

INVESTING IN RESILIENCE: A FRAMEWORK FOR FUNDING AND FINANCING CLIMATE ADAPTATION

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CHAPTER 1. WHY RESILIENCE FINANCE IS HARD, BUT NOT INSURMOUNTABLE

Communities across the country already understand that reducing climate risk is essential to preserving livable and thriving communities. They know that a hardened roof, a relocated water system, or a restored floodplain can reduce vulnerability and associated losses when appropriately designed, implemented, and maintained. Many local governments already have the hazard mitigation plans and vulnerability assessments that identify key risks and needed investments in resilience and adaptation. What most still lack, however, is a reliable way to turn that knowledge into a funded, built project. **That gap between knowing what would help and being able to pay for it is where billions of dollars in avoidable losses quietly accumulate every year, even as the tools to prevent them exist and keep expanding.**

Part of the problem is definitional. Resilience — the ability to prepare for threats and hazards, adapt to changing conditions, and withstand and recover quickly from disruptions — and adaptation — the process of adjusting to a changing climate in ways that reduce harm or capture new opportunity, are both investments against a threat that hasn't happened yet. That is exactly what makes them so hard to pay for: future losses are not typically tracked on public or private balance sheets, people can be poor risk evaluators and overly optimistic, those impacted may not be those with the ability to manage the risk, and there are many competing budget priorities. The current machinery of public and private finance struggles to address these interrelated challenges of securing climate adaptation investments.

But that difficulty is a design problem, not a dead end. The same features that make resilience investment challenging for conventional finance also point toward the fix: organizing not around the funding or financing tool, but around who holds the risk and for how long, and what we know about the impacts on risk reduction. Those two questions (who owns the risk? have we quantified the risk reduction?) are the foundation this report builds on to develop a practical way of matching real projects to the capital most likely to fund them.

The Current Funding and Finance Context

Resilience investment depends on funding, financing, and incentives working together toward a common purpose, and the distinctions between them matter. **Funding** refers to direct dollars from the public sector, philanthropy, or private beneficiaries that do not need to be paid back. Financing refers to capital available at a point in time but that must be paid for before or after its use. Many resilience investments combine both and also might rely on **incentives** — economic or regulatory signals like insurance pricing, loan terms, or tax treatments — to make one option more attractive than another.

Three broad kinds of actors typically supply dollars for resilience projects: government, private entities, and philanthropy. Government (federal, state, or local) carries the deepest pockets and the broadest authority, but that authority is split unevenly across scales. The federal government has the fiscal capacity to absorb catastrophic costs but has historically paid more in post-disaster assistance than pre-disaster mitigation. States sit in between, typically with more capacity than localities and more proximity to the actual risk than the federal government. And local governments hold the land-use and building-code authority that shapes risk in the first place, but most, with some notable exceptions, carry the least fiscal capacity of the three, with state and federal governments often supporting them with needed funds. Across all scales, government tends to carry the cost of investments that benefit large populations with no practical way to exclude anyone from that benefit — what economists call public goods (see call out box on page 11) — precisely because private capital has little incentive to pay for something when it can't capture a return. While these relationships hold in general terms, not all communities can access funding and financing equally; low-to-moderate income (LMI) communities are often underserved, facing added barriers both current and historic, to accessing public and private dollars.

Private entities, from individuals to firms, will often invest in resilience when they receive direct financial benefits that are worth the expense, in financial or other terms. Private capital (banks, insurers, institutional investors) will fund resilience investments more broadly when there is a return to be had, such as offering market-rate debt, actuarially priced risk transfer, and increasingly, pricing climate risk in credit and underwriting terms explicitly. The volume of private capital is much larger than public sector dollars, but it tends to follow demonstrated, quantifiable returns, which means it naturally clusters around projects with a clear revenue stream or a measurable reduction in loss, and stays away from public-good investments.

Philanthropy is smaller in scale than either government or private capital, but far more flexible, and it often shows up precisely where public and private capital are least accessible — funding early-stage planning, technical assistance, or the kind of de-risking work that makes a project attractive to larger investors later. It can act as a grantor, an investor, or something in between, and its willingness to accept a lower return, or none at all, gives it a role neither government nor private capital can easily fill.



None of this is a mystery. The general role each of these actors plays is reasonably well understood. What's missing is coordination around reducing risks in an ever-riskier world. The suppliers of capital — government, private capital, and philanthropy — each act on their own timeline and their own logic, and it can be difficult to find alignment on a given project, returns, and timelines. That lack of alignment, more than any single actor's shortcomings, is a large part of why resilience investment remains so hard to mobilize at the pace and scale the risk demands. It shows up as three recurring, practical problems:

- **Fragmented and inconsistent funding streams.** Funding and financing sources rarely align on timing, eligibility, or purpose, which leaves practitioners piecing together capital from multiple programs with different rules for a single project.
- **One-time grants function as the default funding source, not a supplement to one.** While there are some exceptions, particularly in more affluent areas, competitive public grants are often relied upon for resilience investment. That pattern leaves resilience funding exposed to the timing and availability of individual grant cycles rather than a predictable stream project sponsors can plan around, and it means a project that misses one cycle may have no clear next opportunity. It also is leaving capital “on the table” that could potentially be used to close the large funding gap currently facing climate adaptation investments.
- Mixed and often contradictory signals on the economic value of resilience investments. Markets, regulators, and public programs frequently send conflicting signals with many markets not pricing risk, future losses, or rewarding risk reduction, which weakens the case for making that investment in the first place. This further deters investment.

Investors and policy makers face a structural gap between risk identification and financeable implementation. Closing it requires more than additional money — it requires a clearer way to match the right funding or financing tool to the right risk reduction investment.

■ Why Resilience Investments Are Difficult to Fund and Finance — But There Are Opportunities

Three structural features of resilience investment make it a poor fit for conventional public finance and private investment frameworks.

First, the benefits are long-term, variable, and based on avoiding future potential losses.

This makes them difficult to translate into the kind of predictable cash flows over a known period of time that financing tools are built around. A flood-proofed building does not generate revenue for being flood-proofed; it simply avoids a cost that might have occurred at some future, uncertain date. Avoided losses of this kind are not tracked on most balance sheets, so the value of the investment is real but largely invisible to the financial systems that would otherwise fund it.

Second, the returns on a single resilience investment rarely accrue to a single actor. For many climate adaptation investments, especially those that are the focus of this report, the benefits of an investment accrue to many different entities. For example, a homeowner's defensible space reduces wildfire risk not just for that home, but for neighbors, insurers, and the local fire department's workload. These are benefits that are spread across time and sectors in ways that make it hard for any one investor to capture, and therefore, hard for any one investor to justify assuming the full cost.

Third, political and fiscal constraints often limit how much risk mitigation investment governments can make, regardless of its long-term value. This can include near-term budget pressures competing directly with investments whose payoff may be a decade or more away, revenue-raising structures that misalign beneficiaries with payors, and sometimes regulations that prohibit needed revenue-raising structures.

Faced with these barriers, many policymakers and advocates have turned to solutions that subsidize risk, instead of solving the hard challenge of financing risk reduction. The opportunity ahead is to refocus on **subsidizing risk reduction, instead of subsidizing risk.** This distinction is critical for understanding the best role for government in this landscape. Public dollars spent in a hazard-exposed system do one of two things.

Spending that lowers the underlying risk, as is done through mitigation grants, revolving funds for hardening, certified-standard incentive programs, defensible-space and elevation programs, is subsidizing risk reduction. Spending that offsets the consequences of risk while leaving the risk itself in place, such as suppressed insurance pricing, subsidized rebuilding in risky locations without resilience upgrades, infrastructure supporting new development in high-hazard areas, is subsidizing risk. Both can look like help, and are active policy choices, whether recognized as such or not. But they move potential risk and losses in opposite directions: the first shrinks the risk, while the second mutes the price signals that would motivate other risk owners to act while potentially growing the risk.



Today, this distinction is not well appreciated in practice, and not well investigated since there are real short-term political wins when risk is subsidized, and fewer wins when reducing long-term costs. However, with a clearer articulation of how subsidizing risk can simply balloon future costs, there are avenues to begin shifting political assessments. As these long-term costs become more visible, the benefits of reducing those risks can counterbalance short-term political incentives.

Traditional public finance and private investment frameworks are poorly suited to adaptation. But the same features that make resilience investment structurally difficult also point toward the fix: a framework that starts not with the funding or financing tool, but from who holds the risk, for how long, and why that shapes their incentive to invest in reducing it. This approach then facilitates matching a potential investment with the abilities and motivations of funders and financiers to the investments they are best suited to support.

Introducing the Framework

What this framework is, what it isn't, and who it's for. This report is an actionable typology — not a guide to securing funding for any single project, but a way to help actors across public and private sectors understand where and how capital can be directed toward reducing climate risk. The goal isn't one funded project; it's a clearer shared understanding, across sectors, of how funding, financing, and incentives can align toward resilience investment at scale. It is not an introduction to climate adaptation or a case for why resilience investment matters, as that ground is well covered elsewhere. It is also not a comprehensive catalog of every funding and financing tool in use today, and it is not a substitute for project-level technical or financial analysis.

This report is written for anyone working to drive more investment toward reducing natural hazard and climate risk, including people who design resilience projects, people who fund or finance them, and people who help move them from plan to reality. That includes practitioners already doing this work day to day, the policymakers and investors



who fund and finance it, and the project proponents and technical assistance providers who help carry it into implementation.

The goal is to provide practitioners with an actionable typology for aligning funding and financing sources to project and investment needs, to support project implementation beyond planning phases.

Risk ownership, and using it to align with funding sources, is the thread that runs through the report. Understanding risk ownership starts with three questions: who bears the cost of the risk when a hazard materializes; who benefits when risk reduction is undertaken; and who has the ability, accountability, and resources to actually influence the risk. These three groups of actors don't always overlap, and when they don't, funding and financing choices that ignore the mismatch tend to leave risk — and its cost — with whoever is least able to act on it, or least able to walk away from it.

The rest of this report builds outward from that idea:

- **Chapter 2** lays out the supply of capital: the basic funding, financing, and incentive tools available to pay for resilience investment, and how they map onto a continuum of the financial return each one requires.
- **Chapter 3** turns to the demand side, developing risk ownership as an organizing model: how long different actors hold climate risk, how that changes across the disaster cycle, and what happens when funding and financing choices do not align with risk ownership.
- **Chapter 4** brings supply and demand together, offering a decision-making framework for matching specific projects — based on who benefits and how well the risk reduction can be quantified — to the funding and financing tools most likely to work for them.
- **Chapter 5** offers five recommendations, organized by audience, to help carry this framework forward across the range of stakeholders who shape adaptation funding and financing.

CHAPTER 2. UNDERSTANDING THE SUPPLY SIDE OF RESILIENCE INVESTMENT: FUNDING, FINANCING, AND INCENTIVES

The supply of funds for resilience and risk reduction projects can come from a variety of sources. In this report, we distinguish between **funding**, **financing**, and **incentives**. Funding typically refers to non-repayable capital sources from the public sector, philanthropy, or investors, and financing refers to capital sources that can help provide large amounts of funds at once, but those funds must be repaid and with interest. Many resilience investments use both funding and financing, and also depend on financial incentives that can reward certain types of funding or financing in an attempt to encourage greater investment.

This chapter provides a brief orientation to different types of funding, financing, and incentives, to better enable their use throughout the framework developed in later chapters. Following these brief summaries, these funding and financing sources, along with financial incentives, are mapped along a capital continuum graphic (Figure 2.1), demonstrating how they map to risk tolerance of the capital provider. This capital continuum represents a summary of investment “supply.”

Low-to-Moderate Income (LMI) Community Access

Low-to-Moderate Income (LMI) communities include those who have been historically disinvested or underinvested in, are financially vulnerable, and in many cases are already facing severe weather and climate impacts. Many of these underserved communities have faced a history of redlining, the legacy of which has led to disinvestment and environmental degradation, higher pollution levels, more exposed physical vulnerabilities (e.g. heat island effect, low-lying regions prone to flooding), and reduced capacity to address risks from extreme weather and climate impacts. These communities also face added barriers to accessing conventional funding and financing,¹ which must be considered deliberately in adaptation finance policy and programs, ensuring investment decisions do not perpetrate further disinvestment for these communities.

Funding Options

All projects need funding — sources of capital to pay for the investment. For projects with clear private beneficiaries, they may use their own dollars to pay for the risk reduction investments. Funding for investments that are public goods (see callout box below) tend to be provided by the government and philanthropy, since the benefits are hard to privately capture. Both private entities and the public sector may choose to couple funding to financing, or to use debt or other financial instruments to move dollars in time. This is discussed in the next section.

Public Goods

Economists have a specific technical definition of a public good, and it is not just something that everyone values. Economists define public goods as being both non-excludable and non-rival. Non-excludable means that it is not possible to keep people from using or benefiting from the good, even if they don't pay for it, and non-rival means that one person's use of the good does not reduce the amount available for others. National defense is a classic example: everyone in the country benefits from it, and just because one person is benefiting does not diminish it for someone else. Public goods tend to be provided by government since private provision is difficult when benefits cannot be exclusively captured to recoup investments. In the realm of resilience, there are many local public goods, such as early warning systems or flood defense infrastructure, including levees, sea walls, or green infrastructure.

