A transatlantic dialogue:
Part 1 - Adaptation to Climate Change in Mountain & Coastal Areas

CSC Climate Service Center Germany
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CONTEXT

As the impacts of climate change become more immediate, adaptation to these changes is becoming a greater area of interest and concern among resource managers, planners, and other stakeholders at all scales. However, in spite of advancements in the scientific understanding of climate change, much progress is needed in developing, translating, and disseminating usable knowledge to inform both individual and collective actions, especially at local levels of decision making. As part of this, increased emphasis has been placed on fostering sustained engagement between research communities and users of climate information. Additionally, the documentation of case studies as well as the development of networks that include researchers, practitioners, decision-makers and stakeholders have been identified as helpful mechanisms to support a growing number of communities developing climate change adaptation strategies.

PROJECT BACKGROUND

A diversity of climate change risks, physical, socioeconomic, and ecological contexts, available resources and response options, decision-making processes, and cultural norms shape the societal response to climate change across political and physical geographies. The resulting diversity of approaches makes it difficult to establish best practices and common ground for interaction between research and stakeholder communities.

Working under the hypothesis that comparing these significant differences can help to identify transferable lessons useful for improving strategies for climate change response (primarily adapting to climate change impacts, and secondarily reducing emissions), we compared experiences in mountain and coastal areas, in the United States and Europe.

In 2013, the Aspen Global Change Institute and the Climate Service Center in Hamburg, Germany, hosted two innovative workshops that brought together an international group of scientists and key stakeholders, resource managers, and elected officials from six specific case regions: Bay of Kiel, Germany; Grindelwald, Switzerland; Roaring Fork Valley, Colorado; Virgen, Austria; Chesapeake Bay, US; and Outer Banks, North Carolina, US (see case study at the end of the paper).

The objectives of the workshops were to: (1) better understand the information needs of practitioners; (2) integrate bottom-up and top-down approaches to climate adaptation; (3) facilitate knowledge exchange and learning across different situations; (4) identify “best practices“ or lessons about useful approaches in adaptation planning; (5) build and expand adaptation networks; and (6) identify barriers to adaptation and how actors overcome them. The results of the deliberations are summarized here and in two further briefs. For more information about the project see: www.climate-service-center.de

KEY FINDINGS

- Dialogue between mountain and coastal communities addressing the impacts of climate change offers rich opportunities for learning, despite geographical and other differences.
- Climate change may involve risks to lives, livelihoods and lifestyles in coastal and mountain regions, and the differences surface not just through variation in physical risks but also in socioeconomic vulnerabilities and adaptive capacities.
- Both the risks and attractiveness of coasts and mountains are important entry points for science and practice interaction.
- To adequately meet the climate change challenge, integrative solutions with multiple co-benefits (i.e., meeting adaptation and/or mitigation, as well as non-climate policy goals) across sectors locally and across space, are required.
- Strong leadership and a robust social process are needed to advance adaptation effectively.

A group of scientists and stakeholders from mountain and coastal areas join together in Aspen, CO (left) and Timmendorfer Strand, Germany

Coasts and mountains: surprising commonalities and differences

Adaptation involves various place-based strategies for reducing the physical, ecological and social vulnerabilities and managing the impacts of climate change. In spite of the diversity and differences between specific communities, we convened a series of dialogues among resource managers, planners, elected officials, researchers from various disciplines, and others working on climate change adaptation to identify lessons through the commonalties and differences between mountain and coastal areas. At first glance, mountains and coasts would seem to differ in just about every conceivable physiogeographic and socioeconomic way, making such a dialogue and learning experience difficult. Their historical roots and development patterns, as well as the climate-related resources that attract people there, and the climate change threats faced by each only add to the perceived differences. But are these characteristics really so different, and do they adequately capture the two environments? Moreover, can the diversity of experiences contained in communities across distinct geographies shed light on common strategies for improving—and possibly hastening—societal response to climate change?

