhereNext* magazine.

This example of precision analysis and modeling, impressive on its own, carries even greater significance because the data and analysis were made available to other organizations so that they could benefit and take action.

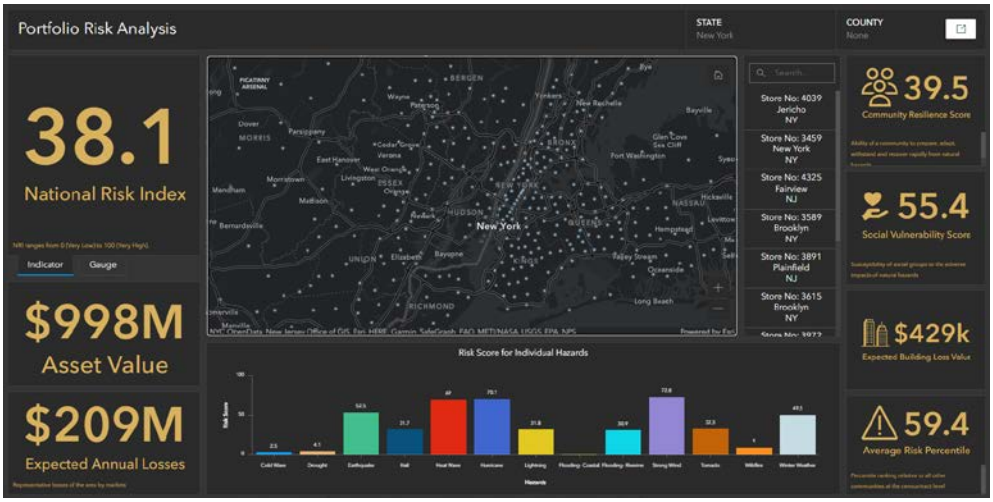
Making It Easier to Understand Risk

It's the type of communication also seen in New Mexico, where drought and rising temperatures are drying up water resources, increasing the number of destructive wildfires, and forcing tough decisions about how to adapt. To help all New Mexicans prepare for climate outcomes, a team of scientists, technologists, and resource specialists launched the *New Mexico Climate Risk Map*.

State and local leaders, agencies, and residents can use the map as a collaboration tool, giving everyone a view of climate impact. They can see predicted drought, heat, flooding, deteriorating air quality, and wildfire—noting where and who will face heightened risks.

Across the greater Southwest, fuel conditions—coupled with projected higher seasonal temperatures and decreases in annual precipitation—increase the potential for more frequent, intense, and extended wildfires.

This dashboard uses geospatial data and data visualization techniques to deliver insights into some of the physical risks of different facilities in a business portfolio. This helps to develop mitigation strategies and enhance resilience measures for leaders to make informed decisions.



"Fires can harm habitat and create conditions that cause major floods that impact drinking water quality," said Maria Lohmann, who coordinates the New Mexico Climate Change Task Force. "It's really important that we start to talk about these repercussions, because New Mexico has some really special and unique landscapes that are already struggling."

In addition to the loss of habitat, fire damage poses an immediate threat

> The strength of this map is its ability to run different scenarios, because everybody has a different focus. Users—whether an agency, a community group, or a local government—can relate it to what's most important to them. They can see where the risks are and examine the issues.

Maria Lohmann
New Mexico Climate Change Task Force

Proof Point:
Investigate and Communicate

"The strength of this map is its ability to run different scenarios, because everybody has a different focus," Lohmann said. "Users—whether an agency, a community group, or a local government—can relate it to what's most important to them. They can see where the risks are and examine the issues."

The state recently conducted its yearly climate strategy report, which includes details about the transition to renewable energy as well as goals to reduce energy costs.

"With extreme heat coming, energy has to be reliable and affordable so people can cool themselves," said Robert Gomez, resilience coordinator for the Energy, Minerals and Natural Resources Department's Sustainability and Resilience program. "Those kinds of connected factors have to be built into our ongoing resilience and adaptation plans."

