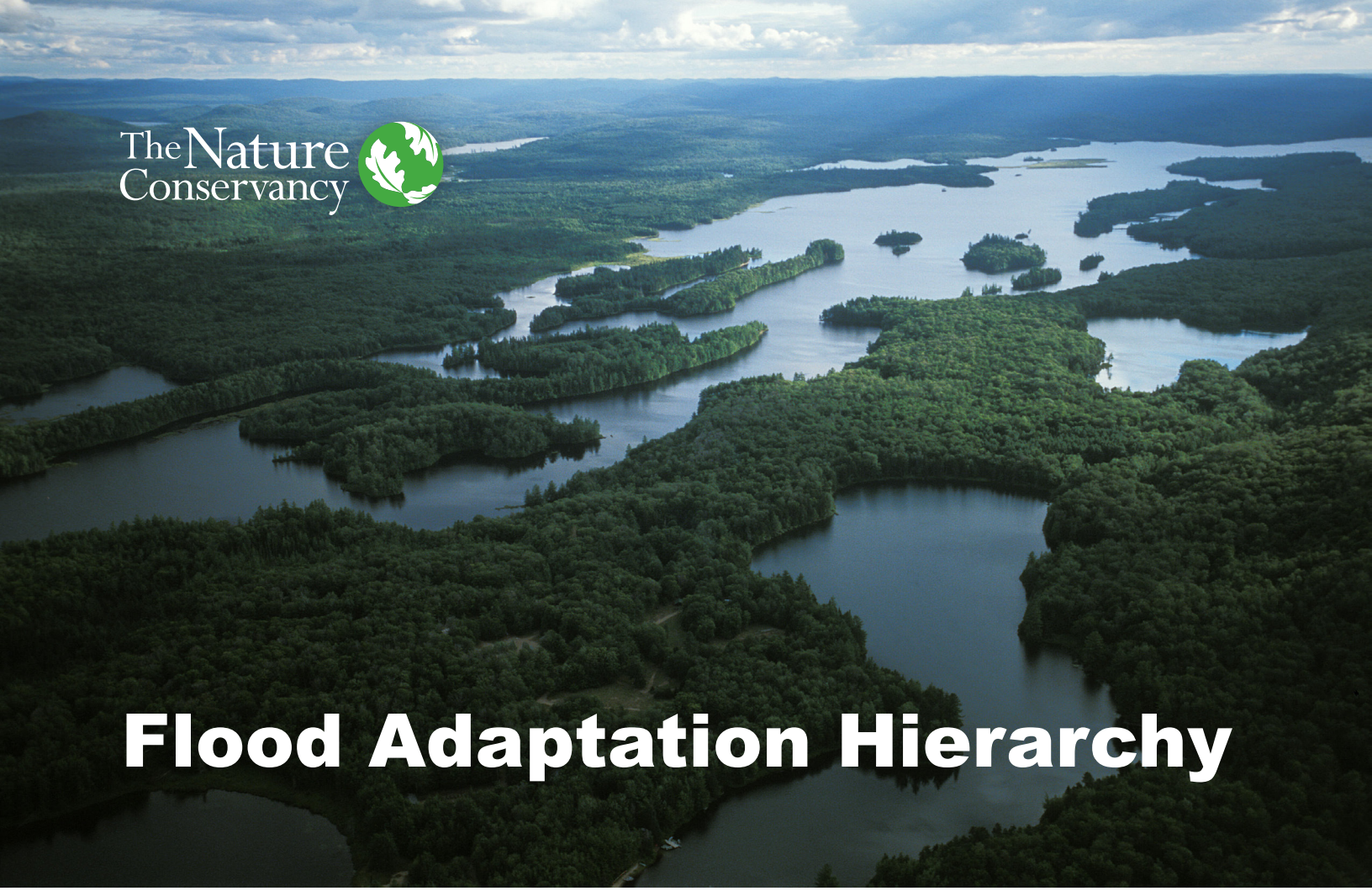

Flood Adaptation Hierarchy

Adirondack State Park. © Mark Godfrey/TNC

A Better Way to Adapt to a World of Floods, Rising Seas, and Social Inequality

Anyone who's lived through a big flood can tell you it's devastating. In the United States, floods cause $8 billion worth of damage and take 100 lives each year. And the problem is getting worse. Along our rivers and coasts, the severe floods that ruin homes, drown farm fields, and wipe out businesses are increasing due to climate change and increased development in risky areas.