Funding ultimately draws on one of three underlying sources of money. One source is public sector dollars, which in turn come from taxes or fees assessed on all or a portion of the population. A second source is philanthropy, which gets its dollars from endowments and ongoing individual and corporate giving. The third source is private capital, which broadly refers to individuals or firms investing themselves or receiving the investments of others. Because each of these sources can be directed toward more than one type of funding or financing, the actors behind them — government, the private sector, and philanthropy — can show up across several funding types rather than being limited to just one. For example, a foundation's endowment can back both a grant and a below-market loan, and public revenue can capitalize both a grant program and a revolving loan fund.

Since private investments, whether by households or firms, tend to be used by the beneficiaries themselves, they tend to be more straightforward in terms of expected sources of financial return, relative to risk. But when government provides public goods, they still must find the dollars to do so. While each level of government — federal, state, and local — has different roles, authorities, and responsibilities, below is a brief orientation to common sources of public funds.

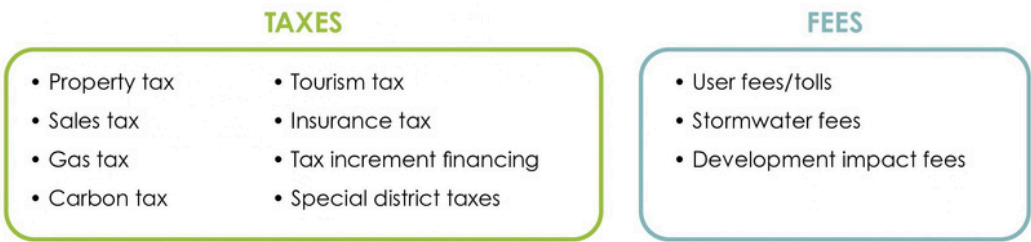
Taxes and fees are the most common funding mechanisms used by all levels of government to raise revenue. Taxes are typically focused on revenue generation from a broad base, such as income or property taxes, whereas fees typically are attached to particular activities, such as user or impact fees.² Fees are often used as a way to ensure the direct beneficiaries of a good or service are the ones to pay for it, such as tolls that are used to pay for road upkeep. District-based funding models like business improvement districts, tax increment financing, or resilience districts can be used to focus taxes on a specific population that benefits from an investment. For example, a business improvement district may levy a tax on commercial property owners to fund improvements directly in the district boundaries, such as public safety or streetscape improvements. Some taxes and fees are also used as financial incentives in order to discourage certain behaviors, such as charging fees for discharges of pollutants or a carbon tax, both of which aim to lower emissions as well as raise revenue. Congestion pricing is another example.³ However, not all examples are applicable everywhere; the state and local context must be considered given regulations vary across the country (see callout box below for an example).

Examples of restrictions to taxes and fees

While governments can typically use the same set of funding tools, it is not always the case that specific funding structures are not always transferable to another location: local legal, regulatory, and political context matters. For example, the Portland Clean Energy Fund receives revenue from a 1% surcharge on retailers with revenue over \$1 billion in national and \$500,000 in Portland-area sales. This fee has raised hundreds of millions of dollars for weatherization, renewable energy, and green infrastructure. While some cities may be able to replicate the model, cities in Pennsylvania cannot. Pennsylvania has a state level tax uniformity clause that requires taxes on a given class of business be applied uniformly; the state cannot single out large corporations for a different tax rate than small businesses within the same category. Since any tax would hit the mom and pop hardware store the same as a global corporation operating in the state, this limits political viability of new corporate taxes, as concern exists that it could unfairly impact smaller and local businesses. This is not the only type of state law that can limit the revenue-raising options of local governments, making it a sometimes complex endeavor to replicate financing structures from one location to another.

Funding sources: taxes and fees

Government-revenue tools that fund resilience investment



Public sector grants are non-repayable transfers of funds from federal, state, or local governments or philanthropic sources. Because they carry no repayment obligation, grants are best suited for investments that generate broad public benefits but little or no direct revenue. Federal funds have typically provided the largest source of public grants for state and local governments; however, the federal programs that fund risk reduction tend to do so after a large disaster, as opposed to consistently supporting the upfront investments needed to reduce risk before disasters occur. With federal disaster mitigation funding significantly reduced in recent years, state-administered grant programs have taken on greater importance.⁴ State-administered grants for local governments typically offer a more targeted alternative to federal funding, with several states having programs that go beyond gap-filling to actively reduce long-term public liability and create conditions for broader private investment. While each state is different and has their own considerations and environment to operate in, there are examples that can serve as models of well-designed state grant programs.

State grant programs for flood and hurricane resilience

New Jersey, Florida, and Alabama each show a different way states can fund resilience.

New Jersey's Blue Acres program buys out flood-prone homes in areas with repetitive flood losses and turns the land into permanent open space. Since it started in 1995, the program has bought about 1,200 properties. Because federal dollars can be delayed, the program also relies on dedicated state funding to be able to move quickly with buyouts post-flood. This includes the use of bonds and a dedicated funding stream from a share of the state's corporate business tax.

Florida's My Safe Florida Home program provides wind-mitigation inspections and matching grants of up to \$10,000 for hurricane-hardening work such as roof upgrades, impact-resistant windows, and exterior doors. Instead of a dedicated revenue source, the program has been funded through annual legislative appropriations from the state's general revenue, which vary year to year. The Florida legislature added \$280 million in new funding in 2025, with low- and moderate-income homeowners given priority.

Alabama's Strengthen Alabama Homes program provides grants of up to \$10,000 to help homeowners retrofit their roofs and obtain an IBHS FORTIFIED roof designation, which improves wind resistance and can qualify homeowners for insurance premium discounts. However, unlike Florida's program, funding does not come from general tax revenue or legislative appropriations; it comes from a tax on insurance industry licensing fees. A dedicated fee can often be more stable than appropriations, but it too, can sometimes vary unexpectedly. The Alabama program got a surge in revenue during the Covid-19 pandemic, from many health insurance agents obtaining licenses in the state. Since the first grants were awarded in 2016, the program has funded roof

retrofits for more than 8,700 homes through over \$86 million in grants,⁵ and Alabama's two coastal counties now have the highest concentration of FORTIFIED-certified homes in the country.

Philanthropic and corporate grant funding plays a growing but still limited role in resilience funding and finance. Foundations increasingly support resilience planning, technical assistance, and pilot projects, particularly in communities where public and private capital is least accessible.⁶ These funds are most effective when used to reduce transaction costs, build local capacity, or de-risk early-stage projects that can subsequently attract larger sources of capital.⁷ Philanthropy cannot substitute for sustained public investment, nor is it large enough to pay for large public works projects, for example, but it can play a meaningful catalytic role.

Other non-repayable funding sources to consider include policy instruments that can generate revenue. For example, **cap and trade** is a market-based policy that uses a declining greenhouse gas emissions cap to put a price on carbon and incentivize emissions reductions. Revenues from auctioning the emissions allowances can be directed toward climate mitigation and adaptation projects. **Climate superfund laws** are emerging state-level approaches that seek to bill major fossil fuel companies for the damages their emissions have caused. States receive payment from polluters paying back their portion of the damages over time, and the funding is often tied to climate adaptation priorities, providing a potentially important revenue source.⁸

Programs that pay for ecosystem services

Nature-based solutions, such as wetland restoration, floodplain reconnection, and ecological forest management, can reduce risk while also delivering habitat, water quality, and recreation benefits that engineered infrastructure alone cannot provide. While these benefits could be provided by public dollars for direct conservation or restoration, there are also times where environmental quality is being lost due to the harmful impacts of private landowners or private firms. When private actors are not forced to pay for the harms, ecological systems can degrade, driving up risks. Economists call these negative externalities. Government can correct them by taxing negative impacts, subsidizing beneficial actions, and building markets that support and maintain functioning ecosystems.

A classic example comes from the approach New York City took decades ago to protect its water supply.⁹ One of the programs, the Watershed Agricultural Program, run in partnership with the nonprofit Watershed Agricultural Council, pays upstate farm and forest landowners to adopt practices that protect the drinking-water supply for nine million New Yorkers. The city has committed roughly \$628 million to the program since

1992, most recently a \$228 million contract in January 2025 — a fraction of the estimated \$10 billion it would otherwise cost to build a water filtration plant.

At the federal level, USDA's Environmental Quality Incentives Program pays farmers, ranchers, and forest landowners nationwide to adopt conservation practices that improve soil health, water quality, and drought resilience. It remains the largest USDA conservation program, and recent legislation actually increased its funding baseline by more than \$1.2 billion a year. However, deep cuts to USDA staffing and technical assistance have made the program harder for farmers to access in practice, even as the payments themselves continue.

Operations and Maintenance Costs

Public finance separates capital expenditure — the cost of building an asset — from operations and maintenance (O&M), the ongoing cost of keeping it working, and treats infrastructure built without a credible O&M plan as mispriced. The challenge is that many sources of funding, such as public grants, pay for the upfront costs to build infrastructure but not the ongoing maintenance. For instance, many federal grants from FEMA or the U.S. Army Corps of Engineers fund construction, but require the local sponsor to fund O&M. This is often a challenge for resilience projects, especially for local governments, because O&M requires a steady flow of funding. However there have been creative applications of funding sources for, such as stormwater utility fees or special purpose districts, that can support ongoing maintenance of risk reduction infrastructure.

Financing Options: Capital That Must Be Repaid

Most projects will need a combination of funding and financing tools as part of their capital stack. Many resilience investments require a substantial amount of funds up front, but sources of revenue to pay for those investments may come as smaller cash flows over time. All borrowing, of course, must not only be repaid, but typically costs additional funds, and the rate on that borrowing can vary depending on the credit risk, lender, and debt instrument. Certain types of risk transfer instruments can also provide access to larger sums of capital at certain moments, such as after a disaster, but are paid for in advance through premiums.

Market-rate debt is borrowed capital repaid from reliable public revenues or project cash flows, typically at rates set by the market based on the borrower's creditworthiness. Municipal bonds are the primary market-rate debt instrument for U.S. state and local governments, financing more than 70% of essential public infrastructure.¹⁰

Although municipal bond interest rates are lower in nominal terms than those on comparable taxable instruments — a result of the federal tax exemption on interest income¹¹ — they are classified as market-rate instruments since the rate reflects what the tax-exempt municipal bond market will clear for a given issuer's credit profile, not a policy subsidy applied to the rate itself.¹² Green bonds are a subset of this market, designated for projects with environmental benefits for investors who value this use of proceeds; they carry the same credit backing and market-rate structure as standard bonds, and green or social bond designations have no direct impact on the underlying rating or borrowing cost.

Bank debt is currently a very small portion of financing at the commercial and consumer level, but also represents a segment for resiliency financing that is worth noting. In a commercial context, resiliency measures may be a component of a larger project such as building rehabilitation where fortified roofs or fire-resistant materials are used. However, bank financing for specific resiliency measures is broadly challenged by the lack of cash flow produced from the intervention (e.g. building stormwater systems, hurricane grade windows, etc). Banks may, however, have an aligned interest related to resiliency as impaired repayments or destroyed physical assets expose them to loan losses.

Below-market-rate financing provides capital at rates intentionally set below what the market would otherwise require, typically through a public or philanthropic subsidy applied to the instrument itself. State revolving funds (SRFs) are the most established example: the Environmental Protection Agency's (EPA's) Clean Water State Revolving Fund (CWSRF) and Drinking Water State Revolving Fund (DWSRF) programs provide loans at rates from zero percent to positive, but below-market, with terms of up to 30 years. The CWSRF alone has provided \$194 billion to communities through 2025, built on \$62.4 billion in federal capitalization;¹³ the DWSRF has funded more than \$41.1 billion in infrastructure projects at below-market rates, as of EPA's last published figure, from 2019.¹⁴

Development banks, government-backed lending programs, CDFIs, and some philanthropic funders similarly offer concessional financing, which are instruments with lower interest rates, longer maturities, or grace periods that differ from comparable market loans, in order to make socially beneficial investments affordable where market financing is too costly or unavailable.¹⁵ Green banks occupy a distinct and flexible position: they use public or mission-driven capital to reduce risk, improve loan terms, aggregate smaller projects, and bring private lenders into underserved markets.¹⁶ Depending on the structure, green bank financing can be market-rate, below-market, or blended — combining concessional and commercial capital to reach projects or borrowers that neither source could serve alone.

Risk transfer refers to instruments that shift the financial burden of a loss from one entity to another, typically in exchange for a fee or premium. Insurance is the most common example. While most risk transfer is not a source for funding risk reduction, it can be

used as a financial incentive, as discussed next, or in some cases, to finance risk reduction after a loss. While not widely used for this purpose, parametric financial instruments, which pay a predetermined amount upon occurrence of certain disasters, could be used to finance risk reduction.¹⁶ In these models, an entity would pay the equivalent of premiums and then, when the disaster occurred, receive flexible dollars that could be used for incorporating risk reduction and resilience into rebuilding.

