



Climate Change and Natural Hazards: Global Change, Local Implications

In 2014, there were 980 natural disasters around the globe; including acute events such as intense and frequent storms, floods and tornados, as well as chronic events such as droughts and high temperature periods. As global and regional climate changes, the timing, frequency, location, and severity of these events will also change. The effects of climate change, including longer term risks from global sea level rise, extreme temperatures, precipitation events and storms, present unique business continuity risks within each region across the globe (see Figure 1).

Governments are taking action to better understand the potential impacts associated with climate change and are taking proactive measures to reduce future risk and vulnerability. The White House has issued several Executive Orders in recent years, including 2015's EO 13690 and EO 13693, which emphasize the U.S. Government's focus on incorporating climate preparedness and resilience into Agency missions, assets, and operations. The United Nations has also led the development of the Sendai Framework for Disaster Risk Reduction, and garnered approval by 187 member states. The

sustainability goals for the framework were issued and COP 21 was recently approved. Each major framework has disaster risk reduction elements, and strong participation from the private sector.

In today's world, it is incumbent on industry to strive for sustainability and long-term planning to achieve the triple bottom line: economic, environmental, and social benefits. For global organizations with local offices, facilities, and suppliers, it is in your best interest to understand the risks regional climate variability could pose to operations and assets.





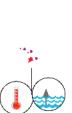


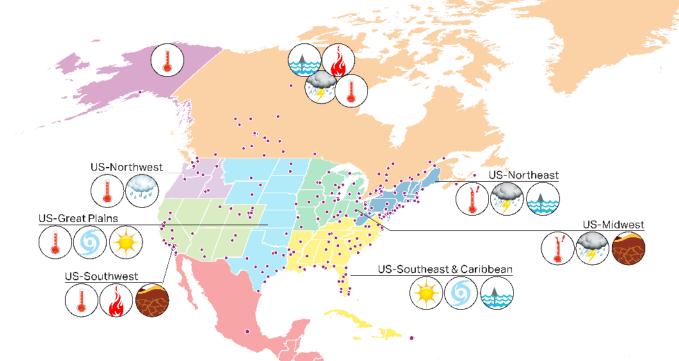
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High Level Overview of Climate Change Trends

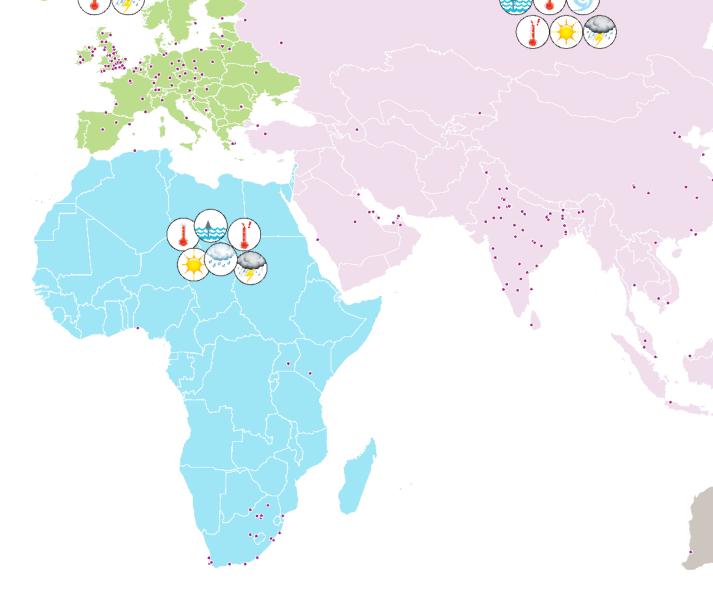
From sea level rise to increased temperatures and extreme weather events, climate change is having an impact across the globe. This map provides an overview of significant climate trends driving key risks and impacts in different regions. This map does not attempt to catalogue all climate risks, rather it presents the most significant trends as reported by the Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC AR5) and the Third National Climate Assessment (NCA)*. Due to variation within regions, lack of a symbol in a region does not preclude that region from experiencing other climate impacts not indicated.