The climate risk map places an emphasis on supporting equity and addressing the needs of overburdened communities, including demographic factors like race and poverty levels. Work is ongoing to get the *New Mexico Climate Risk Map* into the hands of community planners, leaders of tribal nations and pueblos, and anyone interested in understanding their risk.

The map's scope could be expanded by working with other agencies, including the New Mexico Department of Health. The department's workers are responding to climate-related health effects such as respiratory and heat-related illnesses and conditions due to wildfire smoke.

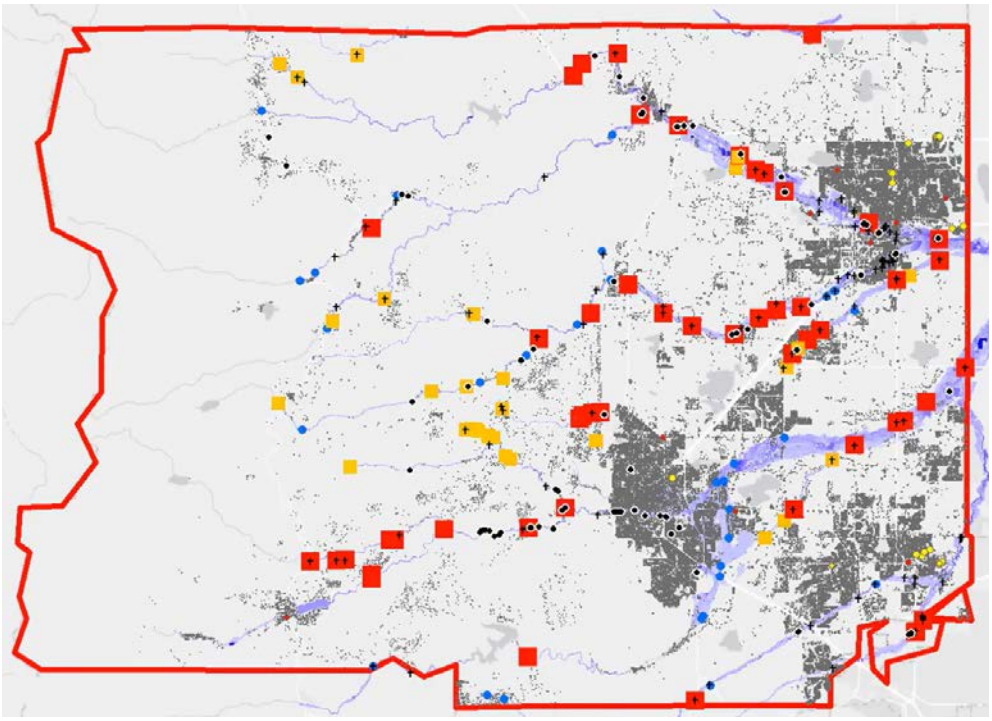
"Health outcomes of climate change raise important questions we need to ask ourselves," Gomez said. "And specifically examining who in which areas are particularly vulnerable."

Read the full story in *Esri Blog*.

Simulating Climate Impacts

Looking at vulnerability and sharing the resultant analysis widely sets up a company, state, or county for effective action. This was the case in Boulder County, Colorado. In the aftermath of a 2013 storm that killed nine people and destroyed 2,000 homes, officials there launched a resiliency study that modeled future flooding, using a GIS-based simulation.

A map of Boulder, Colorado, shows a simulation of potential flooding impacts from future storms, using spatial analytics to help the local government understand the likely effects of a changing climate in the region.



when rainstorms carry away soil no longer held back by vegetation. This debris can clog channels and culverts, fill up reservoirs and retention ponds, and destroy fields and crops.

> Our idea was to try to push aside all the disciplines and just try to generate a digital twin with everything in it. Then we can measure anything we want—from wait times for buses to the depth of flooding—because we're modeling everything in the GIS environment.