Financing mechanisms

Capital that must be repaid, organized by return required

MARKET-RATE DEBT

- Municipal bonds
- Green bonds
- Bank loans

BELOW-MARKET-RATE FINANCING

- State revolving funds
- Green banks
- CDFIs
- Development banks
- Government-backed lending programs

RISK TRANSFER

- Insurance
- Catastrophe bonds
- Parametric instruments

What is catalytic capital?

Catalytic capital is not a funding or financing tool on its own — it's a strategy for using flexible money to unlock greater levels of funding. It steps in at the point where a project's risk or uncertainty would otherwise keep private investors away, and takes on enough of that risk to make the rest of the deal viable.

In practice, this usually means catalytic capital accepts a lower return, a longer timeline, or a greater chance of loss than a typical investor would accept. That willingness to absorb more risk is what lets other, more risk-averse capital, such as a bank loan, a bond, a pension fund, come in behind it on better terms. Catalytic capital effectively turns the dial on the rest of the deal, moving it further toward market-rate financing than it could reach on its own.

Two common forms of catalytic capital are first-loss capital, where a funder agrees to absorb the first losses if a project underperforms, protecting other investors further down the stack, and mission-driven investment, where a foundation, government program, or other mission-aligned funder accepts a below-market return because the project's public benefit matters as much as its financial return. Both function the same way: a smaller amount of flexible, risk-tolerant money placed at the right point in a project's financing stack, making it possible to raise a much larger amount of money that would not otherwise be available.



Economic and Financial Incentives

Economic or financial incentives refer to rewards or costs tied to a particular decision or activity. Such incentives are often used as a way to shape the decisions of individuals, firms, and institutions by altering the relative price of one course of action versus another. It preserves freedom of choice, but tips the scale. Some economic theories assume that 'actors' (individuals, organizations, institutions) respond rationally to these signals: incentives that raise the expected return or reduce the expected cost of an activity encourage its adoption, while those that do the opposite discourage it. A discounted insurance premium for wildfire-resilient construction is a simple example: the homeowner is still free to skip the upgrade, but the price signal can help make one choice more attractive. Financial incentives operate through specific channels — interest rates, insurance premiums, tax treatments, subsidies, penalties, and access to capital — that directly affect the costs or benefits of an investment or a behavior. Because these mechanisms influence decisions without requiring direct regulatory mandates, they are frequently favored by policymakers seeking to correct market failures or internalize externalities in a manner compatible with decentralized decision-making.

Applied to climate resilience, economic and financial incentives offer a mechanism for aligning private investment decisions with the broader social objective of reducing vulnerability to climate-related hazards. Absent such incentives, investments may not be the most economically beneficial from the perspective of society as a whole. Financial incentive structures seek to correct this by making resilience economically legible: pricing risk more accurately, rewarding risk-reducing behavior, and penalizing risk-exacerbating behavior through many markets, including the instruments available to insurers, lenders, and credit-rating agencies. A lender offering a lower interest rate on a construction loan for a home built to a wind-resistant standard is one example of this in practice, where the cost of capital itself becomes a tool for reducing risk. The sections that follow examine public sector incentives, insurance markets, loan terms, and credit ratings as mechanisms through which financial incentives can be, and increasingly are, mobilized to promote climate resilience.

Regulatory incentives from the public sector. The public sector can adopt various policies or approaches that incentivize certain resilience actions. These can directly change relative costs and benefits, such as through taxes or subsidies, or can shape markets more indirectly through regulatory actions. These can include:

- **Performance standards**, like stormwater retention requirements or water-efficiency standards, set a minimum bar that new construction or development must meet, pushing the market toward more resilient outcomes without dictating exactly how to get there.
- **Permitting incentives**, such as faster review or reduced fees for projects that incorporate approved resilience measures, reward developers for building in flood- or fire-resistant features by making the approval process quicker or cheaper.
- **Transferable development rights** let a landowner in a high-risk area sell the right to develop their land to someone building in a lower-risk area. The high-risk land stays undeveloped or is converted to open space, while the landowner is still compensated for the development potential they're giving up.
- **Disclosure requirements** require sellers, landlords, or companies to share known climate-related physical risks — like flood history or wildfire exposure — with buyers, tenants, or investors, so decisions are made with accurate risk information rather than none.
- **Insurance and financial regulation** shapes the rules insurers and lenders operate under, which in turn changes the price signals reaching property owners and developers. California's Safer from Wildfires regulation, for example, requires insurers that factor wildfire risk into their pricing to also offer premium discounts to homeowners who voluntarily take specific mitigation steps, such as installing a fire-resistant roof or clearing defensible space.

Insurance. Insurance can act as a financial incentive for climate resilience because it prices risk. When premiums accurately reflect risk and are lowered when a policyholder invests in loss-reduction measures, that discount is both an information signal and a direct financial reward for taking action. When insurers do not offer these discounts on their own, regulators may step in to require them. Many southeastern states have done this for FORTIFIED construction, which has been shown to substantially reduce wind damage,¹⁸ and California has attempted something similar through the Safer from Wildfires regulation.¹⁹ The federal National Flood Insurance Program also provides premium reductions when homes are elevated, flood vents installed, or when mechanical systems are moved higher in a property or building. More broadly, when the cost of insurance varies with how risky a location is, it can discourage building in high-hazard locations and reward moving to safer ones.²⁰ Conversely, when premiums are subsidized, capped, or otherwise decoupled from actual risk—as has historically been the case in some public insurance programs—insurance stops sending a useful signal, and its power as an incentive weakens.



There is, however, one key limitation to insurance providing financial incentives for climate resilience: policies are typically only for one year. As such, they price for the current year's risk only and not future risk. If hazard-related risks are worsening as the planet warms, then premiums will need to increase in the future to account for this, but policyholders have no way to see that coming from their insurance bill today. Other tools — like other types of policies and other ways of pricing risk — are needed to give people that longer-term signal.

Loan terms. The rates and terms lenders offer can themselves function as a resilience incentive when better terms are tied to resilience measures being taken. This could include, for example, a lower interest rate on a loan being used for resilience, reduced origination fees, guaranteed faster processing, or a rebate upon completion of the investment. Other examples could include allowing reduced collateral requirements or a higher loan-to-value ratio for resilient properties or upgrades. A proof of concept using lowered rates is being explored in Los Angeles as part of the wildfire recovery and rebuild. A more established example is Montgomery County Green Bank's Resilience Dedicated Fund, launched after the county expanded the Green Bank's authority in 2023 to cover physical climate resilience alongside clean energy (see box on page 44). The fund is structured as a low-interest revolving loan facility, giving affordable housing owners and developers access to flexible capital for resilience-related rehabilitation work (such as water conservation, HVAC upgrades, and similar measures) without having to seek separate funding project by project. In March 2026, Montgomery County's Council passed legislation allowing the Green Bank to draw on existing fuel-energy tax revenue to scale the fund further, an example of a dedicated revenue stream being used to sustain better loan terms for resilience investment over time.

Credit ratings. Municipalities and corporations receive credit ratings on their ability to repay debt. These ratings are among the most consequential non-budgetary signals in public finance.²¹ By establishing a benchmark for credit quality, ratings influence the cost of capital for state and local governments, which shapes how much it costs to borrow funds for infrastructure, resilience investments, and long-term capital projects. In principle, if climate risk exposure or inaction were explicitly reflected in ratings, governments would face stronger financial incentives to take proactive risk mitigation action. In practice, however, the current treatment of climate and physical risk in credit ratings remains marginal, inconsistent, and largely qualitative.

Toward climate-informed credit ratings

Understanding risk has a nexus to credit and is important for issuers and market participants alike. Assessing those risks is a fundamental role of credit rating agencies, which already evaluate physical hazard exposure using their own methodologies. Natural hazard risks are often difficult to translate into financial terms, particularly when evaluating the extent to which mitigation efforts reduce future exposure. More reliable methods for estimating both potential fiscal impacts and risk reduction could improve governmental decision-making and support more informed discussions among issuers, investors, and rating agencies. In government accounting, a liability reflects an obligation from a past event, like debt already issued or pension benefits employees have already earned. Natural hazard risks are different: they concern possible future events. Estimating what those risks could cost is useful for planning and analysis, but it does not turn them into liabilities on the financial statements.

The Capital Continuum: mapping financing, funding, and incentives

Figure 2.1 maps out the funding, financing, and incentives discussed above along a continuum. The graphic maps out the investment supply side for risk reduction projects: the capital available to fund and finance a given investment. The figure arranges the investment mechanisms along a continuum of financial returns, adapting the capital-spectrum convention familiar from impact investing. At one end sits capital that requires market-rate, predictable returns, such as bank loans or private risk transfer instruments. Next would be investments for which returns are needed, but a smaller return is sufficient — municipal bonds and other mission driven lending. At the other sits capital that accepts low or no financial return in exchange for high social return — grants and philanthropy, with concessionary and catalytic capital in between.

Some notes on the figure:

- Notably, the public sector is not a point on this spectrum but an actor that operates across all of it — issuing market-rate bonds, capitalizing below-market revolving funds, and making direct investments in infrastructure and providing grants, sometimes all within a single program.
- Philanthropy can also sit across the spectrum in a similar way - as an investor, asset owner, and grantor. Not exclusively, but in adaptation finance, private capital tends to sit on the 'higher returns' side of the spectrum.
- Economic incentives - insurance pricing, loan terms, credit ratings, taxes and subsidies can act like a dial, moving investments along the continuum by changing how risk and return are priced. A project that today requires grant funding could become financeable with the right incentives.

- Finally, projects can combine multiple investment instruments through blended finance, depending on the applicability of a given stage of a project to the various funding instruments described. For instance, with alignment around a shared goal and understanding of the financial needs of a given project, government could support a “high risk” portion, and philanthropy can provide the “mezzanine” portion; this then allows private capital with market rate returns to invest where it is more aligned with their risk and return models. In a resilience context, this “capital stack” approach facilitates a larger investment amount and blended-down interest rate to address financial viability, while creating a financial vehicle to strengthen goal alignment.

The Capital Continuum

Funding and financing mechanisms mapped to financial return

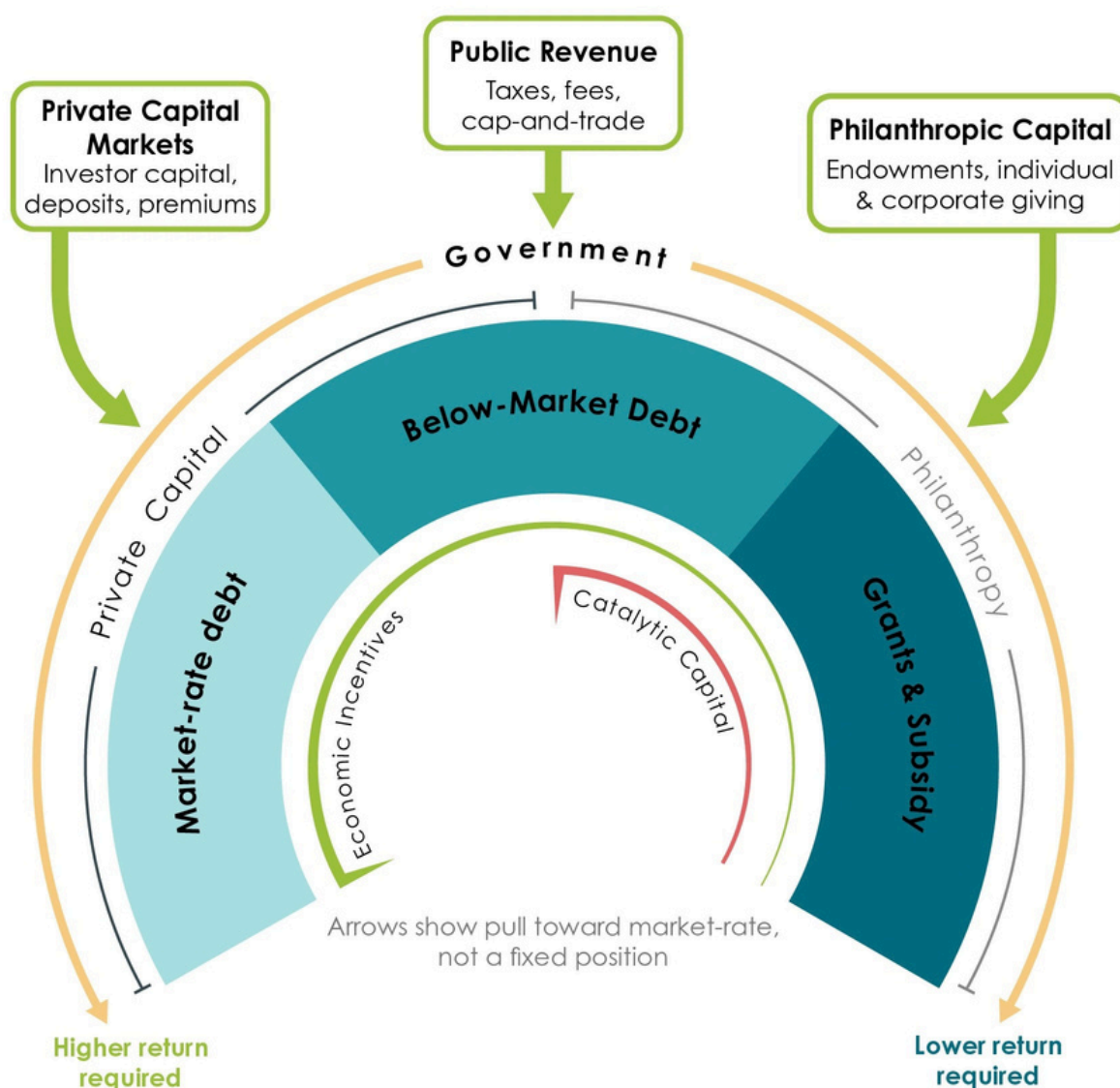


Figure 2.1. The capital continuum: funding and financing mechanisms mapped to financial return.