Table 1. Comparison of mountain and coastal experiences in adapting to climate change

	MOUNTAINS	COASTS
Historical roots	Mountain communities evolved originally around mineral exploitation, pastoralism, and more recently forestry and tourism.	Coastal communities grew up around seafaring/trade and shipping, fishing, and military installations; more recently tourism, oil/gas and a diversification of the economy play a role, all of which have contributed and continue to foster intense urbanization and economic growth.
Human geography	Most high-mountain communities are small, isolated, contained, and less intensively developed, often surrounded by extensive natural areas. In the U.S. much land is held in public ownership, though used in diverse ways. A high degree of resource dependence and seasonality characterize these areas. Demographic changes (e.g., aging population, outmigration) and economic conditions (limited local job opportunities, high level of commuters) add to challenges. Important highland-lowland interactions link people and the economy.	Very diverse environments (depending on geology/geomorphology), ranging from small (barrier) island communities that are isolated and contained, to contiguous, well-connected, highly developed, urbanized, diversified, and industrialized mainland cities with coastal plains of varying extent. Range from vibrant cosmopolitan coastal centers to laid back, economically constrained or single-sector dependent rural communities. Important coast-hinterland interactions link people, infrastructure, and the economy.
Challenges	Tourism-dependent, wealthier communities exhibit a resort-town development "syndrome" with cyclical development, "Aspenization" (establishment of second homes by wealthy elites), boom-bust economy and demography, and problems with land use, housing, and transportation.	Second-home and seasonal vacation rental economies are common on the shorefront and on islands. In U.S. only limited publicly owned land, most land highly developed and privately owned. Urbanized economies mixed and non-seasonal. Much of urban development is intensive, older, and protected by hard measures. Sprawl, encroachment on natural areas and wetland loss are pervasive. Emergency evacuation problematic on some coasts, islands.
Climate-related resources	The cold/cool climate is a critical resource, as are orographic precipitation, very cold streams and lakes, the seasonality, and diverse landscapes creating multiple microclimates that support a diverse ecology, forests, and refugia.	The generally cool(er)/mild(er) climate than inland areas at the same latitude, along with ocean views, open landscape, beaches and wetlands are key resources.
Climate-related risks	Higher temperatures will enhance melting of mountain glaciers and lead to more precipitation falling as rain than as snow. Earlier run-off and longer dry periods increase wildfire risk and affect aquatic habitat. Melting permafrost will increase risk of rock fall, mudslides.	Intense extratropical or tropical storms with high winds and floods constitute the major hazards. Coastal erosion, wetland loss, permanent land inundation – as well as the extent of flooding and height of storm surges will all be increased by sea level rise.

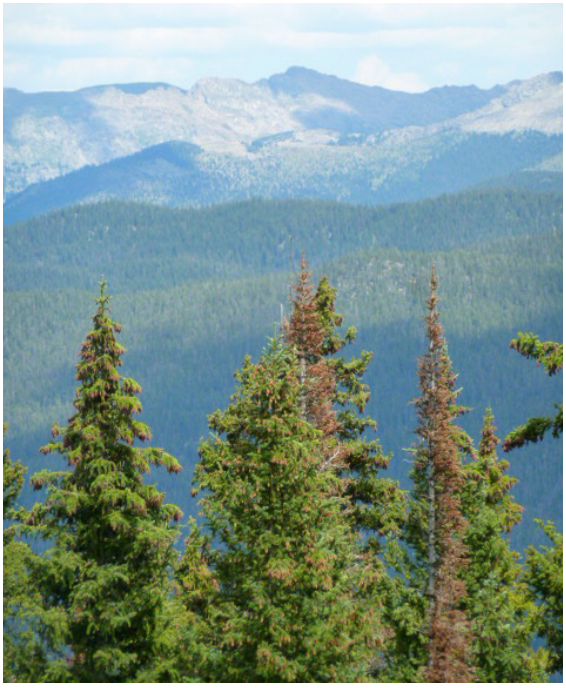
CLIMATE CHANGE THREATS TO COASTAL AND MOUNTAIN REGIONS

Together, the geography and historical patterns of development create different climate change-related threats and social-ecological vulnerabilities that combine in place-specific risks. These risk profiles show important similarities and differences across the coastal and mountain communities involved in the Hamburg and Aspen transatlantic dialogues.