	SLR	WT	ET	DT	P	EP	D	F	ES
REGION							SK.		9
	Sea Level Rise	Warming Trend	Extreme Temperature	Drying Trend	Precipitation	Extreme Precipitation	Drought	Fire	Extreme Storm
US - Alaska		•							
US - Northwest		•			•				
US - Southwest		-					•	-	
US - Great Plains		•		•					
US - Hawaii	•	•							
US - Midwest			-			-	•		
US - Northeast			•			•			
US - Southeast & Caribbean	•			•					•
Canada	•	-				-		-	
Central and South America		•	•	•		•			
Europe	•	•	-	•		-			
Australasia	•	•	•			•	•		•
Asia	•	•	•	•		•			•
Africa	•	•	•	•	•	-			





RESOURCES:

- IPCC, 2014: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 688.
 NCA, 2014: Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds., 2014: Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, 841 pp. doi:10.7930/J0Z31WJ2.

Supporting Our Clients with Emerging Issues

AECOM has extensive experience delivering climate adaptation and resilience improvement services to our clients, undertaking more than 100 projects globally for both public and private sector. We have established best practices for various sectors and geographies, including: developing a strategic, risk-based approach to climate change adaptation for Rio Tinto, conducting detailed vulnerability analysis for gas utilities, piloting the Federal Highway Administration (FHWA) climate adaptation framework, and in Australia, undertaking a portfoliowide assessment for the Department of Defence and developing national guidance for considering climate risks in managing and funding coastal assets.

Our adaptation expertise is supported by 30 years of experience supporting the Federal Emergency Management Agency's natural hazard risk assessment, mitigation, disaster response and long-term recovery planning efforts across the U.S. and internationally. These programs include the Public Assistance Technical Assistance Contract (PATAC), Hazard Mitigation Technical Assistance Program (HMTAP) and RiskMAP. The programs have increased awareness, preparedness, and resilience to natural hazards, including floods, hurricanes and heavy wind events, earthquakes, and wildfire.

Increasingly, the private sector is recognizing the risks that climate change poses to assets, operations, supply chains, and long-term sustainability: climate change is becoming a consideration and component within business continuity planning. AECOM has combined our in-depth industry-specific knowledge with climate change expertise to support our clients with understanding what climate change means to them. We have supported global manufacturing companies such as Xerox and confidential High-Tech manufacturers with understanding site-level vulnerability, and provided detailed hazard modeling considering future conditions for utilities, ports, and other clients. In addition, we continue to facilitate the dialogue between public and private sector to further the discussion on disaster resilience in order to reduce vulnerability and create more prepared and resilient communities.

AECOM has developed a Framework (Figure 2) to support our clients in developing and increasing resilience to climate-related hazards and to review performance against business objectives and sustainability. Key to this process are the steps of understanding climate change trends and projections in relation to assets, operations, and other business critical elements; determining

vulnerability; and assessing risk. These elements are critical to a Climate Risk Management Plan, a process and tool governments and companies alike are increasingly undertaking to increase preparedness, reduce risk, and help them become a stronger organization. Figures 3 and 4 further elaborate the process involved in conducting a vulnerability assessment and assigning risk. Upon understanding risk, the final stage is creating strategies and implementable actions, and prioritizing next steps that will address and reduce identified risk.

Why is managing the risk of natural hazards important?

As can be seen in Figure 1, depending on where your assets and operations are located, you will face different climate change effects with varying degrees of severity.

It is important to understand how this may affect your company holistically, but also at the individual facility level. Downtime for a single facility can have a far-reaching effect on a company's broader objectives, as well as operations at other sites, significantly impacting costs.













Figure 2. Climate Resilience Framework

A six-step process to help businesses develop and increase resilience to climate-related hazards and review performance against business objectives and sustainability.