Stephen Bourne
City Simulator Developer and Project Director
Atkins

"We were looking at things that we could do from the perspectives of floodplain management and public infrastructure," said Stacey Proctor, a project manager for Boulder County. "And we wanted to take into account that, due to climate change, the past is not necessarily predictive of the future."

Planners looked at time-lapsed scenarios on digital maps using a tool called City Simulator, an analytics software platform. The tool was developed by Atkins—a multinational engineering and design consultancy and SNC-Lavalin Group member—using Esri technology.

City Simulator was designed primarily to help local governments understand the likely effects of climate change on their regions. It considers factors both natural—such as a city's elevation or weather patterns—and social, such as zoning requirements and population trends. An analysis might focus on specific climate change outcomes, including heat waves, droughts, and storms.

This level of spatial modeling and simulation provides a digital twin—a way of digitally mirroring dynamic real-world systems.

"In City Simulator, when the storm hits, you actually see all the buildings that get flooded and all the culverts and bridges that get overwhelmed by flooding," said the platform's developer, Stephen Bourne, project director at Atkins. "We did that very deliberately because we think that if a community can see those things, they become a lot more visceral, which moves the needle in terms of taking action."

Proof Point: Prioritize and Plan

Since Boulder County's resiliency study concerned flooding and infrastructure, Bourne's team made rainfall the focus of the simulation, which imagined how the county might look in 2050. The team drove the simulation with a range of future rainfall projections derived from global climate model results.

Amid the findings for Boulder County, the data suggested that more 2013-level floods were possible in the coming decades and that even infrastructure originally constructed to withstand once-in-a-century weather events may need upgrades.

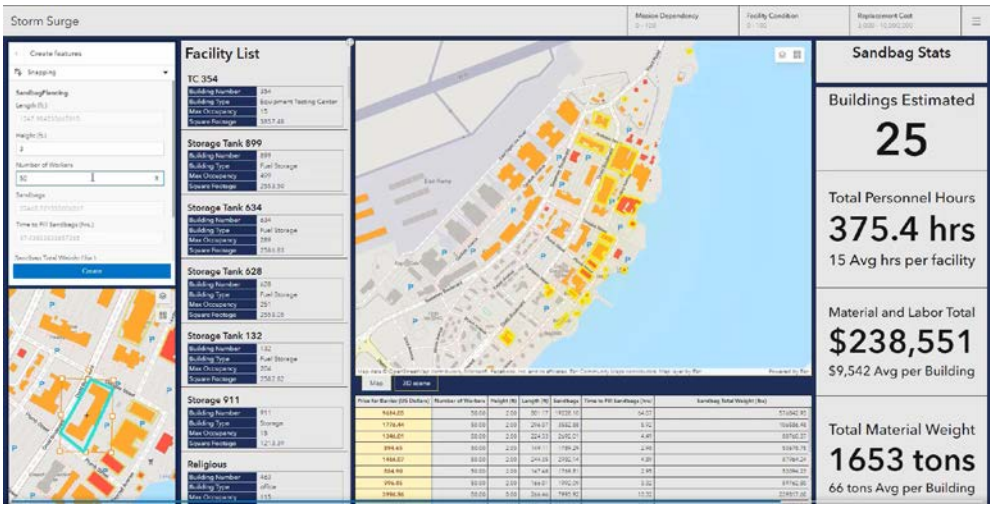
As Bourne sees it, modeling and visualization make these questions easier to confront, if not answer. "If we provide the kind of information that moves the needle," he said, "we have the power to take action."