Mountains

In the U.S. Rocky Mountains and European Alps, climate change is already being observed. Some of the experienced and expected changes offer opportunities, while others pose significant threats to ecosystems, human communities, infrastructure, and locally, regionally, and nationally significant economies:

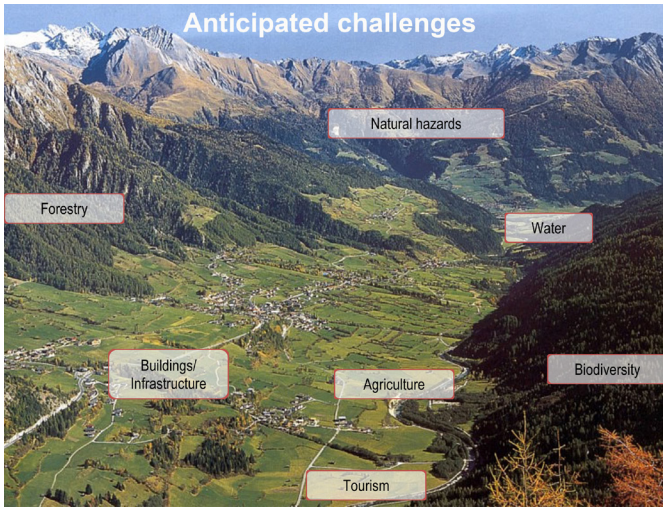
- Lengthening of the summer season and frost-free period;
- Declining snow cover due to higher temperatures and aggravated by land-use driven dust on snow; increased likelihood of mid-to-late winter thaws and rain-on-snow events;
- Decrease of precipitation as snow due to higher temperatures, resulting in more precipitation falling as rain and earlier run-off, as well as more intense rainfall events and longer dry periods, even if annual totals remain relatively unchanged;
- Shift in peak runoff resulting in greater challenges for water management (supplies, timing and equitable distribution);
- Worsening of familiar natural hazards such as melting of permafrost, mudslides and debris flows (mainly in the Alps), extreme rainfall events, wind storms, droughts and wildfire (mainly in the U.S.) posing growing threats to increasing populations in high-risk areas (e.g., wildland-urban interface, valleys);
- Intensifying impacts on terrestrial and aquatic ecosystems and biodiversity as a result of higher temperatures, changes in precipitation, runoff, stream/lake temperatures, and extreme events: suitable habitats move upland, thereby declining in size, ecosystems become disjointed, number and composition of species is changing with particular threats to habitat “specialists“;
- Growing economic and socio-cultural impacts, some of which are negative, positive, or neutral depending on the opportunities and limits to adaptation:
    - A longer growing season can benefit agriculture/ranching, such as extending the suitable area for production (as long as water supply is sustained);
    - Forest growth may benefit to some extent from higher CO_2 levels and more efficient water use, but become threatened by increasing drought risk, spread of pests and increasing wildfire danger;



In many places in the U.S. and Canadian Rocky Mountains, warming temperatures and drying conditions have led to enhanced tree mortality caused by insect and disease. Credit: Susanne Moser.

Extreme precipitation intensifies natural hazards like debris flows in mountanious regions e.g. the Alps. Credit: DeWe/fotolia.

- Impacts on outdoor recreation (e.g., trout fishing, hiking) can be negative or mixed;
- Tourism (e.g., hiking, cultural offerings);
- Winter (snow-dependent) tourism may see increasing challenges from higher temperatures and competition for water resources for snowmaking, while summer tourism will be impacted by changes in extreme events, wildfire risks and direct impacts on hydrological and ecological resources, but also benefit from lowland visitors seeking temperature relief; opportunities lie in extending summer and shoulder season;
- Growing damages to transportation infrastructure from extreme events, causing challenges for access and emergency evacuation, and entailing growing maintenance costs.