CHAPTER 3. UNDERSTANDING THE DEMAND SIDE OF RESILIENCE INVESTMENTS: RISK OWNERSHIP AS AN ORGANIZING MODEL

This chapter examines the demand side of resilience investment. The idea is simple: who owns climate risk and for how long influences why different actors have different reasons to invest in risk reduction. Funding and financing choices that ignore risk ownership do more than miss opportunities, they can leave risk, and its costs, with the people and institutions least able to handle it. This happens because investment decisions tend to follow incentives, and if the risk isn't clearly tied to the party making the decision, there's little reason for anyone to pay to reduce it.

To illustrate this idea of risk ownership as a way to understand demand for resilience investments, the chapter introduces the idea of a 'risk ownership stack' (Figure 3.1). This model visualizes *who* holds climate risk and for *how long*, identifying who has the ability and authority to manage risk, and where investment incentives do and do not exist.

Defining Risk Ownership

In the simplest cases, it's easy to say who owns a risk. The International Organization for Standardization defines a risk owner as a “person or entity with the accountability and authority to manage a risk” — a single, identifiable party who both bears the consequences of a risk and holds the levers to manage it.²² Many everyday risks fit this model. The owner of a car, for example, is also the owner of its accident risk: they bear the costs of a crash, and they control the ‘magnitude’ of the risk through how, when, and how often they drive and through the safety features they choose to pay for. The consequences of risk, and ability to reduce it, sit in the same hands, so the incentive to invest in risk reduction is direct.

Climate risk breaks this model. For the physical risks that climate change is intensifying — wildfire, flood, extreme heat, hurricanes, drought, and sea-level rise, for example — there is rarely one entity that bears all the consequences, and never one that can fully and exclusively influence the magnitude of the risk. For instance, reducing a community's wildfire risk requires many actors, from homeowners to other local landowners to local and sometimes state or federal governments.

Understanding risk ownership starts with answering three questions:

- **Who bears the cost of the risk?** The entities who absorb losses when hazards materialize, whether those losses are from property damage, displacement, financial defaults or claims, service disruption, or other expenses.
- **Who benefits from risk reduction?** The actors whose exposure, costs, or losses are reduced when risk mitigation is undertaken.
- **Who has the ability, accountability, and resources to influence the risk?** The actors who are accountable for a risk, hold the levers (e.g., land-use authority, building standards, capital, operational control) that determine how large the risk becomes, and the financial resources to pay for risk reduction.

These roles often overlap — an infrastructure agency, for example, may both bear the cost of a risk and hold the authority to reduce it — but just as often they don't: the actor with the authority to raise building standards is rarely the one absorbing the flood losses. That gap is what makes adaptation finance structurally hard. Beneficiaries in particular tend to be more numerous and more diffuse than the actors positioned to actually influence the risk, and the two groups aren't always the same people.

Four features of climate risk ownership deserve emphasis:

- **Ownership is fractured.** Multiple entities sit on both dimensions of ownership — bearing costs and influencing outcomes — with no single actor holding both completely.
- **Ownership is often unrecognized.** Some risk owners do not realize or acknowledge the risk they hold, in part because many markets — from lending to housing to insurance — do not yet price future climate risk, or they price it inconsistently. Adding to this challenge, information on risks may not be fully or widely communicated to all relevant parties. Recent research estimates that U.S. residential property alone may be overvalued by roughly \$121–237 billion relative to projected increases in flood risk as the planet warms, which means owners, lenders, and local tax bases are carrying risk that their balance sheets do not show.²³ In 2022, economic losses from natural disasters totaled approximately \$275 billion, but less than half was covered by insurance - \$125 billion.²⁴
- **Authority and resources are frequently separated.** Some actors have the mandate to manage a risk but not the resources to act on it — a mismatch that occurs at every scale, from households to local governments.
- **Ownership shifts at thresholds.** Severe events can trigger transfers of ownership from one entity to another — the line at which a disaster passes from local to state to federal management, or at which a private insurance market gives way to a public insurer of last resort.

Risk Ownership Across Time

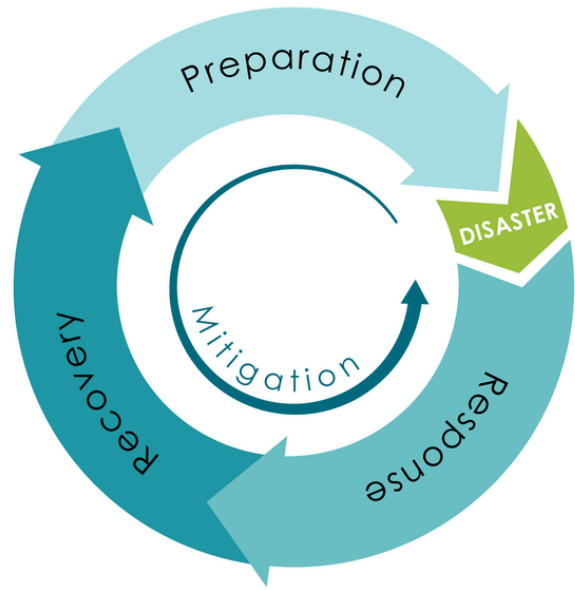
Another factor in defining risk ownership is the element of time - both in terms of timing relative to a disaster (before, during, or after) and how long risks are held in financial terms.

The disaster cycle: ownership shifts across phases

First, ownership shifts across the phases of the disaster cycle (see figure). During the **preparation phase**, ownership of climate risks can be at their most diffuse and investment decisions made here determine everything that follows. For example, local land use decisions, local or state building codes, household investment decisions, business disaster plans, and community hazard programs all shape the extent of the risk when a disaster or the next event happens. This is also where investment is often the most cost-effective: benefit-cost studies of pre-disaster mitigation consistently

find returns well above break-even.²⁵ Yet precisely because ownership is diffuse before an event, it's difficult for any single actor to capture enough of the benefits to justify the investment alone. For example, the often cited positive returns of mitigation is based on benefits across all of society; yet,²⁶ someone (or some combination of actors) still must make that first dollar investment. This is a central collective-action problem that is addressed in chapter 4.

During event response, ownership concentrates rapidly in public institutions: emergency services, mutual aid systems, and local, state, and federal response frameworks. [†] The costs of this phase are rarely weighed in financial or budgeting decisions — they are absorbed as they arrive often through savings or “rainy day funds,” reallocating resources, or off-budget spending — but the anticipation of how actors respond in this phase can shape behavior beforehand. The reliable expectation of public response is itself a kind of standing transfer of risk ownership from private



[†] The federal government's role in disaster and resilience funding is in flux at the time of writing. Recent years have seen a pullback from historic levels of federal involvement, shifting more of the burden onto state and local governments — but federal engagement hasn't disappeared, and the longer-term trajectory is genuinely uncertain. Even a change in administration would be unlikely to fully restore the pre-existing baseline; the way the disaster system is structured may look meaningfully different from its Stafford Act-era norms for some time. This report describes the roles of federal, state, and local government as they generally function, with the understanding that the federal role in particular is actively being renegotiated.



actors to government, and also often from local to federal. Public backstops are essential — without them, many communities would be left with no way to recover at all — but they also shape pre-disaster incentives, sometimes in ways that work against resilience. The goal is not to remove public backstops, but to target and size them appropriately: strong enough to protect people who need them, without quietly shifting risk onto public balance sheets that other actors could have helped manage earlier.

During recovery, ownership of the risk shifts again, this time to whoever ends up paying to rebuild. Figuring out who that is can be contentious, since everyone affected is trying to get the money they need to recover. This can lead to disagreement and lawsuits, among insurers paying claims, households covering losses their insurance did not, lenders dealing with missed payments, and governments funding the rebuild. Governments may also put new policies in place during or after recovery that change who owns the risk the next time one happens. The choices made during recovery shape how much risk remains going forward: rebuilding the way things were puts the same risk back in place, while rebuilding to higher standards lowers the risk and the costs for everyone down the line. Recovery, then, isn't just something that costs money — but is an opportunity to change who owns how much risk moving forward. Right now, most recovery funding isn't set up to take advantage of that.

Holding horizons: how long each actor owns the risk

Second, different actors hold climate risk for different lengths of time, because some are able to walk away from it, sell it off, or move on, while others cannot. An insurer usually holds the risk of a covered property for the length of an annual contract, and — subject to regulatory rules — can reprice, non-renew, or leave a market when the next renewal comes. A tenant holds risk only while occupying a property. A property owner holds it for their tenure of ownership. A lender's exposure runs the term of a loan on paper, but is shortened in practice by refinancing, sale, and securitization. Government sits at the end of this chain: it cannot non-renew, relocate, or sell its service area.

Government holds climate risk in perpetuity.

Figure 3.1 provides an example of risk ownership as a visual “stack.” The figure organizes actors into five groups based on how long they hold climate risk:

1. Annual-contract holders (like insurers)
2. Occupancy and relationships holders (such as tenants)
3. Tenure holders (like, property owners)
4. Asset-lifetime holders (including lenders and utilities)
5. Perpetual holders (government)

Each row notes the terms for how long each actor holds risk. Section 3.5 includes a set of examples that show what the **ownership stack** looks like in practice — in the property market, in supply chains, and in California's utility–wildfire system.

Generic risk ownership stack

Actors grouped by how long they hold climate risk

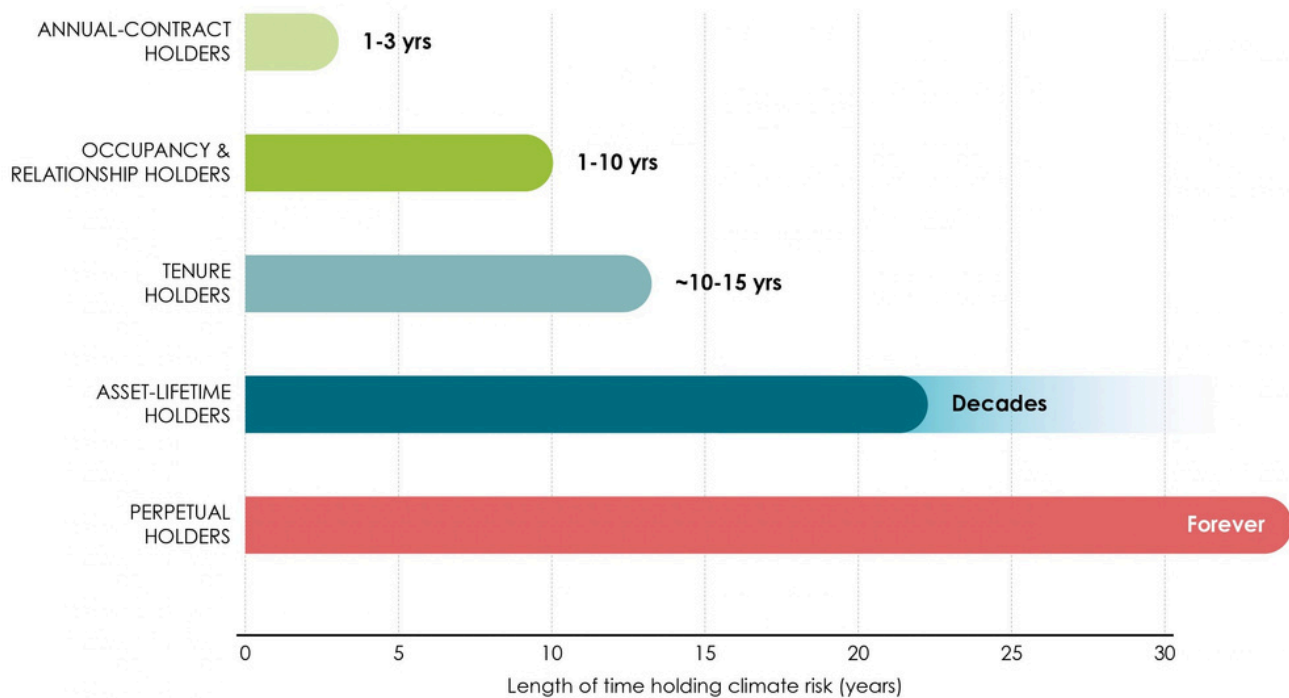


Figure 3.1. The risk ownership stack, generic form: five groups of actors sorted by how long they hold climate risk, with notes on the terms for how long each holds risk. Durations are illustrative, conveying the idea of differing holding periods rather than specific estimates.