Scoping

- Discuss project drivers with stakeholders to create shared vision.
- Review approach options and requirements and select methodology.
- Define scope for climate variables, hazards, and timeframe (e.g., present, 2030, 2070).
- Determine scope including relevant business and site elements and systems.



Screening Risk

- Consider climate trends for relevant hazards (temperature, precipitation, flooding, drought, sea-level change, wind)
- Screen business, systems and site elements against climate hazards to determine high-level risks and priorities for risk assessment
- Review relevant climate policy, regulatory and planning approvals requirements



Apply Science

- Determine whether climate data can be gathered and analyzed internally or externally.
- If internal, collect climate projections based on a moderate to high emissions scenarios for years and scale. Gather long-term (100 yrs) and recent (30 yrs) historical climatic data.
- Consider collecting other data studies to support project (e.g., flooding reports, inundation mapping, urban heat island, erosion, etc.
- Consider GIS to spatially display information.



Detailed Risk Assessment

- Select business, systems and site elements with greatest risks to climate impacts. Use results from screening phase to focus analysis.
- Identify stakeholders for determining priority risks or valuing risk implications.
- Conduct assessment of climate risk, site or project. Use spatial and impact modeling data to inform site or project specific risk including future climatic conditions (food, groundwater re-charge, etc.).
- Prepare documentation to meet regulatory, planning, approval and investor requirements
- Ensure climate risks are integrated into wider risk management processes. Assign organizational groups as part of ongoing business process. (e.g., procurement, insurance, capital planning, logistics).



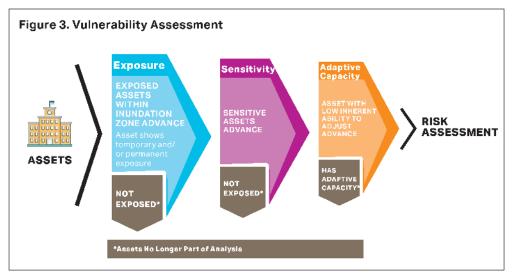
Resilience Options

- Identify stakeholders to determine and implement resilience options, and who may beneft from implementation.
- Review risk assessment for priority options and resilience solutions.
- Research and rank resilience options for: effectiveness in responding to climate risk, value for money, practical implementation. All business benefits should be considered when assessing options.
- Integrate preferred climate resilience measures into business planning, operational procedures and capital design.
- Document how resilience options address climate risks. Where risks are unaddressed, provide rationale.



Implementation

- Justify large climate resilience investments with cost benefit analysis. Allocate resources to implement lower cost/high benefit options.
- Assign responsibility for embedding climate risks into operational plans.
- Document implementation of resilience options and reduced risks achieved for investors, insurers and customers.
- Ensure notes are clear in presenting climate risks in operations.
- Ensure appropriate monitoring and review. Build in review on a five-year basis.





- Focus on Most Vulnerable assets and select Critical assets
- Bridge gap between knowing vulnerabilities and planning action

More frequent damage or disruptions may also affect employees, as well as place additional financial costs on the organization. However, planned renewal of aging infrastructure provides organizations with an opportunity to increase the resilience of facilities. The interruption of critical components through a supply chain could halt production. This has already occurred for major manufacturers around the world, including Toyota, which experienced facility damage and down-time as a result of 2011 floods in Thailand, which resulted in 150,000 vehicles not sold or delivered in the North America market.

Climate Change and the Industrial Sectors

The industrial sectors play a critical role in supporting the economy and wellbeing of communities through employment, access to resources and manufacturing and distribution of goods. Extreme weather events affect our built and natural environments. Rising sea levels in vulnerable areas can cause increased erosion and flooding of infrastructure, as seen during storm events like Hurricane Sandy in New York/New Jersey. In Thailand in 2011, excessive flooding

closed over 1,000 factories. Many areas have also seen increased temperatures, more extreme hot days, intense storms and shifts in the water cycle, affecting communities and natural resources. In some locations, these high temperature events have led to brownouts and power failures. Building resilience into design, planning and development has become imperative and a fundamental part of any organization's risk management strategy.