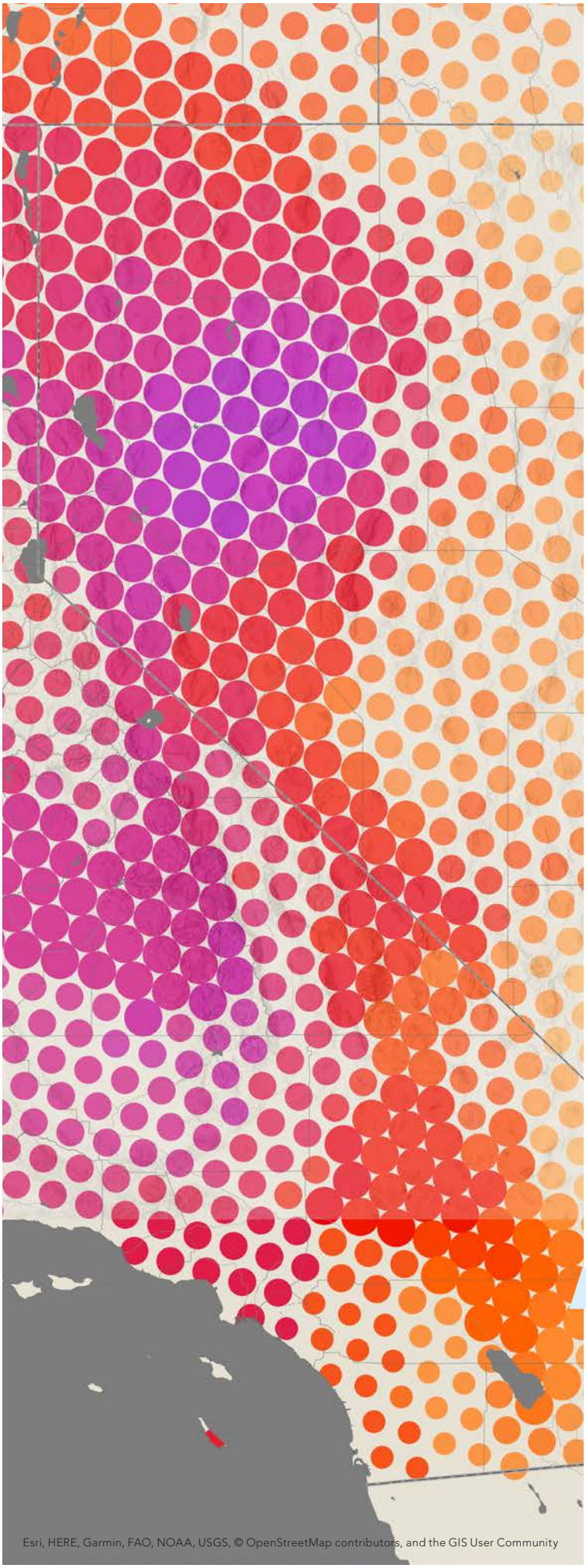
Read the full story in *Esri Blog*.

Turning Science into Action

Climate action to improve climate resilience can range from planting green spaces in a heat-prone neighborhood to moving network assets outside flood zones. It can look like clearing wildfire fuel across a state or developing climate-resilient infrastructure. At the International Monetary Fund (IMF), climate action comes in the form of tracking global

A GIS-powered dashboard displays information about the deployment of sandbags to mitigate flooding. The technology calculates the average time needed to sandbag each building, as well as the costs of material and labor to protect the facilities, so leaders can take action.





Proof Point: Take Action

trade disruptions and protecting the world's ports.

IMF economist Serkan Arslanalp teamed up with colleagues from Oxford University to develop PortWatch, a GIS-powered tool that tracks climate-related shocks to the supply chain. Policymakers can access PortWatch to see alerts, analyses, and forecasts about port activity around the world.

Arslanalp and other collaborators developed PortWatch using near real-time data from commercial satellites along with input such as economic and social indicators. The tool is designed to inform governments around the world, especially those in small island countries.

"Monitoring the ports in real time allows you to essentially have your finger on the pulse of the economy," Arslanalp said. "GIS boosts the power of data, resulting in a more granular understanding of social, economic, and environmental issues."

Arslanalp advises anyone who's curious about GIS to start with a simple problem. "Collect data, start overlaying it on a map, and try to understand what you're looking at. The rest will follow from there."

Read the full story in *The Washington Post*.