So, what's the answer? Traditional approaches to handling flood risk, which may be summarized as "defend, accommodate, or retreat," include building sea walls, levees, or reinforced dunes to keep water out. But these short-term solutions are no longer sufficient to handle the increasing rainfall, sea-level rise, and continued development in floodplains that are making flooding worse.

The traditional approaches also perpetuate social inequities and leave those who are the most vulnerable at greatest risk. What we need are long-term solutions that make way for water and allow us to adapt to changing conditions.

Building in a floodplain (the generally flat land alongside a river, coast, or other waterway) is like making a sandcastle too close to the water's edge. When the water comes in, adding walls around the outside and bailing out the moat may work for a while, but ultimately the water wins. Rather than building in floodplains and trying to keep the water out, our goal should be to make room for water and protect people by enabling natural floodplains to function.

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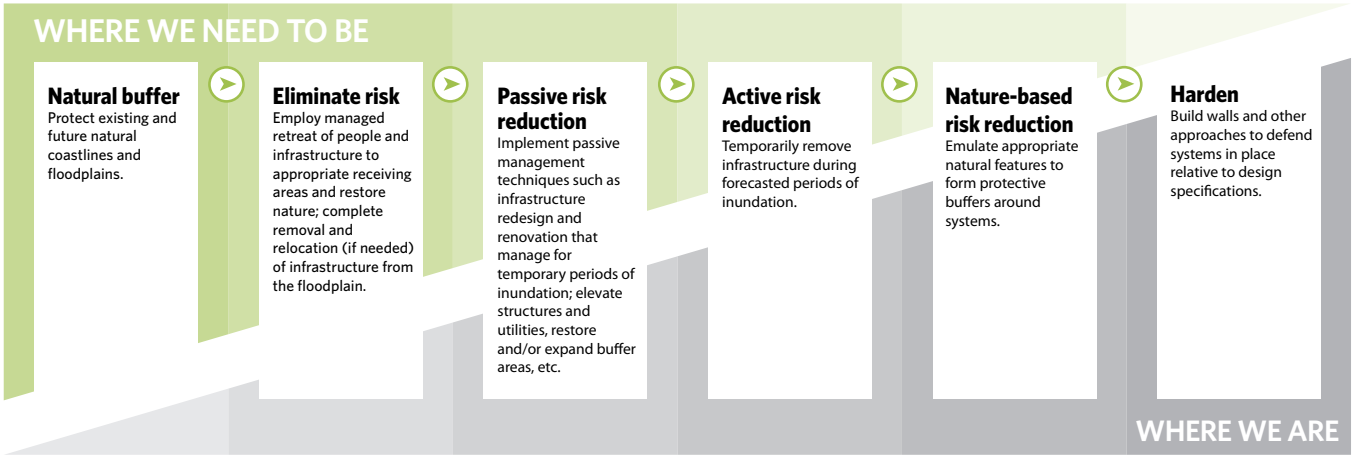
Instead of dealing with repeated floods, we can keep people, homes, and businesses safe and keep nature intact by protecting and restoring floodplains so they can store excess water during floods, helping people who live in floodplains relocate out of harm's way, and accommodating floodwater with better infrastructure.

For too long, the worst consequences of flooding have hit poor communities and people of color. Low-income housing is often built in low-lying areas that are prone to flooding. In addition, low-income groups and communities of color often lack access to resources and have little opportunity to participate in decisions about flood management in their own neighborhoods. Studies also show that after disasters, higher income neighborhoods were the first to receive help, and they received more assistance than low-income areas.

A team of scientists at The Nature Conservancy examined decades of research and practice from around the United States and developed a way to make decisions about flood risk solutions. They prioritized these solutions in tiers that would provide the greatest benefits to people and nature.

Road closure sign as floodwaters cover the road. © Djperry/iStock



Tier 1

The top priority is to **protect and restore natural floodplains** so they can store excess water during flood events. When rivers can flow freely, and when dunes and sand bars can shift, nature can provide its full suite of recreational, cultural, and other benefits to people and communities.

Sand dune. © Alison Branco/TNC

Tier 2

The next priority is to help people who are willing to move to **relocate out of harm's way**. Although relocation is expensive, recovering from repeated floods takes an even greater toll, both financially and emotionally. Removing buildings from areas that are destined to flood and helping people who want to move to safer locations can avoid tremendous losses and create opportunities to restore natural ecosystems.