The first step to building resilience involves understanding the risk exposure. This may include risks to physical assets, supply chain vulnerability, health and safety of staff or customers, or reputational risks associated with impacts to operational performance, like the ability to deliver minimum service or maintain environmental management standards.

Quantifying these business risks can be achieved by undertaking an initial screening of the likely impacts and identification of the priority areas that warrant further detailed investigation. This detailed investigation is supported by the development and prioritization of adaptation solutions, which may include a combination of policy or procedural changes or physical engineering options.

Climate Impacts to Industrial Sectors

- Supply chain interruptions of critical components
- Physical damage to property and production assets
- Loss of raw materials, components, electricity, gas and water
- Inability of staff to evacuate to safe location
- Spills of hazardous materials including wastes
- Interruption of shipping logistics to get critical components to the factory or finished product shipped from facility
- Lack of infrastructure for staff to return to work
- Destruction of critical inventory
- Exposure to wildfire events in response to drought conditions

Select Experience in Climate Change Vulnerability, Risk, and Adaptation

Regional/Portfolio-Wide Assessments

Companies as well as government organizations need an efficient and consistent method to identify their vulnerabilities, prioritize the investigation of risks and develop adaptation plans or mitigating measures. An example of select AECOM projects are illustrated below:

- Global Site Vulnerability Assessments for Confidential Food/Beverage Company
- Facility siting, considering current and future water availability for confidential large global electronics manufacturers
- High-level assessment of global climate change trends for Xerox' largest facilities
- Climate Change Adaptation Assessment for power stations, China Light Power (India, China & Australia sites)
- Adaptation and planning strategies to manage the impact of climate change-induced sea level

- rise, flooding and erosion at select Australian Department of Defence sites: Risk screening of 38 sites across the country to prioritize those for further investigation
- Support for cities such as Miami Beach, San Francisco, and New York City with understanding threat of sea level rise and coastal flooding, incorporating future conditions into building codes and planning, and developing adaptation strategies
- Silicon Valley Climate Adaptation Strategy 2.0: Regional study to minimize the anticipated impacts of climate change and reduce the generation of local greenhouse gas emissions. Led to the development of an online tool that allows users to conduct vulnerability and risk assessments.
- U.S. Department of Veteran's Affairs national sea level rise vulnerability assessment of medical facilities

- Climate change and adaptation analysis for the NEC FUTURE Tier 1 EIS: Reviewed the current, and projected future, coastal and riverine flooding risks for rail corridor in a region from Washington, D.C. to Boston, MA
- Adapting to Rising Tides: San Francisco Baywide Transportation Vulnerability and Risk
 Assessment that applied the Federal Highway
 Administration's conceptual risk assessment
 mode
- Development of an international climate change adaptation framework for road infrastructure for the World Road Association
- Climate change review and assessment of Port Pirie Rare Earth Treatment Plant and Radium Hill Uranium Mine







Hazard Modeling and Analysis

Assessments of vulnerability and risk and the design of adaptation solutions are most effective when supported by a thorough understanding of current and projected future, hazards. This involves combining sophisticated modelling tools, knowledge of historical environmental conditions and projected climate information.