How vulnerable mountain communities are to these changes depends in large measure on the size, and distribution of the exposed population and on the wealth, stability and diversity of the economic basis of the community. Generally, mountain populations are smaller, spread over large and difficult-to-access regions. Resource-dependent communities have different vulnerabilities than resort communities. In some of the case study regions, the threats from climate change are perceived as less serious than the threats from the resort industry or distant economic drivers to “mountain culture“ and traditional, “outdoor“ lifestyles.

A presentation from the Mayor of Virgen, Austria outlines the many issues of concern for mountain communities facing the impacts from climate change. Credit: Dietmar Ruggenthaler.

Coasts

Along the U.S. Mid-Atlantic coast (Virginia, and North Carolina) and Chesapeake Bay, as well as the coast of the Baltic Sea and Bay of Kiel, climate change and sea-level rise are also experienced realities, albeit to varying degrees. Contrary to the mountain areas, fewer of the expected changes are viewed as potential opportunities. Indeed, while not too serious in the case locations yet, many expected coastal impacts pose significant and even transformative threats to ecosystems, human communities, infrastructure, and local (and nationally significant) economies:

Flooding in Crisfield, Maryland following Hurricane Sandy in 2012. Credit: Maryland National Guard.

- Higher air (and coastal water) temperatures and a longer summer season;
- Variable rates of sea-level rise (global and large-scale regionally varying rates are superimposed on local land movement), resulting in
  - Different rates of permanent inundation and land loss;
  - Increases in the inland extent and height of periodic flooding, including higher storm surges (smaller increase along the Baltic Sea, greater for the Chesapeake Bay);
  - An increase in erosion of beaches (e.g., North Carolina), cliffs (Schleswig-Holstein);
  - Wetland loss, where wetlands can‘t migrate inland and grow upwards (e.g., Chesapeake Bay)

These risks are generally larger for exposed, open ocean areas of the Atlantic than for the more sheltered Baltic Sea or estuarine shorelines of the Atlantic seaboard.

- Variable regional changes in precipitation but everywhere more intense rainfall events, resulting in growing flood risks in areas where runoff from coastal and inland areas combine;
- Threats to coastal ecosystems magnified by the high degree of human development and related stressors (constraints on habitats and migration corridors, pollution, overuse);
- Impacts on buildings, property, infrastructure such as water supply and sewer systems, energy installations, and roads, as well as on economies are increasingly experienced, especially in those coastal regions already experiencing higher rates of sea-level rise (e.g., Chesapeake Bay, Virginia); these infrastructure impacts can have far-reaching implications, even for inland areas:
    - Greater erosion of beaches will negatively impact recreation and tourism as well as private properties unless beaches can be replenished;
    - Flooding is more frequent and reaching further inland, disrupting lifelines, urban communities, local/regional economic activity, and requiring greater flood protection;
    - Higher air and water temperatures may be a potential benefit as tourists come from hotter inland areas to cool-off at the coasts; extended summer and shoulder seasons offer new and additional opportunities for tourism.

Flooding in the city of Hamburg after a storm surge. Credit: Matthias Krüttgen/fotolia

Accelerated erosion near Baltic coastline results in damage to infrastructure. Credit: Horst Sterr

Coastal communities are generally highly vulnerable to climate change threats due to higher concentrations of people in high-risk areas, direct threats to buildings, and the disruption of essential infrastructure functioning and economic activity. Wealthy, economically diverse and stable communities may have the resources to implement a range of adaptation strategies, but those can cause negative impacts themselves (e.g., impacts on coastal ecosystems, neighboring properties, moral hazards, high costs, constraints on coastal access).

There are physical limits to adaptation in both geographies (e.g., sea level encroaching on land, orographic limits to upward movement of species) as well as risks to lives, livelihoods and lifestyles unfolding as a result of climate change. In particular, the vulnerability to extreme events is very high along coasts and in mountain areas, but mountains are relatively neglected as regions deserving special attention (the Second IPCC assessment in 1995 included a mountain chapter, but no other assessment since has focused specifically on mountains while there have always been chapters focused on coastal areas). Both regions have long histories of changing economies, people migrating in and out. Change thus is not unfamiliar and in many ways inevitable regardless of climate change. However, because of the high concentration of people, infrastructure, development and economic activity in coastal areas, change – and adaptation to that change – seems more daunting there.