Vacant lot. © Brendan E. Casey/Shutterstock

Tier 3

The third priority is to **accommodate floodwater with passive measures** by building structures that can temporarily accommodate floods, such as elevated buildings and adequately sized culverts to carry water under roads. This approach weighs the short- and long-term tradeoffs between relocating and accommodating floodwater.

Culvert. © John DiGiacomo

Tier 4

As a next step, **use active measures** like evacuation, sandbag dikes, and other responses to handle an immediate flood. Disaster research shows that these measures are more common in wealthier communities, with low-income residents often left most vulnerable.

Flood protection sandbags. © Marc Bruxelle/iStock

Tier 5

Next, reduce **risk through nature-based engineering**, using living systems like oyster reefs and planted edges to stabilize the landscape against storms and flooding. Nature-based solutions differ from nature as a solution in that they are artificially installed and not an inherent part of the landscape, but they are still preferable to the solutions in the final tier.

Engineered nature-based shoreline. © SERC

Tier 6

A last resort is to **defend communities using hardened engineering** like sea walls and bulkheads. This action leaves adjacent properties and communities in peril, harms natural ecosystems, and may diminish access to coasts, shorelines, and floodplains.

Concrete and steel breakwater seawall. © Akiyoko/iStock

Communities, institutions, and homeowners should apply the solutions at the top of the hierarchy first, and thoroughly evaluate each tier and apply it to the extent possible before considering the next tier down.

A closer look at the solutions

Our priority is to make way for water—not just the water that flows in our rivers and along our coastlines today, but the water that's coming because of sea level rise, stronger storms, and heavier downpours. Areas that were not previously vulnerable to floods will soon begin to experience them. Our best tools to respond to this threat are our natural floodplains, and if we want them to function as they should, we need to protect and restore them.

Floodplains are tremendously valuable from an ecological standpoint. They are critical habitat for plants and animals and provide important environmental services. For example, they store excess water from storms, filter out pollutants, absorb carbon to offset emissions, and serve as important cultural and recreational areas. They also help us adapt to environmental change. In 2012, coastal wetlands protected communities from a potential $625 million in losses due to Hurricane Sandy. Accordingly, floodplains are key to our flood adaptation approach.

- **Tier 1.** **Protecting floodplains** means not developing there. These lands are ecologically active and naturally prone to flooding, so they are not suitable for long-term human habitation. According to a 2020 study, every dollar spent protecting floodplains in the United States can yield five dollars of net economic benefits through avoided flood damages. **Restoring floodplains** means caring for existing, degraded landscapes by restoring flows, removing harmful human alterations, and re-planting native species. Floodplain restoration can enhance cultural access for indigenous and local communities through community engagement and participatory planning processes.

- **Tier 2.** Our next priority for flood management is relocation: h**elping households or entire communities who want to move out of danger**. This is a long-term, permanent solution that will save lives, money, and effort. Flooding events are extremely expensive and take a serious toll in terms of lives lost and emotional suffering. Floods are well worth avoiding. The frequency of flooding is increasing: In New York State alone, there were 20 major floods in the past 25 years, the same number as in the 100 years before that. This means that whereas building in a floodplain might once have been a calculated risk that would pay off (with only a few severe floods each century), in many places it's no longer a viable option. Where communities are likely to experience repeated, devastating floods, the sooner they relocate, the better. Managed retreat can be done equitably with programs that are voluntary, fair, and timely; that engage affected parties in planning and implementation; and that provide equitable support for disadvantaged people, including rental tenants.

After a community has applied the above solutions to the greatest extent possible, the next step is to consider passive and active risk reduction.

- **Tier 3.** **Passive measures** are permanent infrastructure that can accommodate excess water in a flood, like elevated buildings, adequately sized culverts and bridges, and tidal backflow valves (which prevent seawater from flowing back up into storm drains). They are durable, lasting 25–100 years, and require little operation or maintenance after the initial investment. While passive measures are attractive to those who can afford to stay, they may not be affordable for low-income communities. Furthermore, decisions between managed retreat and passive measures should engage affected parties, including those that have been historically excluded.

Delaware River floodplain. © Nicholas Tonelli

- **Tier 4. Active measures**, in contrast, are short-term, immediate responses to an imminent flood. They include deployable dams, evacuation during extreme weather events, and preemptive shutdowns at power plants. Trained professionals must swing into action when a flood is predicted to deploy these measures. They can protect communities and save lives during a crisis, but they can also fail for many reasons, such as when the water levels exceed their capacity, when they are put in place too late, or when residents do not evacuate. Furthermore, inequities in disaster response resources tend to privilege wealthy and white communities, and not all community members have the same means and abilities to evacuate.