There are two important takeaways from using risk ownership as an organizing model for understanding the demand side of resilience investment.

First, how long an entity or actor holds risk influences their willingness to invest in risk reduction. While many factors influence decisions to mitigate, a risk owner often does not voluntarily pay for risk mitigation if the payback extends beyond the time they expect to hold (or own) the risk. That said, this can change if the owner is able to recoup some of the investment over a timeframe that is reasonable for them. For example, if an owner can get a higher sale price when the property is sold or a lower insurance premium or mortgage rate. Most decisionmakers will also consider the co-benefits (or co-costs) of an investment in their decision — not just the value of the risk reduction — from peace of mind, to lower maintenance costs, to energy savings.

Second, because most private firms can shorten or shed their exposure but government cannot, **risks that other actors decline to reduce do not disappear, they often just accumulate with the risk owner of last resort.** In many cases, this is the public sector who will end up paying more in disaster recovery or support costs throughout the economy when losses from disasters cascade. This does not mean government *should* be left holding risk, or that it currently holds the right amount. It means government should have a distinctive, structural motivation to get other actors to invest in risk reduction, because whatever they do not reduce, government will eventually own. Unfortunately, the mismatch of election cycles to long-term problems, public balance sheets that also do not track future disaster liabilities, misaligned incentives, and misunderstanding of risk versus risk-reduction subsidy, are all current barriers to public sector resilience investment.

Implications for Finance

Each actor's incentive to pay for risk mitigation is related to the slice of risk they hold, the length of time they hold it, and their discount rate. This has a direct consequence: **because actors hold climate risk in different ways and for different times, each requires differently structured incentives and investment vehicles. A one-size-fits-all approach cannot work.** An instrument that fits a lender's decade-scale exposure (for example, resilience-linked loan terms) is structurally different from one that fits an insurer's annual contract cycle (premium incentives tied to certified mitigation), which differs again from what motivates an owner with a 15-year expected tenure (financing whose payback shows up at time of sale) or a government holding risk in perpetuity (long-horizon public investment justified by avoided future losses). The key idea here is simple: whether a given funding or financing choice will be able to support needed risk mitigation depends on which actor is taking ownership, and how long the actor holds the risk.

A Note on Economic Rationality

The economic framework in this report treats resilience investment as largely a calculation of expected costs and benefits, but decision-makers routinely depart from this model in predictable ways. Behavioral economics and psychology research has documented that people tend to underweight low-probability, high-consequence events like floods or wildfires until after they occur; discount future losses too steeply relative to upfront costs; and anchor on recent experience rather than long-term risk. Status quo bias and the sheer complexity of resilience decisions — which often require specialized knowledge, large upfront outlays, and trust in uncertain future payoffs — further dampen investment even when it is clearly cost effective. Beyond these well-documented biases, households and firms are also weighing resilience against other legitimate priorities: liquidity constraints, competing near-term needs, place attachment, and non-monetary values that don't reduce neatly to a risk calculation. These factors mean that policy relying solely on correcting price signals or providing information is unlikely to fully close the resilience gap; effective strategies may need to incorporate default enrollment, simplified choices, financing structures that ease upfront costs, and other tools drawn from behavioral economics.

Common misalignments and their consequences

When financing arrangements ignore risk ownership, a set of predictable challenges follow:

- **Transferring risk without pricing it in.** Actors with the ability to exit a transaction can pass climate risk along the chain without the price of that transaction adjusting to reflect it. When a bank makes a mortgage, it can either keep that loan on its own books or sell it to another buyer — commonly a government-backed mortgage entity — which moves the risk of default off the bank's books and onto the buyer's. That sale is priced: the bank pays a fee to make the transfer. But the fee that government-backed buyers charge for taking on a loan generally doesn't adjust for the disaster risk the underlying property carries.²⁷ The risk transfers, but so does mispricing, and because the price of that transfer doesn't reflect the added risk, neither the bank nor the buyer has a financial reason to invest in reducing it. The risk doesn't disappear. It just lands with whoever was willing to absorb it most cheaply, at a price that never accounted for it.
- **Horizon mismatch.** Annual insurance contracts only price this year's risk, not future climate risk. If risks increase, subject to regulatory constraints, they may raise prices. But prices are not a reflection of future risk, only how risks have changed to date. As such, they do not provide incentives or signals about climate impacts yet to materialize. This can mute incentives for risk reduction that would pay back if future risk was being priced.²⁸



- **Post-disaster support crowding out pre-disaster investment.** Public backstops for disasters are critically important features and a role of the public sector, but they come with the challenge of avoiding perverse incentives. For example, historically, federal individual assistance grants have been modest, intentionally designed to not make any survivor whole, thereby encouraging the use of insurance for disaster recovery. However, the perception of federal aid may influence decisions, although perceptions of aid might influence decisions. Local and state governments, who possess the power to limit risk in the first place (e.g., building codes and land use rules), also often receive substantial federal post-disaster assistance. However reliable disaster relief after the fact, while necessary, can weaken the incentive to reduce risk beforehand.
- **Fractured ownership producing collective-action gaps.** Where costs and influence are spread across many entities, as with networked infrastructure or region-scale hazards, no single actor has the mandate, reach, or tenure to lead, and cost-effective risk mitigation goes unfunded. For example, systemic supply chain risk from flooding on roads and railways can drive up losses across logistics, agriculture, and for public assets; with no single risk owner having the mandate or reach across the supply chain, there is no single funding or financing entity to drive comprehensive solutions.

The consequences of these misalignments follow a clear pattern: unmitigated and unpriced risk rolls downhill to whoever holds it the longest. Households absorb it as uninsured losses and lost equity; financial asset holders through portfolio performance and loss; local governments as eroded tax bases and rising service costs; and state and federal governments as insurer, lender, and rebuilder of last resort. Therefore, investment choices that ignore risk ownership amplify fiscal and social vulnerability — not as a side effect, but as the mechanical result of letting risk migrate to the actors who cannot exit a market or move to another location.



Enabling Conditions - Climate Risk Analysis

An important condition must be met for risk ownership to organize actual investments — analysis that quantifies risk, benefits, and return. Risk ownership can only organize investment if the risk — and the value of reducing it — can be known. Making that visible requires analysis that most jurisdictions and asset owners do not yet routinely undertake or acquire:

- probabilistic risk modeling that reflects changing rather than merely historical conditions,
- exposure and vulnerability assessment that translates hazard into expected losses for specific assets and populations,
- robust evidence on how mitigation measures map to avoided losses, and
- standards and certification that make those results legible and transactable to insurers, lenders, and rating agencies.

Each link matters because the systems that determine capital flows work best when value has been measured, modeled, and certified.²⁹ It is worth noting that many jurisdictions and private actors are beginning to tackle the issues outlined in the bullets above, especially applying risk modeling and developing vulnerability assessments. However, these analyses still are not routinely undertaken or operationalized across all actors and investments. With most balance sheets not tracking avoided future losses, there may be insufficient demand for these types of analyses.³⁰

One example of such an analysis, was the 2023 Federal Reserve Board's Climate Scenario Analysis pilot exercise with six of the US largest Global Systemically Important Banks (GSIBs) to explore potential climate-related vulnerabilities as a means to understand financial risk at the firm and financial system levels. Notably, climate-related risks were highly uncertain and challenging to measure with related difficulties around data and modeling challenges in estimating climate-related financial risks. As of that undertaking, such scenario analysis has not yet become mainstreamed.

The Stack in Practice: Three Snapshots

The generic ownership stack of Figure 3.1 becomes concrete when traced through specific value chains. Three snapshots follow: the property market, supply chains, and the utility–wildfire system.

Each illustrates the same three lessons:

1. Understanding where and for how long different actors hold climate risk is critical to understanding the motivations that will drive investment in risk reduction.
2. Because actors hold risk differently, incentive and investment structures must be designed actor by actor as one size will not fit all.
3. Government is a terminal risk owner in each of these 'stacks'. That does not mean it is the only one that experiences loss: disaster costs fall across the entire economy, including directly on households and small businesses, many of which are never made whole, and those losses can be multigenerational. But government occupies a unique position among these actors — it cannot walk away from risk ownership the way others can.

Snapshot 1. The property market

Figure 3.2 maps how a single home's climate risk is held by its owner (physical damage, value loss, rising premiums), its tenants (displacement and living costs), its lender (default and collateral risk over the loan's life), its insurer (claims over an annual contract), and government (disaster response, infrastructure repair, and the public services that keep the surrounding community viable).

Each actor's "market exit" options differ, so each actor's motivation to invest differs. For example, an insurer facing rising wildfire risk, subject to regulations, can reprice and non-renew policies. As such, where owners' mitigation does not reliably translate into premium reductions or sale-price premiums, owners may rationally under-invest. When risk grows and mitigation is not undertaken, insurers may pull back, which can concentrate risk in state insurers of last resort.³¹

What is missing are tools that make risk reduction financially viable and beneficial for each actor over the time frame they hold the risk. For insurers, that could mean lower premiums tied to certified mitigation work, renewed each year. For lenders, it could mean risk-adjusted interest rates based on a property's resilience. For property owners, it could mean financing that lets them pay for improvements now and recover the cost when they sell. And for risks that benefit the public as a whole, it means long-term public investment; for example, public investments in vegetation management and fire breaks that provide risk reductions to individual properties within a community, even if not the location where the treatments occur.

Risk ownership across the property market

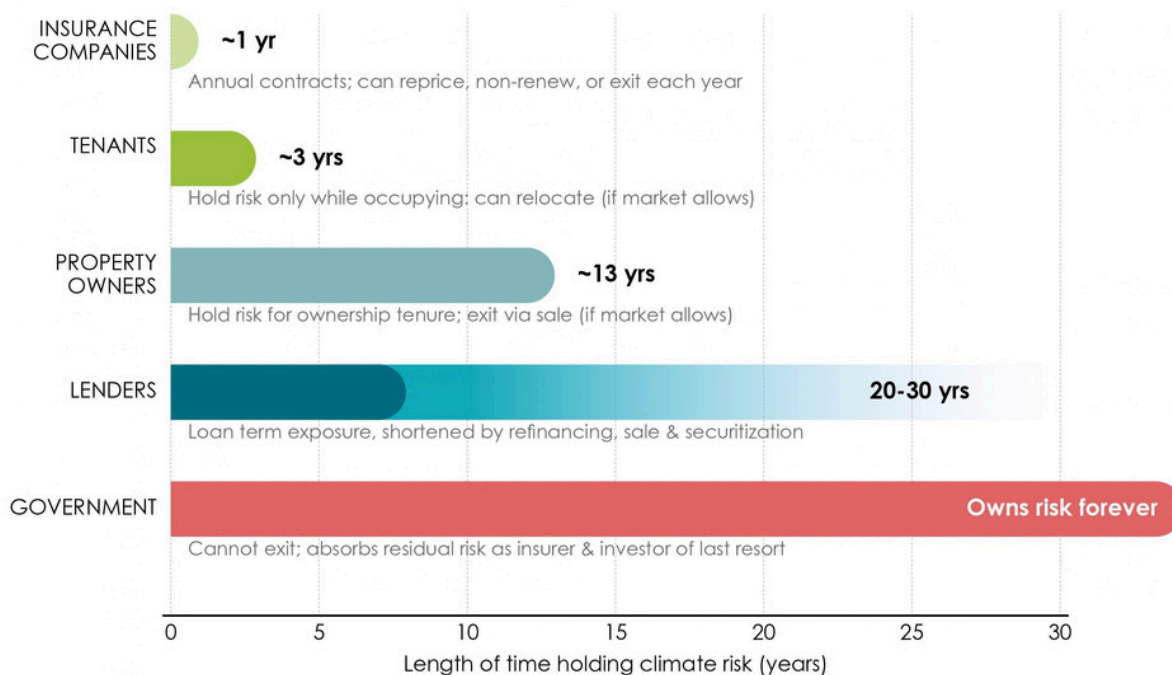


Figure 3.2. Risk ownership across the property market: how long each actor holds climate risk, shortest holder at top, government — the terminal holder — at bottom. Durations are illustrative.

Snapshot 2. Supply chains

There are also many climate risk owners in a supply chain. Firms hold the risk at their own facilities as well as the risk of suppliers facing damage and being unable to provide needed inputs. Studies of company supply chains show that when a disaster hits a supplier in one location, the resulting losses are felt by the businesses that depend on them further down the chain.³² For example, when a firm's location is hit by a wildfire or flooding, it cuts into profits for both that company and the businesses that buy from them. And when a supplier turns out to be riskier than customers expected, those customers become roughly 7% more likely to drop them — and switch to a supplier they see as less risky.³³

A telling example comes from the Thailand floods in 2011. An industrial zone was flooded, shutting down manufacturing plants that supplied hard disk drives and automotive components. This rippled through supply chains relying on “just in time” inventory and interrupting businesses around the globe. Many firms realized they had not appreciated the extreme event in their supply chains and were unprepared for it. Large firms will often have business interruption insurance, which covers losses to their own property that force a business closure. Contingent business interruption is needed to cover losses when a supplier is damaged and that causes a business shut down. These claims were so large after the 2011 floods, that this type of coverage became more expensive and harder to get as insurers repriced risk.