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>
> **Serkan Arslanalp**
> International Monetary Fund

Conclusion

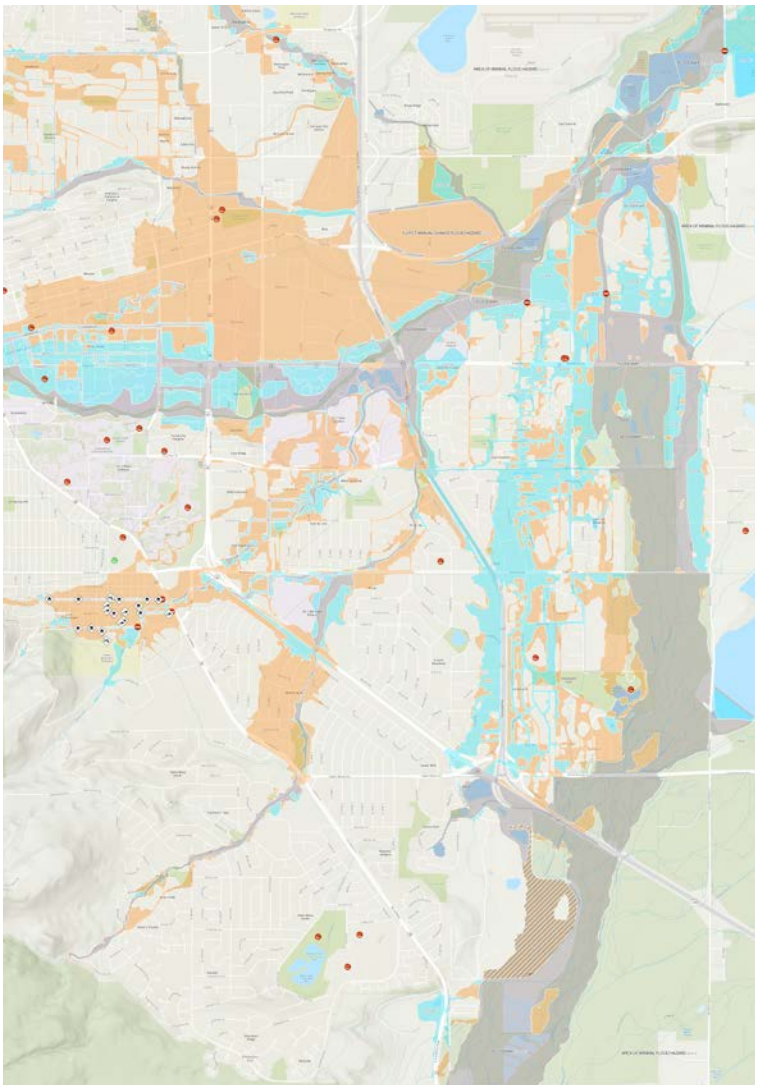
The real and long-term climate impacts our planet is facing cannot be wished away. Climate risks must be assessed and mitigation and adaptation strategies put into action. We have the science, data, and technology to make this happen. We have the incentives—saving lives, protecting livelihoods, and attending to regulatory regimes and social urgency—that will only grow in intensity.