The remaining solutions both share the mindset that water can be kept separate from people and infrastructure. Neither allows water to move freely through the landscape or ecosystems to adapt to change. Places where the land and water meet are inherently dynamic; they want to move. An engineered structure, whether it is nature-based or a sea wall, holds that interface in place and prevents its movement, interfering with the dynamism. For this reason, these solutions should be considered only if the earlier solutions have been attempted or are not feasible for the situation.

- **Tier 5**. **Nature-based engineering** helps to dissipate the energy of a storm or stabilize streambeds during high flow. For example, planting oysters and mussels on artificial reefs along the coast or installing offshore sills can help break wave energy, while placing vegetation and rocks can stabilize a shoreline or streambed. These solutions use a combination of living materials (like plants) and natural materials (like sand and gravel). These measures may disrupt some people's access to and engagement with natural spaces. They may also contribute to a false sense of security, as they are susceptible to failure.

- **Tier 6.** Finally, as a last resort, communities can invest in **hardened engineering**. These built structures, like sea walls and levees, are intended to keep out water, and they work well in some cases. But they also harm the very landscape features and processes that would normally buffer storm damage, and they are prone to catastrophic failures. Their existence encourages people to build in areas that are not safe. Furthermore, these measures have unintended impacts on adjacent people and communities, and they rarely involve any efforts to mitigate these transboundary impacts.

Overcoming challenges

One challenge of applying this framework of adaptation tiers is that traditionally, communities have applied solutions to flooding in almost the opposite order—first building walls and other infrastructure. These engineering approaches are only a quick fix that ultimately aren't a good use of a community's resources. Sometimes they even make the toll of a storm worse. For example, during two recent hurricanes in North Carolina, properties behind bulkheads experienced more damage and nearby shorelines suffered more erosion than properties protected by natural shorelines. In addition, hardened engineering worsens social and economic inequities because these structures are typically built to protect wealthier communities, leaving less wealthy neighborhoods vulnerable.

It will take some dedicated effort to shift patterns of engrained thinking to embrace better long-term approaches. But new development in the floodplain and climate change aren't a distant threat; they are happening now, and the impacts of more extreme weather will continue, so we need to find ways to live with increased flooding.

We also need to apply this framework in a way that seeks to remedy current inequities in our society rather than making them worse. When communities are making decisions, it is critical that they give historically disadvantaged populations protection from flooding, allocate the resources needed for flood recovery by just and fair means, and include marginalized voices in decisions about flood management. They must consider equity in the planning and implementation processes for every tier in the framework.

Putting the solutions into practice

We can use incentives and regulation to help communities choose the top-priority approaches first, and only after exhausting their possibilities move to the lower-priority approaches that are less effective in the long run. Incentives should apply at multiple scales, from individual homeowners and businesses up to state regulators. For example, a state's department of natural resources (or its equivalent) might offer tax abatements and other financial incentives to property owners who agree to keep their floodplain property in a natural state or to plant native species there.

Here are other examples of incentives and regulation:

- The National Flood Insurance Program's Community Rating System (CRS) is a voluntary program that provides flood insurance discounts to homeowners and businesses that have taken steps to reduce their property's flood risk. CRS member communities could be encouraged to use the framework in local land-use planning or local laws.
- State agencies or municipalities could allocate funding for communities to implement the top-tier solutions and include guidance for an equitable process.
- Jurisdictions could use building codes, zoning, and permitting to allow development only in areas that are not prone to flooding. Generally, the permitting process should be easier for actions high on the hierarchy and more difficult as communities move to the lower options. Regulations that are carefully crafted and implemented can account for and help to reconcile inequitable resource distribution.
- Urban and community planning should take a long view, locating development out of harm's way and allowing coastal and riverine systems to function naturally in the floodplain. It is critical to include diverse voices and historically excluded perspectives throughout the planning process.

The Cohocton River flows through the hamlet of Atlanta. © Mat Levine/TNC

Although our analysis focused on U.S. flood management and adaptation, the lessons have applicability to other regions of the world and even other environmental issues. We know that in the future, climate change will bring more major storms, more intense precipitation, and higher water levels. Our recommended approach to flood management will allow people and nature to adapt to the changes that are happening now and that will continue to escalate in the future, saving both money and lives.

The Nature Conservancy