From a risk ownership lens, this example demonstrates that supply chains can be complex and many firms do not adequately understand the climate risk in their supply chains, especially as a warming planet is increasing and expanding those risks. This can leave firms holding a risk they never realized was on their books. It is also the case that much of the exposure in a supply chain can run through shared networks — roads, rail, ports, water, and power — where ownership is most fractured: individual firms bear the disruption costs, but often, the public sector owns the infrastructure.

Risk ownership across supply chains

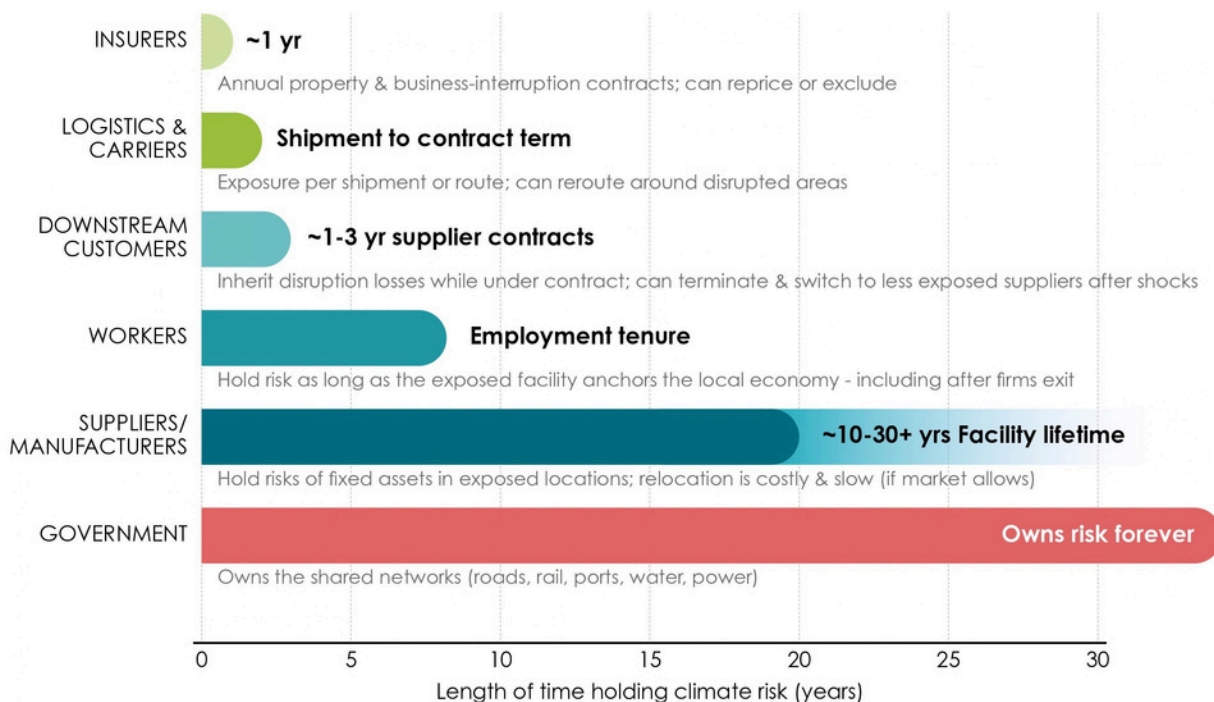


Figure 3.3. Risk ownership across a supply chain. Durations are illustrative.

Snapshot 3. California's utility-wildfire system

California's utility-wildfire system demonstrates what happens when risk ownership concentrates beyond an actor's capacity to hold it. Under the state's inverse condemnation doctrine, an investor-owned utility whose equipment substantially causes a wildfire is strictly liable for the resulting losses.³⁴ This means they are strictly liable for any damages associated with a wildfire that was ignited by their equipment, even if not found negligent.³⁵ This liability regime is unique in the country.

After being found to be the cause of the 2018 Camp Fire, the \$30 billion in wildfire liabilities losses to be paid were so large that PG&E was forced to enter bankruptcy.³⁶ In response, the legislature passed AB 1054 (2019) to re-engineer risk ownership. The state created a wildfire fund of up to \$21 billion, capitalized jointly by utility shareholders and ratepayers, to pay claims from utility-caused fires; conditioned utilities' access to the

fund on approved wildfire mitigation plans and safety certification; and required the three largest utilities to make their first \$5 billion of safety investments without shareholder return on equity.³⁷

Figure 3.4 shows how this specific example fits using the same structure as the earlier snapshots; it contains two quasi-perpetual risk holders. Alongside government, the utility itself cannot exit — its franchise obligation to serve its territory, to maintain assets for decades, and its strict liability combine to make it hold risk on a near-governmental horizon, while its shareholders, at the top of the stack, can exit in a single trading day. This example illustrates three things. First, risk ownership is not fixed — it is constructed by law and can be reconstructed, but this usually only happens after a crisis forces the question. Second, the settlement redistributed the cost of risk across the ‘stack’ — shareholders, ratepayers, and the state — because no single entity could cover the full costs. Third, the AB 1054 wildfire fund requires certified risk mitigation activities, which is an example of designing a program that moved closer to subsidizing risk reduction and away from subsidizing risk itself. The fund’s design purposefully included a mitigation-conditioned backstop, rather than an unconditional one.

Wildfire Risk ownership for California's Investor Owned Utilities

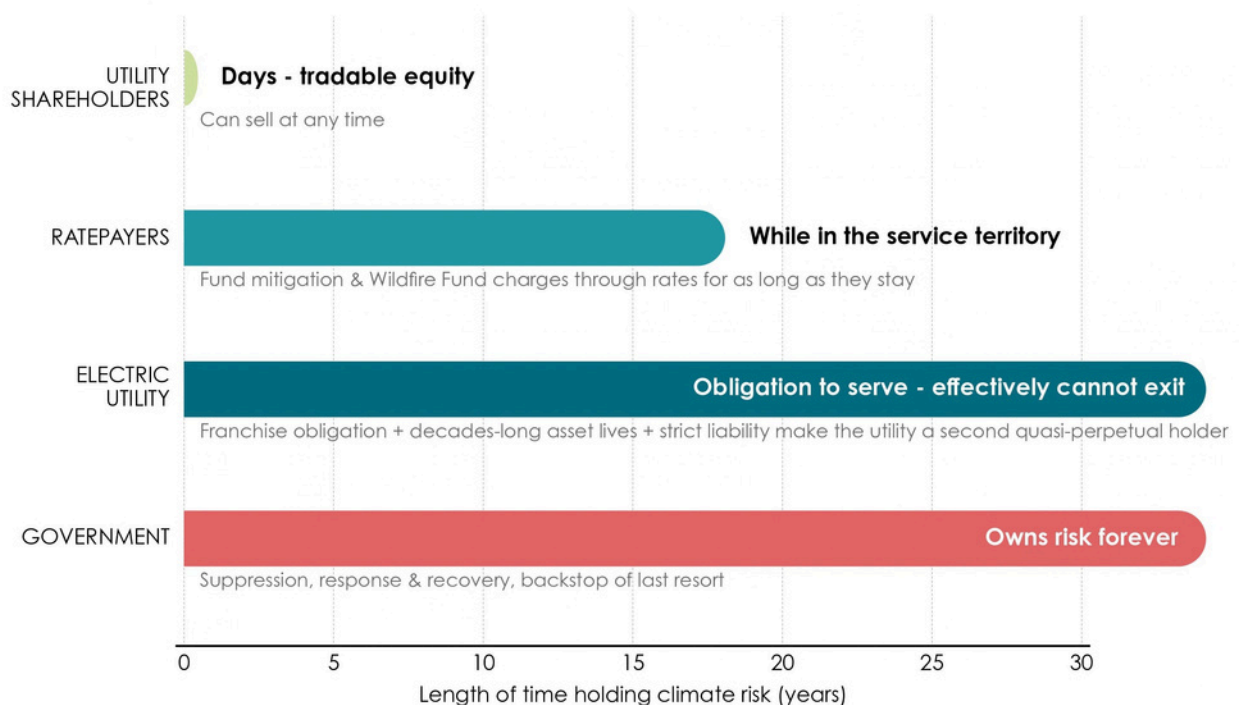


Figure 3.4. Risk ownership across the wildfire–utility system (California). Durations are illustrative. Note the two quasi-perpetual holders — the utility (obligation to serve) and government.



This chapter presented the risk ownership stack (Figure 3.1) as a model for understanding **demand** for resilience investments, and the sector snapshots are templates for how this analysis can be recurring: markets, systems, or projects can be stacked the same way, and doing so is an important analytic step to consider while evaluating investment choices and **supply** of capital (Chapter 2).

The following chapter organizes supply of capital for resilience investments to demand for those investments into a framework. The framework matches investment needs to capital and risk by asking who benefits from a given investment, how well the underlying risk and the value of reducing it have been quantified and, through the risk ownership stack, the timeframe the investment's capital stack must reach.

CHAPTER 4. MAPPING FUNDING AND FINANCING TO INVESTMENT CHARACTERISTICS

Chapter 2 mapped the supply side of resilience investments: the tools available to fund and finance investment, and how they line up along a continuum of the return each one requires. Chapter 3 turned to demand, using risk ownership — who bears the cost when a hazard hits, who benefits when risk is reduced, and who can actually influence the risk — to explain why different actors need different funding and financing tools, depending on how long they hold the risk.

This chapter is organized around who benefits when risk is reduced. It is important for investment approaches to understand not just who the beneficiaries are, but how concentrated or diffuse they are as a group. The beneficiaries could be a concentrated and defined set of entities, such as one neighborhood, or beneficiaries could be the general public — with a huge spectrum in between. Similarly, there is a spectrum in the ability of risk owners to measure the benefits of a given risk reduction.

These questions are the basis of the following decision-making framework, which is organized across:

1. the degree to which an investment's beneficiaries are diffuse or clearly defined, and
2. the degree of quantification of the benefits stemming from the investment.

Together, these dimensions define a simple framework that policymakers and practitioners can use to sort investment needs into four broad types, each with different implications for funding and financing. This framework is modified from PRE Collective's infrastructure predevelopment process.³⁸

These two dimensions are presented along two axes. The horizontal axis represents the beneficiaries of a project, ranging from diffuse and dispersed on the left, to clearly defined and direct on the right. This dimension influences funding and financing: when beneficiaries are clearly identifiable and are able to fully capture the value of a project, it is far easier to structure financing that beneficiaries repay, or to motivate them to fund the resilience benefit directly. The vertical axis captures the extent to which the benefits of a project can be quantified. For adaptation investments, the key benefit is typically risk reduction, which is the focus of this framework. For projects where risk reduction is well quantified and/or monetizable, a wider range of finance instruments becomes viable, and beneficiary contributions can be defined with more precision to drive flows of funding.

Plotting these two dimensions against one another produces the four-quadrant typology, shown in the figure below. Locating a project within this framework points to the types of funding and financing instruments, payors, and institutional structures best suited to the project. This typology is a screening and discussion tool, not a substitute for project-level engineering, actuarial, legal, financial, equity, environmental, or implementation analysis.

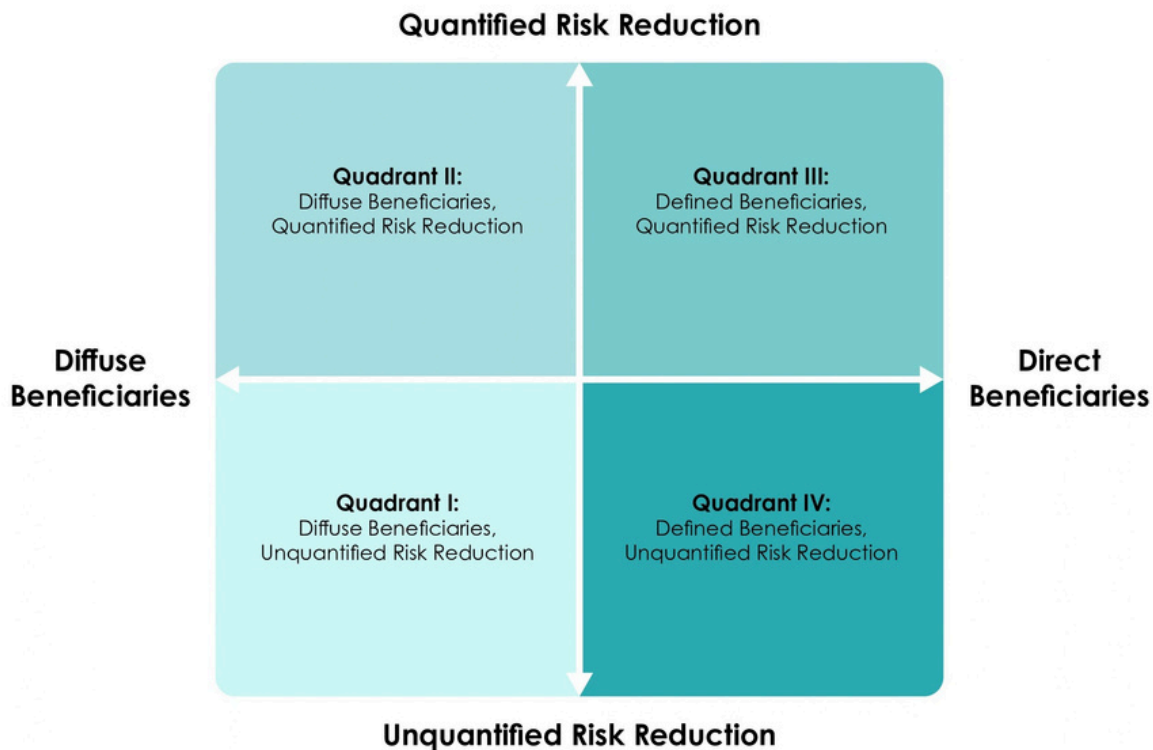


Figure 4.1: Four-quadrant typology of funding and financing approaches for climate adaptation and resilience projects. This is adapted from PRE Collective's description of the process: <https://cafwd.org/news/why-resilience-finance-starts-with-predevelopment/>.