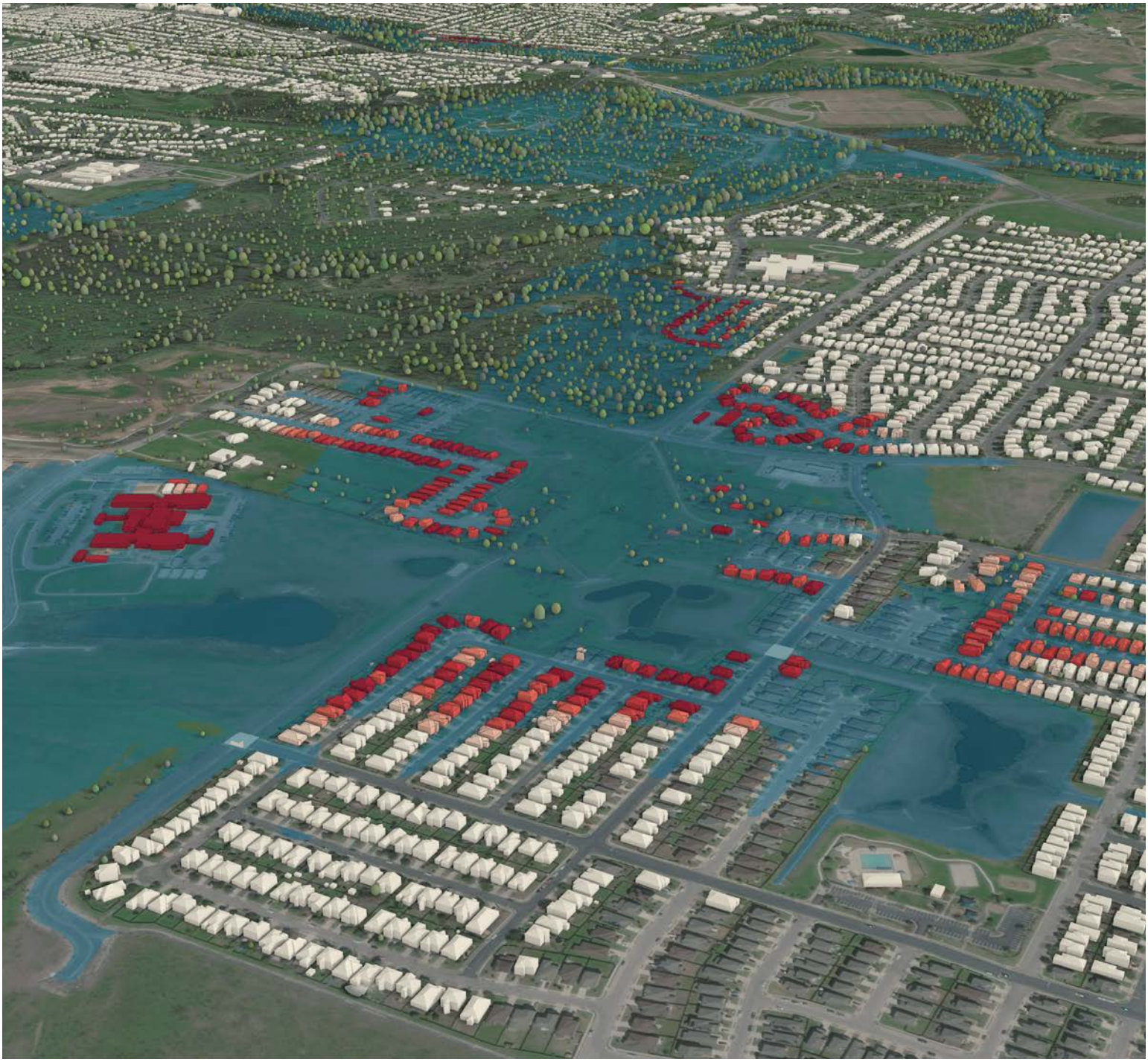
Intuitively, geography is the key to understanding and answering climate-related questions, but it's this new kind of precision geography that relies on modern GIS. This technology lets us see the whole picture with clarity, without the distortion of wishful thinking. It lets us use data, high-powered computing, and cutting-edge software to do three things: See the problem in detail, prioritize cost-effective solutions location by location, and then assess their effectiveness.

Leaders can get where they need to be by embracing GIS-enriched risk analytics, real-time dashboards, and predictive simulations. They can count on GIS technology to process volumes of data streaming in from satellites, as well as sensor data, weather patterns, demographics, and economic trends. They can take advantage of modern GIS mapping and analysis tools for visualization, communication, and decision support.

With a clear understanding of climate hazards and vulnerabilities, governments and businesses can make risk assessments and strategic plans for mitigation and adaptation. This leads to collaboration, taking action, and monitoring for effectiveness. Empowered by data and technology, leaders can reduce risk and minimize disruption, contributing to a sustainable future.

Geography plus technology does more than make climate action possible—it compels it.





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