- Current state of climate change review and hazard modeling, mapping and analysis of potential riverine and coastal flood impacts on several gas utility companies in the Northeast, United States
- Site-specific modelling of coastal flooding, riverine flooding and coastal erosion for the Australian Department of Defence Adaptation and Planning Strategies Study
- Process development for the New York
 Department of Environmental Conservation that identifies areas vulnerable to erosion along Lake
 Erie and Lake Ontario shorelines
- Seward Bear Creek, Alaska Flood Service Area Hazard Mitigation Plan: Modeling natural hazards with climate change considerations including erosion, flood (riverine and coastal), ground failure, severe weather, tsunamis, and fire

- Sea level rise inundation mapping for NASA Ames Research Center
- Integrating climate change risk and adaptation into project development and delivery for a multinational resource development company
- Water scarcity in supply chain study for global electronics manufacturer Xerox plc, Carbon Disclosure Project (CDP) Assistance

Site-Level Adaptation Planning

Sometimes, organizations have an urgent need to build up resilience of specific sites or assets due to their known criticality or vulnerability, for example as a result of damage from a recent weather event. Site-level adaptation planning utilizes hazard information to undertake detailed risk assessments and develop prioritized adaptation solutions. AECOM typically integrates benefit-cost analysis into the adaptation planning process. Some sites may also require stakeholder engagement in the planning and design of solutions. Recent AECOM projects include:

 Adaptation assessments of power stations in China, India, and Australia: Assessed sitespecific operational and supply chain risks, used sophisticated cost-benefit analyses and financial assessments to prioritize adaptation options

- Toronto Hydro engineering vulnerability assessments and climate change advisory services: Identified infrastructure types and locations most vulnerable to the impacts of extreme heat, wind and flooding.
- Port of Long Beach Climate resiliency strategy: Enhance the resiliency of the Port's assets and operations based on an evaluation of climate impacts and an assessment of risks to business continuity
- FHWA Hurricane Sandy follow-up vulnerability assessment and adaptation analysis of select transportation assets in New York, New Jersey and Connecticut
- Post-flood emergency recovery of the Warwick Advanced Wastewater Treatment Facility, RI.
 Planning, design and construction of adaptation measures to better protect the facility during extreme events







Resiliency Planning and Capacity Building

In order to effectively reduce the long term vulnerability of an organization to the risks of natural hazards and long term changes in climate, organizations should focus on capacity building of all levels of staff and stakeholders. We have supported government and private sector clients in building their capacity through the development and implementation of guidance material, workshops, and tools related to climate vulnerability, risk assessment and adaptation planning. Recent projects include:

- Climate change adaptation advisory services for Rio Tinto
- Developed a methodology and guidance materials for USAID, focusing on incorporating climate change adaptation in the engineering design of infrastructure as well as primers for specific sectors, including roads and bridges
- Developed a site assessment methodology and framework for the Australian Department of Defence and then applied the methodology to 38 critical sites across Australia

- Contributed to the development of "AS 5334-2013 climate change adaptation for settlements and infrastructure – A risk based approach", and are currently contributing to a similar adaptation guidance document being prepared by the ASTM.
- Co-developed the City Disaster Resilience
 Scorecard (with IBM), a tool and set of metrics
 based on the United Nations' Ten Essentials
 for Disaster Risk Reduction. The scorecard is
 directly applicable to facilities and surrounding
 communities, and useful for engaging the public
 and private sector on the topic of resilience
 (Scorecard received the ND-GAIN Corporate
 Adaption Prize in 2015).
- Performed a disaster resilience survey for small and mid-size enterprises based on Disaster Resilience Scorecard in New Orleans
- Provided training to 16 global cities on how to assess exposures and build resilience plans that are achievable from an engineering point of view, are financially feasible and politically acceptable, for the Rockefeller Foundation, as part of the 100 Resilient Cities Program

- Contributed to the development of the National Institute of Standards and Technology (NIST)
 Community Resilience Planning Guide
- Provided support to FHWA in development of guidance materials, following the Adaptation to Rising Tides study in San Francisco. We are currently delivering further assessments in NY, NJ and CT
- Helped the World Bank Group incorporate climate change into their lending decisions through training and tools
- Engaged the Private Sector in Climate Change Adaptation on behalf of the Organisation for Economic Co-operation and Development (OECD)
- Developed climate change adaptation standard for settlements and infrastructure, Standards Australia
- Provided adaptation to climate change within Environmental Impact Assessments, OECD







AECOM Climate Adaptation Leadership Team

AECOM's climate adaptation and natural hazards leadership team has experience working in all regions of the U.S. and internationally, with staff based across the United States, as well as in Canada, Australia, the United Kingdom, and Columbia. Our team has over ten years of experience in climate risk assessment and adaptation planning, and over 30 years of experience in natural hazard risk assessment, mitigation, disaster response and long-term recovery planning. In addition, they are supported by AECOM technical specialists with detailed knowledge and experience with physical infrastructure across power, water, communications and transportation sectors.