ADAPTATION: PLANNING, ACTIONS, AND CHALLENGES

The physical- and human-geographic contexts, the climate change risks experienced or expected, and the adaptation efforts underway in the case examples explored during the transatlantic dialogues reveal interesting similarities and differences between coastal and mountain communities.

Similarities between Coasts and Mountains

Adaptation opportunities and constraints arising from the geographic setting:

- Coasts and mountains are among the ***most dynamic physical environments*** on Earth. In both, the extremes in physical and climatic conditions are attraction and peril at once; the impacts of climate change are already visible, either through gradual and in many ways familiar changes, or through more extreme events. Where extreme events have happened in the recent past, they help focus public and policy-maker attention on the risks of climate variability and change and the need for greater disaster preparedness and adaptation.
- The ***coast-hinterland and upland-lowland connectivity*** creates teleconnections that link local impacts and distant events in complex and underappreciated ways. Often it is difficult to involve those further away in conversations about local adaptation; cross-scale governance is needed to enable dialogue, planning, and support for implementation.
- Both regions have seen (or continue to experience) the ***greatest increase of population in the highest-risk areas***, such as coastal floodplains, mountain valley bottoms, and at the wildland-urban interface, with planning inadequately considering current and growing risks.
- The ***influence of wealth*** on local economies and political culture is significant. “Aspenization“ has a coastal counterpart in Europe “Syltization“ (referring to the German North Sea island Sylt).
- While not true in all mountain or coastal communities, those explored here have a strong ***economic basis in tourism***, shaping not only the dominant local risks but also the “delicate balance” (Aspen Mayor, Steve Skadron) that needs to be struck in reducing socio-economic vulnerability and shaping adaptation options that manage growth, protect local values and meet tourist expectations.

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Climate change risks:

- In most communities examined, there is still relatively low ***awareness of local climate change risks*** in the general public, which speaks to a need for awareness raising and education, but also to the difficulty in communicating climate change: people easily get overwhelmed by gloom-and-doom messaging and leaders struggle to find ways to positively engage people in active solutions.
- ***Water issues*** – while manifesting differently – are key issues in both regions: coastal areas, being very close to sea level, face challenges with sewage, runoff and water treatment; many mountain areas face challenges with water supply and storage.
- The ***prospect of having to abandon current land uses*** due to climate change in the future is a real possibility in both regions as there are real limits to technological adaptation options.

- Coastal and mountain communities face both ***lifestyle and existential risks***. They point not just to the physical nature of risks but to the underlying socioeconomic vulnerabilities and adaptive capacities that different communities have.

Adaptation activities to date:

- ***Extreme events and climate variability are key entry points to adaptation***, both for scientists and for practitioners. ("Never let a good crisis go to waste," as per a comment made during the community dialogue).
- In all cases, ***a strong local leader or champion*** has been key to getting climate action and adaptation planning efforts launched (e.g., Mayor of Virgen; former Mayor of Timmendorfer Strand; former and current mayors of Aspen). Far from merely an artifact of the cases included in the transatlantic dialogue, this is found repeatedly elsewhere.
- ***Legacies of the past shape adaptation approaches and options*** considered and perceived as feasible now, be they structural, institutional, political, or related to the civic culture and history of community engagement.
- At this early stage of adaptation planning, there is a strong emphasis on ***raising individual awareness of climate risks and household-level actions*** (e.g., "Klimapavillon" along the Bay of Kiel; exhibits and public education at several nature centers in the Aspen area; "Klimapfade" [climate trail] in Grindelwald; individual home or property protection in U.S. cases; public education and household water conservation in Aspen).
- Not only are ***climate change risks perceived negatively, but so are many of the proposed (or imposed) adaptation strategies***. Participants stressed the importance – as familiar and beloved aspects of the communities are lost –of making the alternative attractive. This can happen through multi-functional, beautifully designed adaptation measures and creating immediate community benefits (health, economic opportunities, jobs, safety, local pride).
- Generally, adaptation strategies to date in the cases explored, ***lack a strategic approach*** and are instead ad hoc, opportunistic or focused on small, individualized responses. Communities need to learn how to be more strategic, how to think about future, more frequent, converging and amplifying crises, and how to overtly address things people don't want to talk about.
- Adaptation, and especially the more transformational changes needed in the future, constitute ***fundamental changes to long-standing social contracts and expectations of government***. These cannot be achieved immediately and need sustained community dialogue (e.g., denial of development rights, loss of private property protection, help in and after disaster).
- To date, communities ***inadequately consider synergies and trade-offs between mitigation and adaptation*** and how they change over time (e.g., reforestation with young trees leads to greater water need and greater flood protection now, will change over time).