Quadrant I: Diffuse Beneficiaries, Unquantified Risk Reduction

Projects in the bottom-left quadrant combine diffuse beneficiaries with benefits that are difficult to quantify or monetize. Investments with diffuse beneficiaries are often public goods – non-excludable and non-rivalrous, meaning once provided, no one can be effectively excluded from using them and one person's use doesn't reduce availability for others. Private markets, as discussed earlier, tend to under-provide public goods because people can "free-ride;" that is, benefit without paying. This quadrant, however, is also investments where the benefits are qualitative or not yet quantified. These aspects combined include investments such as climate adaptation planning or technical assistance to communities: value that is real and often substantial, but that is spread across a broad population and not easily quantified. It could also be projects focused on emerging or compounding hazards that are not well

understood, such as chronic extreme heat in places without heat-risk models, cascading infrastructure failures, or long-horizon coastal risks. The harm may be real and widely shared, but it has not yet been translated into the data and models that markets require.

Challenges: Since neither beneficiaries nor benefits are well defined in this quadrant, these investments are very difficult to fund or finance with private capital. The absence of a clearly defined payor and the difficulty of quantifying benefits limit revenue flows. Conventional financing tools, including most debt instruments, are poorly suited to this space, and even public budgeting processes can struggle to prioritize investments whose returns are diffuse and hard to demonstrate.

Opportunities: These investments are best matched to public sector budgets, including public research funding, and philanthropic capital, which do not require a direct repayment mechanism. Because planning and enabling work in this quadrant often lays the groundwork for more finance-ready projects, dedicating public or philanthropic resources here can at times also be understood as an upstream investment in the pipeline of investable resilience projects. It can include investments to reduce uncertainty and turn a poorly understood risk into a measurable and quantifiable one.

Quadrant I Case Study: Climate data for planning and decision-making

The State of California invests in high resolution climate modeling and applied research through its Climate Change Assessments, an important effort to understand climate-related vulnerability and future impacts throughout California. This effort turns global climate models into more localized projections for long-term changes in temperature and precipitation, with specific scenarios focusing on sea level rise, hydrology, and wildfire, allowing for improved planning and preparedness. Targeted research and development of decision-support tools elevate these models into planning and decision-making processes; for instance, applying heat models to predict the number of extreme heat days or nights, which allows public health officials to better prepare for public health needs.³⁹ The data and associated tools are available through the Cal-Adapt Enterprise. The Vulnerable Communities Platform is another tool developed to visualize community vulnerability across the state, through the intersection of climate impacts with social and demographic factors.

The beneficiaries of this work are diffuse and the benefits difficult to quantify, but their widespread use speaks to their impact, making it well suited to government and philanthropic dollars. An important outcome of providing publicly-available and localized climate data for planning is that other state and local government agencies can use the data in their own decision-making.

For example, the California Department of Transportation (Caltrans) develops detailed climate vulnerability assessments for state-owned roads, highways, bridges, airports, and railways.⁴⁰ The vulnerability assessments guide analysis of at-risk assets, leading to adaptation plans and investment to reduce the likelihood of damage to the state transportation system, which allows Caltrans to reduce costs and build resilience. The California Public Utility Commission also points to assessment data in the rulemaking for private utilities to use in decision making.

While many states do not lead their own assessment (exceptions include Massachusetts, Oregon, Washington, Hawaii, Montana and New York), many states and local governments use publicly-available data (typically federal) to develop plans or vulnerability assessments for individual agencies and sectors. The federal government has historically supported the National Climate Assessment, which provides a foundational synthesis and presentation of updated climate data for the country.

Quadrant II: Diffuse Beneficiaries, Quantified Risk Reduction

The top-left quadrant covers projects where the benefits are well quantified but accrue to large, dispersed numbers of beneficiaries. Preventing hospitalizations and other health impacts from wildfire smoke exposure are a clear example: the evidence base documenting the harm, and by extension the value of prevention, is strong and well-quantified, but those affected are numerous and spread out. Local public goods such as a levee serving an entire community fall into this quadrant as well: quantifiable risk reduction for many residents.

Challenges: The central problem funding and financing projects in this quadrant is institutional rather than analytical: even with strong quantification of risk reduction benefits, it is an institutional, governance, and logistical challenge to collect payment from a large number of diffuse beneficiaries, each of whom captures only a small share of the total value. The problem is one of aggregation, not analysis. The challenge of free-riding typically suggests the need for an enforced public-sector payment method, such as taxes, making this often a quadrant of public funding. The clear benefits, however, can unlock the use of municipal debt or other arrangements. As projects move to the right, and the number of beneficiaries becomes less and more defined, other financing becomes easier to arrange.

Opportunities: Because the underlying benefit is quantifiable, this quadrant is well suited to collective financing mechanisms that can aggregate many small, diffuse contributions into a single funding stream, such as special assessment districts, dedicated taxes or fees, or utility-style charges. Blended structures that pair public cost-sharing with such collective mechanisms can help convert well-documented benefits into a workable repayment structure. In addition, emerging community models that can bring together beneficiaries could also work well in this quadrant, as can

mechanisms to segment markets to create willing payors. Public funding mechanisms typically anchor the payment side — along with a strong role for government to serve as a convener, bringing together diverse parties that may each hold an interest — but it is the quantified risk that makes these structures possible.

Quadrant II Case Study: Philadelphia's Green City, Clean Waters Stormwater Fee

Philadelphia's older sewer lines carry both wastewater and stormwater in the same pipes across roughly 60 percent of the city. During heavy rain, that combined system overflows, sending billions of gallons of stormwater and diluted sewage into local waterways each year, a violation of Clean Water Act requirements that put the city under a legal mandate to reduce this pollution by at least 85 percent.⁴¹ Facing an estimated \$8 to \$10 billion price tag to solve the problem entirely with traditional "gray" infrastructure, the Philadelphia Water Department (PWD) instead launched a 25-year plan in 2011, called Green City, Clean Waters, that pairs lower-cost green infrastructure, such as rain gardens, permeable pavement, or tree trenches, with targeted upgrades to treatment capacity, at an estimated \$2.4 billion over the 25-year period, a fraction of the all-gray alternative.⁴²

To fund the plan and align incentives with its goals, the city restructured how it charges for stormwater service. Rather than billing every account a flat rate tied to water meter size, PWD moved to a parcel-based billing system, charging non-residential parcels according to each property's gross area and impervious area, a direct proxy for how much runoff that property contributes to the system, while residential customers pay a uniform flat charge. Property owners who install stormwater management practices that measurably reduce their own runoff can earn credits that reduce their monthly charge, turning the funding mechanism into a financial incentive as well as a revenue source.

The results have been substantial: in the program's first five years, Philadelphia installed more than 1,600 green stormwater tools across 440 public and private sites, reducing pollution from sewer overflows by 1.5 billion gallons a year, and the program continues to be tracked against its citywide 85 percent overflow-reduction target.

Philadelphia's example is a strong example of Quadrant II at work. The beneficiaries are diffuse: every resident and waterway user in the combined-sewer service area gains from cleaner water and less overflow-driven flooding, and no single one of them could capture enough of that value to pay for it alone. But the benefit itself is well quantified, tracked in gallons of overflow avoided against a legally binding regulatory target. Rather than relying on a one-time grant or general tax revenue, the city solved the aggregation problem this quadrant describes with a utility-style parcel fee tied to each property's actual contribution to the risk. The credit program layered on top shows a financing tool built for revenue collection doubling as an economic incentive, nudging property owners toward the same behavior the fee itself funds.

Quadrant III: Defined Beneficiaries, Quantified Risk Reduction

The top-right quadrant represents the most finance-ready category: a clearly defined beneficiary paired with a benefit that is quantified and often monetized. Installing an IBHS FORTIFIED roof is a representative example. The beneficiary is the individual household, and the loss-reduction impact has been documented in numerous studies and sometimes reflected directly in a reduced insurance premium.⁴³ This is the space where many investments can be made through closed-loop value, where the party that pays for the improvement is the same party that captures its financial benefit—when they have the means to do so. For lower-income households, small businesses, and under-resourced communities, there could still be a role for philanthropy and public funds to support access to risk reduction.

Challenges: Since the financial case is already strong, the barriers in this quadrant are typically frictions rather than fundamentals: low consumer awareness, the upfront cost and hassle of undertaking the work, and transaction costs associated with financing, contracting, or verification.

Opportunities: This is the quadrant where private capital, including loans, mortgage products, and insurance-linked incentives, work well. Markets can price risk effectively and align economic incentives. Public and philanthropic actors can add the most value here by reducing friction rather than subsidizing cost, for example through consumer education, streamlined financing products, or contractor certification programs that lower transaction costs and speed adoption.

Quadrant III: Case Study: The North Carolina Wind Pool's Mitigation Programs

The North Carolina Insurance Underwriting Association (NCIUA), the state's \$1 billion nonprofit “insurer-of-last-resort,” has been a leader in home retrofits to reduce hurricane damages. Beginning in 2011, NCIUA began offering premium discounts for wind-resistant roofs. Then in 2016, NCIUA began offering grants to homeowners to install an IBHS FORTIFIED roof. Its programs have assisted over 20,000 residents to date. These programs showcase Quadrant III in action: the avoided losses from FORTIFIED roofs are well quantified with a large evidence base and the benefits accrue clearly to the homeowner and to their insurer. Indeed, not only could NCIUA price premium reductions, they could model the avoided losses to their entire portfolio to justify lower reinsurance costs, using the savings to fund more grants for these roofs.

The NCIUA story also showcases the challenges of Quadrant III, which tend to be those of information and consumer frictions. When NCIUA began their FORTIFIED programs, there was lack of awareness of wind-resistant construction and its benefits and a dearth of certifiers, roofers, and builders trained in installing a FORTIFIED roof. All of this

slowed adoption and made NCIUA realize they also had to invest in awareness and workforce development for their programs to be successful.

The NCIUA has continued to be a leader in integrating resilience into all aspects of its business. They have a FORTIFIED endorsement, which allows any policyholder with a substantial roof claim to rebuild to higher standard of storm-resilience. More recently, it placed a novel catastrophe bond with a resilience payment to expand home hardening in low loss years.

All the NCIUA programs demonstrate how quantified risk reduction can be integrated directly into financial markets. Because the beneficiary (NCIUA and its policyholders) is clearly defined and the underlying mitigation measures—IBHS FORTIFIED roofs—have well-established and quantified reductions in insured losses, the financial value of resilience can be recognized and incorporated into multiple structures for financing resilience. At the same time, the NCIUA highlights the complementary role of public and philanthropic capital: years of investment in home hardening programs and the evidence base demonstrating their effectiveness helped create the measurable risk reduction that private markets could recognize and reward.

Quadrant IV: Defined Beneficiaries, Unquantified Risk Reduction

The bottom-right quadrant includes projects with a clearly identified beneficiary but a risk-reduction benefit that is not well quantified. A household wildfire preparedness plan illustrates this well. Such plans are understood to help as a useful organizing tool, but their specific value in avoided losses is difficult to measure or attribute. The beneficiary, however, is clear and defined.

Challenges: Because the beneficiary is clear but the financial case is not, the primary obstacle is motivating that beneficiary to commit their own time or money without market incentives or financial products. Without a demonstrable return, it can be harder to justify the investment on financial grounds alone, and adoption often depends on non-financial motivators such as perceived safety or convenience.

Opportunities: Education, outreach, and technical assistance that help beneficiaries understand and act on risk are the most direct lever in this quadrant. Over time, efforts to strengthen the evidence base and better quantify the benefits of these measures can shift projects toward the top-right quadrant, unlocking a broader set of financing tools.