Dale Sands Chicago, IL, US

Senior Vice President & Global Director, Metro Regions & Climate Adaptation Services Environment Business Line. Mr. Sands has 30 years' environmental management experience. He leads AECOM's global air quality, EHS management, impact assessment, EMIS, remediation, natural resources, and climate adaptation practices. Vice Chair, UN Private Sector Advisory Group for Disaster Reduction, Sands leads a partnership with IBM on the UN's Disaster Resilience Scorecard—assisting cities in building sustainability, preparedness and resilience to natural disasters.



AMERICAS

Josh Sawislak Washington, DC, US

Global Director of Resilience. Mr. Sawislak has 30 years' of public and private sector experience in infrastructure development, environmental planning, and policy development. He works across the entire AECOM enterprise offerings in planning, design, construction, finance, operations, and development to help develop and leverage resilient strategies projects and clients.



Dr. Thomas Tang Hong Kong, China

Director, Sustainability Asia, Managing Director, Kuala Lumpur Centre for Sustainable Innovation. Dr. Tang has 20 years' sustainability experience with extensive engagement on sustainability policy and projects across Asia including consulting to the Hong Kong Government, World Bank, APEC, the United Nations. With special expertise in urban development, he coauthored "Global Best Practices in Sustainable Urban Development," a review of 55 cities worldwide and best practices in sustainability.



Jon Philipsborn Atlanta, GA, US

Climate Adaptation Director, Americas.

Mr. Philipsborn has 10 years' experience in climate change, environmental management, sustainability and scientific research. He advises private sector and government, NGOs and academe clients on strategic integration of climate change into planning, project development and management decisions. His work ranges from incorporating climate change into hazard mitigation plans in Alaska and Florida, supporting gas utilities with vulnerability assessments and carbon reduction projects.



Adriana Figueiredo Brazil (Portuguese/ English)

Architecture/Sustainability Coordinator, Buildings and Places. Ms. Figueiredo has 20 years' of experience in architecture and urban planning, focusing on sustainable design and sustainability strategies. She worked on the sustainability framework for the Rio 2016 Olympic Park Masterplan and Venues design, and leads AECOM's advisory team supporting Olympic Park sustainability. She manages AECOM's team in Brazil that supports the UN Disaster Resilience Initiative.



Guillaume Prudent-Richard Canberra, Australia (French/English)

Associate Director, Environment/Climate Adaptation. Mr. Prudent-Richard has been working on climate adaptation and disaster risk management since 2003, and has led over 40 climate and disaster projects in Europe, Asia and the Pacific. He assists multilateral agencies (such as OECD, World Bank and the Asian Development Bank) and national governments. He has a strong scientific background in natural hazards and climate change, and had led four global studies on these issues.



Claire Bonham-Carter San Francisco, CA, US

Principal, Climate Change Planning and Sustainability. Ms. Bonham-Carter has 20 years' experience in climate change, planning, strategy, sustainable design, and construction for the public and private sector. She works with municipalities on sustainability frameworks and feasibility for mixed use to minimize environmental, social and economic impacts She has completed climate mitigation and resiliency plans for Seattle, Baltimore and New York. She manages AECOM's Resilient Cities partnership in over 13 cities globally.