After nearly a decade of planning and discussion between community members, scientists, and regional officials, the coastal resort community of Timmendorfer Strand completed a sea wall. In many places the structure blends into the natural landscape, thereby minimizing aesthetic impairment while protecting the community from the impacts of storm surges. Credit: Susanne Moser.

Differences between Coasts and Mountains

Adaptation opportunities and constraints arising from the geographic setting:

- As described above, there are ***obvious biophysical differences which compound differences in socioeconomic vulnerability*** (among all cases). Aspen, for example, is very wealthy, while Virgen is quite constrained in financial means; Grindelwald falls somewhere in between and North Carolina and Chesapeake Bay communities can vary considerably along the socioeconomic spectrum, as well as in the physical risks and the extent to which climate change impacts are already emerging.
- Coastal regions have much ***larger population concentrations exposed to climate change*** than mountain communities.
- The ***longer occupation of coastal areas*** also generally means there are a greater number of older, historical buildings at risk, which makes it more difficult to implement structural adaptations (if at all) due to historic preservation rules

Climate change risks:

- In mountain areas, climate change is causing predominantly ***temporal shifts*** in physical and ecological processes (e.g., snowmelt, runoff, length of fire season) while coastal areas can expect predominantly ***spatial shifts*** (inland movement of shoreline, freshwater/saltwater lens, extent of inland flooding).
- In most of the cases examined (though not necessarily true with all or elsewhere), mountain communities may have a shorter ***lead time before adaptation measures will need to be implemented*** as changes are unfolding rapidly; for some coastal communities, impacts are still further in the future, allowing more time to determine appropriate adaptation strategies (though this will depend on the rate of local sea-level rise and concurrent stressors).
- In mountain areas, ***competition for water uses*** may be greater than in some coastal areas.

Adaptation activities to date:

- In the mountain communities studied here, ***mitigation*** was the first ***entry point into climate action*** whereas addressing experienced or preparing for immanent impacts (adaptation) was the entry point in the coastal cases.
- Due to the different degree of urbanization and development, ***adaptation in mountain areas – while challenging – is expected to cost less overall than adaptation in coastal environments.***

Snowmaking is one practice adopted by ski resorts in mountain communities to adapt to variability in winter snowfall patterns.

Overcoming Barriers – Advancing Adaptation Action

Originally, the transatlantic dialogue was designed to surface barriers to adaptation that research and better science-policy/practice interactions could address. The dialogue revealed, however, that the challenges to adaptation in coastal and mountain communities were not primarily, much less only, rooted in lack of science or inadequate climate services. Instead, barriers to adaptation were overcome (or proposed to be overcome) through communication, governance, resources and cultural and behavioral shifts:

Improved Communication and Connection to the Public

- ***Raising public awareness of emerging and growing climate change risks*** is an important component of effective community engagement.
- ***More consistent and clearer communication from scientists*** would be helpful, although scientists are not alone in shaping a difficult communication environment. There are many areas in which climate science is firm and consensual while continually changing still in others. Vested interests play a big role in muddying the waters about what the public hears about climate change.