T. Luke Young Colombia (Spanish/English)

Director, Building and Places, Latin America. T. Luke Young has 20 years' experience in architecture, urban planning, and social infrastructure design. He integrates participatory planning and innovative design to foster urban resilience, climate adaptation and sustainability.

resilience, climate adaptation and sustainability. He's organized dozens of global participatory planning workshops on climate adaptation, resilience and post-disaster reconstruction, bringing together stakeholders to exchange knowledge and develop innovative strategies to aid communities faced with climate risk.



Will Symons Melbourne, Australia

Practice Leader, Sustainability & Resilience. Will leads AECOM's Sustainability and Resilience Practice in Australia/New Zealand, and has been assisting private and public sector senior executives in responding to climate change risks and opportunities. Recently, he led the Australian Department of Defence's climate risk assessment and a study focused on training. He is also supporting cities of Melbourne, Christchurch, Wellington, Sydney and Bangkok to develop resilience strategies in the 100 Resilient Cities program.



Elise Foong Toronto, Canada (English)

Social Scientist, Climate Change.

Dr. Foong has a diverse background in social sciences, risk analysis, sustainability, climate change research and community education. She has conducted climate change impact assessments, working with global climate models and historical data to understand trends and impacts of climate change, including addressing the rapid pace of climate change in the Arctic.



Chee Chan Vancouver, Canada (French/English)

Urban Planner, Climate Resilience Specialist.
Mr. Chan has experience providing urban planning, climate resilience and decision support for urban settlement and infrastructure, focusing on the risk and vulperability to

support for urban settlement and infrastructure, focusing on the risk and vulnerability to transportation, water and electrical infrastructure, and stakeholder engagement. He develops adaptation solutions, using cost-benefit, multicriteria and financial analyses for prioritization and evaluation of risk scenarios.



Allan Klindworth Melbourne, Australia

Senior Manager, Climate Adaptation. Mr. Klindworth has 14 years' climate adaptation and sustainability management experience helping the public and private sector understand risks presented by climate change, and build resilience through adaptation planning. His signature climate adaptation work includes the Australian Department of Defence Climate Risk and Adaptation Planning project, and the Climate Change Assessment for the Federal Railway Administration's Northeast Corridor Environmental Impact Statement.



Kris May Oakland, CA, US

Climate Adaption Practice Leader. Dr. May has 20 years of experience providing leadership and technical expertise related to extreme hazard analyses, climate change resilience, and adaptation strategy development. She blends of science, engineering, policy, and visualization techniques in climate change vulnerability and risk and adaptation projects supporting built and natural environments. Dr. May served as technical advisor on the Mayor of San Francisco's Adaptation Initiative in developing landmark policy to increase sea level rise and storm resilience.



Ben Smith London, UK

Director, Sustainable Development, Design Planning + Economics. Mr. Smith has extensive experience working with public- and private-sector clients to integrate sustainable development and climate mitigation, adaptation and resilience into business processes, strategies, policy and plans in the built environment sector. Working with planners, architects and developers, his research and planning projects have focused on climate resilience at the regional and city scale.



EUROPE, MIDDLE EAST, INDIA, AFRICA

Sally Vivian Bristol, UK

Technical Director, Business Sustainability. Sally Vivian has 24 years' experience helping businesses and organizations develop and implement strategies and programs embedding sustainability into activities, products and services, and business decision-making. She has led multiple projects, including low-carbon strategy and policy development, climate change adaptation, quantifying and reporting performance, and managing water risks, working with regulators, development agencies and multi-national businesses.

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About AECOM

AECOM is built to deliver a better world. We design, build, finance and operate infrastructure assets for governments, businesses and organizations in more than 150 countries. As a fully integrated firm, we connect knowledge and experience across our global network of experts to help clients solve their most complex challenges. From high-performance buildings and infrastructure, to resilient communities and environments, to stable and secure nations, our work is transformative, differentiated and vital. A Fortune 500 firm, AECOM had revenue of approximately \$18 billion during fiscal year 2015.

See how we deliver what others can only imagine at aecom.com and @AECOM.

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