Extreme rainfall events, such as those experienced in Boulder County, CO in September 2013 pose direct hazard to mountain communities as well as the longer term challenge of deciding whether to re-build or relocate. Credit: FEMA.

- Because climate change and adaptation options may be difficult for the public to take in (both cognitively and emotionally), there is an overriding need to ***find ways to communicate that resonate with the public's values.*** Tapping into the local sense of place, (place identity or, in German *Heimat*) have proven effective. Focusing on something that benefits the community in the near- and longer-term (health, safety, welfare, civic pride, economic development/job, sense of place) is also important as are adaptation strategies that solve multiple problems at once.
- The ***language of adaptation*** is challenging for some audiences, as it can be jargon-laden or holds different meanings for different people. For others it is simply not resonant or familiar yet. A more resonant language must offer concrete, imaginable activities, highlight benefits and opportunities, show how selected strategies help avoid suffering, and contribute to community health, innovation, and the protection of what locals consider "sacred."
- ***Improved social relationships*** (built on mutual respect, trust, operating in good faith) need time to develop. In many localities they also need to undo and work against existing polarization and antagonism. ***Time and dialogue*** are needed to get to acceptability of climate change and adaptation.

Modified Governance Structures and Procedures

- ***Legal frameworks need to be established to facilitate adapting to changes.*** Existing ones do not allow for the consideration of changing baselines or for different future scenarios. However, historical values are no longer an adequate guide to the future; regular updates with the latest science should be required, as well as not foreclosing future adaptive options in light of uncertainty.
- Given the teleconnections between mountains and lowland areas and between coasts and hinterlands, and the multi-scale governance systems that shape resource management and investment decisions, ***cross-scale connections in governance*** need to be established at higher levels of government. For example, tree planting in mountain areas can support flood prevention in

Chesapeake Bay Bridge closed in anticipation of Hurricane Isabel in 2003. Credit: FEMA.

- lowland areas. Connecting adaptation plans across communities, ensuring two-way flow of information, helping to clarify roles and responsibilities and even cost-sharing mechanisms may be aspects of such trans-local governance.
- Moving toward ***regional and more widely collaborative approaches*** helps overcome silos in thinking and management (e.g., sharing information, joint planning along littoral cells, around bays; integrated forest and water management in a watershed).
- In light of continued and substantial uncertainties (e.g., precipitation changes in mountain areas, sea level rise projections along coast), managers must ***manage for uncertainty, not expect resolution of uncertainty*** ("you do the best you can"); generally, uncertainty causes managers to get started with low-regrets planning (e.g., system reliability, diversification, flexibility), focusing on establishing a good process, not just achieving narrow outcomes, planning for multiple futures through scenarios, and carefully assessing a portfolio of response options.

Adequate financial backing and investment

- Cost of adaptation is not as big a barrier as it may become in the future (although anticipation of negative economic impacts of climate change and, particularly, of adaptation measures e.g. development restrictions, is already impacting the political debate). Communities, regions, states need to ***pool resources, find ways to compensate losses or damages, and reduce their financial liabilities.***
- Communities need to find ways to ***create jobs with adaptation*** (similar to experience with mitigation) so it becomes more attractive to people.

Work toward slow, but crucial cultural shifts

- Governments and local authorities may need to ***plan for worst-case scenarios, long before the public accept the possibility of such major threats.*** It is the obligation of government to think beyond individual interests and productively use this "luxury time" before impacts get worse and come faster.
- Adaptation to climate change demands that the ***roles and responsibilities of private sector, individual and public entity actors be reexamined.***
- Adaptation, especially deeper, transformational adaptation, will ***require cultural shifts***. For example, what are now considered fundamental rights – such as access to sufficient water or protection of private property – may well need to change in the future. Moving toward a "culture of drought," in which water is not expected as a given coming out of the faucet, or a "culture of preparedness," in which post-disaster bail-out becomes replaced by self-reliance and local resilience, are conceivable cultural shifts in situations grappling with drastic climatic changes.

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