Quadrant IV Case Study: Montgomery County Green Bank Resilient Housing Dedicated Fund

The Montgomery County Green Bank's Resilience Dedicated Fund is a revolving, low-interest loan facility that helps affordable housing owners finance climate resilience, renewable energy, and water and energy efficiency upgrades before disasters occur. Created in partnership with affordable housing borrowers in 2025, the fund combines up to \$5 million of revolving fast, flexible financing with embedded technical assistance, enabling developers to integrate resilience into predevelopment and ongoing operations, maintenance, and planned capital improvement cycles, rather than just reactive post-disaster triage cycles. The portfolio-level financing replaces the often inefficient and unpredictable cycles of grants that cover individual projects - demonstrating that below market rate financing can be more cost-effective than irregular grants.

This structure addresses a persistent financing gap: while the beneficiaries – affordable housing owners and residents – are clearly defined, resilience upgrades are often treated as optional enhancements rather than core capital needs, because their financial value remains difficult to quantify and incorporate into traditional underwriting. While a proactive approach to resilience is expected to reduce long-term operating costs, damages, and disruptions, the financial returns of certain individual investments are often not always sufficiently quantified to support conventional financing. While some, like installation of FORTIFIED roofs, have this level of quantification, many others, such as low-cost flood retrofits or landscaping to better manage stormwater or heat do not. Rather than requiring a fully monetized business case for each resilience upgrade, the affordable housing owners use flexible, mission-driven capital to finance investments across their portfolios. While the financial value of those investments may not yet be fully recognized by conventional markets, over time, as the evidence base for these interventions grows, similar investments may move toward the finance-ready conditions of Quadrant III, illustrating how public and philanthropic capital can catalyze future private investment.

Using the Framework

Locating a project within this framework can provide actionable insights on the type of funding and financing structures that may be most appropriate for a project. Projects in the upper-right quadrant are generally ready for private capital and need mainly a reduction in adoption friction. Projects in the upper-left quadrant require institutional mechanisms to aggregate diffuse payments. Projects in the lower-right quadrant need better evidence and stronger awareness to unlock financing. Projects in the lower-left quadrant will continue to depend on public or philanthropic funding, but should be understood as still necessary and foundational, as well as including upstream investment that can move future projects toward more finance-ready quadrants over time.

Given limited public and philanthropic budgets, there is often a desire to mobilize more private capital into climate adaptation — that is, to move projects into Quadrant III when possible. Doing so matters not because private financing is preferable in itself, but because it frees up scarce public dollars for the investments that most need it — those in the public good that private capital won't reach. To move investments into Quadrant III requires improving quantification of risk reduction. Where climate risk is well quantified, insurers can price it, lenders can underwrite it, mitigation standards can be written and verified against it, and the value of risk reduction can be credibly established. As such, investments in data, modeling, empirical studies, and standards development (activities in Quadrant I) can be seen to help move risk reduction projects up into Quadrant III, as shown in the figure. Much of this is predevelopment work — the early-stage effort to fill data gaps and build confidence that often determines whether financing is even an option later.

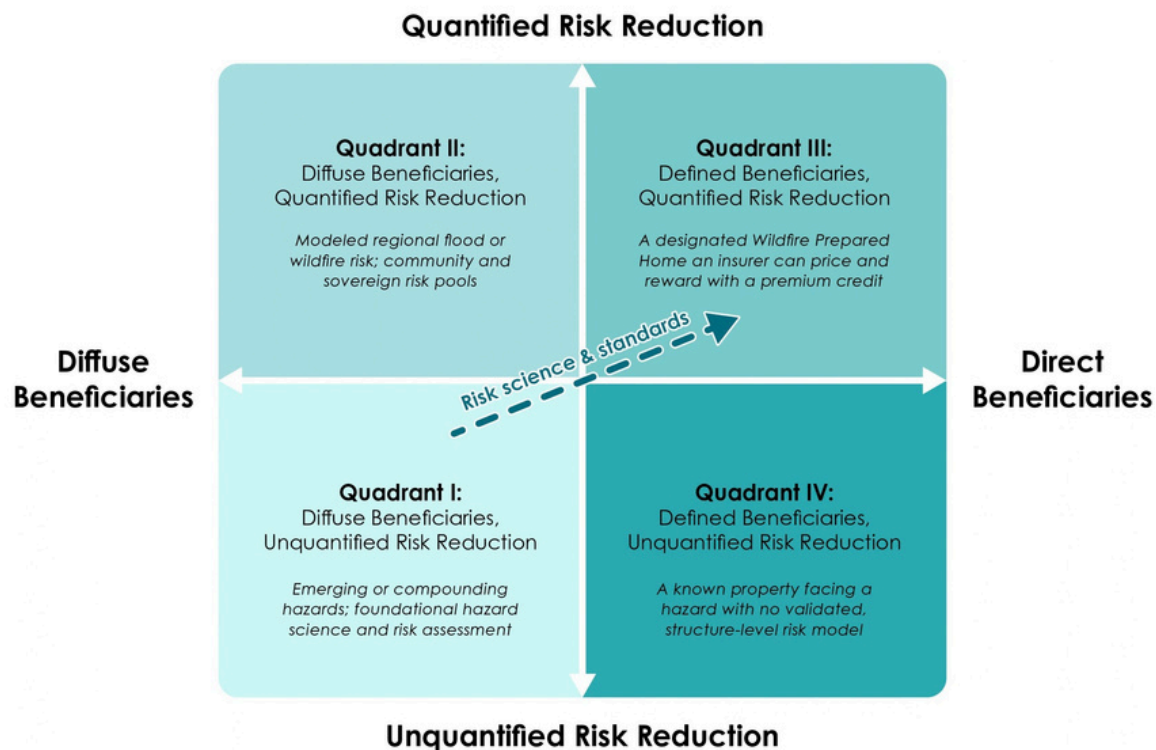


Figure 4.2: Four-quadrant typology of beneficiaries and the quantification of climate risk

The goal, however, is not to move every project into that corner and sometimes, large investments or portfolio investments might fall across multiple quadrants at once. Essential activities such as community planning, capacity building, and protection for those least able to pay are properly funded by public and philanthropic capital and treating financeability as the universal target would only divert scarce grant resources away from the work that most depends on them. Identifying where a project sits — and what specific gap in risk quantification is keeping it there — points directly to the research, data, or standards investment most likely to make it financeable.



Moving Across Quadrants Case Study: Turning Wildfire Resilience into a Financial Investment Through Research and Standards Development — The IBHS Wildfire Prepared Home Designation

One of the greatest barriers to financing climate adaptation is uncertainty. While many wildfire mitigation measures are believed to reduce risk, insurers, lenders, investors, and homeowners need confidence that those measures are both effective and consistently implemented before they can be reflected in financial decisions. IBHS developed Wildfire Prepared Home (WFPH) to provide a consistent, science-based, and verified approach to evaluating specified property-level wildfire-mitigation actions.

IBHS begins with scientific research. Through laboratory experiments, post-fire field investigations, and full-scale testing at its Research Center, IBHS has identified the building features and site characteristics that measurably reduce a home's vulnerability to embers, radiant heat, and direct flame exposure. This research is translated into a standard that specifies the combination of mitigation measures needed to improve wildfire resilience.

The program extends beyond standards development. Homes seeking designation undergo an independent third-party evaluation to verify that the required mitigation measures have been correctly implemented. This verification provides confidence that is missing from many resilience investments, creating a consistent and trusted signal that a home has met an evidence-based standard rather than relying on self-certification or isolated mitigation actions.

The WFPH program illustrates how investments in research and standards development can move resilience projects toward Quadrant III. Scientific evidence alone is rarely sufficient to unlock private capital. Research must be translated into measurable standards and paired with trusted verification before markets can confidently recognize and value reduced risk. In this way, organizations such as IBHS play an enabling role within the resilience finance ecosystem—not by directly providing capital, but by creating the evidence, standards, and credibility that allow private financing, insurance incentives, and other market mechanisms to support resilience investments.

Two points bear emphasis as the framework moves from concept to application. First, matching the right funding and financing tools to each type of project and each actor is not a fixed formula but a matter of judgment that sharpens with practice: as the approach is applied to real projects — a levee district, a wildfire-hardening program, a green bank portfolio — the patterns of what works for whom will come into clearer focus. Second, how long an actor holds risk is only part of the picture. Whether a given actor can actually influence the risk matters just as much, and the two together determine where investment can realistically be expected.

Moving Across Quadrants Case Study - Financing the Forest Resilience Bond

Forest restoration has traditionally been seen as producing diffuse public benefits (aligned with quadrants 1 and 2)—cleaner air, healthier watersheds, lower wildfire risk—that were hard to measure and even harder to invest in. However, better data and monitoring are starting to change that, making it possible to put real numbers on outcomes that used to be too difficult to quantify. The Forest Resilience Bond (FRB), developed by Blue Forest, USDA Forest Service, the National Forest Foundation, and the World Resources Institute, is a conservation finance model that funds forest restoration by pairing upfront private capital with new revenue streams from the beneficiaries of that work, typically water agencies or utilities. Impact investors provide the initial capital needed to fund restoration and fuels reduction projects. Then, the FRB brings in additional revenue by working with beneficiaries to model and quantify the many benefits of resilient forests and watersheds, from water quantity enhancement and quality protection to wildfire risk reduction, protection of infrastructure and communities, and avoided economic loss. In practice, this means projects with direct beneficiaries can now quantify benefits like water yield and quality, translating that into a repayment stream. From there, the structure builds out to include other parties who benefit more indirectly.

The FRB model works at a landscape scale: a single project can span tens of thousands of acres and generate benefits for thousands of people, utilities, and agencies at once. This difference in scale is what allows a project to move across the framework in a way an individual-level investment cannot. As a project gets larger, more direct beneficiaries can join, and the cost to each one goes down. That lower cost, combined with the added visibility of a large-scale project, makes it easier for diffuse beneficiaries to participate as well, even without a direct stake of their own. The Yuba I FRB shows this in practice: grant funding, modeled ecological co-benefits bringing in corporate capital, and federal funding all came in alongside Yuba Water Agency, the core water beneficiary, as the project scaled. In effect, the scale at which FRB projects operate enables the FRB mechanism to move within the framework—shifting a project from serving a single direct beneficiary (quadrant III) toward supporting a much broader set of diffuse ones (quadrant II).



CHAPTER 5. CONCLUSION

Communities across the country already know what would make them safer. What has kept that knowledge from turning into funded, built projects is not a shortage of ideas, but a market and policy context in which funding and financing are not matched appropriately to needed investments accounting for how risk ownership is distributed throughout the economy. That was the gap this report set out to close.

The organizing idea running through the preceding chapters is a simple one: match funding and financing not to the type of project, but to who holds the risk, and for how long, based on how well quantified risk reduction benefits are for the given investment. Chapter 2 showed that funding, financing, and incentive tools sit along a continuum defined by the return they require, and that their position on that continuum is a dial, not a fixed point. Catalytic capital and economic incentives can shift a project that requires grant funding today into something financeable tomorrow. Chapter 3 showed why that dial needs turning in the first place: different actors hold climate risk for very different lengths of time, from annual-contract holders like insurers to perpetual holders like government, and a financing tool built for one holding period rarely works for another. Financing arrangements that ignore this mismatch don't make the risk disappear — they leave it with whoever is least able to walk away from it, which is usually government. Chapter 4 turned that insight into a practical sorting tool: projects differ along how defined their beneficiaries are and how well their risk reduction can be quantified, and moving a project up and to the right on that typology — through better data, standards, and predevelopment work — is often what turns a project that depends on public dollars into one that can attract private capital instead.

None of this argues for moving every project toward private financing. Some resilience investment is, and will remain, irreducibly public: work that protects diffuse beneficiaries through risk that can't yet be quantified and has no clear path to a market-rate return, no matter how well it's structured. The point of sorting projects this way is not to eliminate the public role, it's to make sure scarce public and philanthropic dollars go to the work that genuinely depends on them, rather than being spent on projects that could have attracted private capital with the right groundwork first.

Recommendations

These recommendations follow directly from the framework laid out in the preceding chapters, organized by the audiences this report is written for.

- **Subsidize risk reduction, not risk.** Policymakers should audit resilience-related policy choices against the distinction between subsidizing risk reduction and subsidizing risk. Spending that lowers underlying risk and spending that simply offsets its consequences can look identical on a budget line, but they move future risk and cost in opposite directions.
- **Use the full capital continuum, not just grants:** Government at every level should use the full range of tools available across the capital continuum — market-rate and below-market debt, direct investment, and grants — rather than defaulting to one-time competitive grant cycles as the primary path to funding resilience. Government is the one actor positioned to operate across the entire continuum, and a funding strategy that relies on a single point of it leaves resilience investment exposed to the timing of individual grant cycles rather than a sustained pipeline.
- **Diagnose before defaulting to a grant application:** Practitioners and technical assistance providers should use the quadrant typology in Chapter 4 to diagnose what is actually missing before defaulting to a one-time grant. More than funding, some projects may instead need institutional organizing to bring beneficiaries together, risk education to motivate investment, or better quantification of risk reduction.
- **Find the pivot points for catalytic capital:** Private capital and philanthropy should look for the pivot points on a capital continuum where a small amount of flexible, catalytic capital can pull a project toward market-rate financing, rather than treating every resilience investment as either fully bankable or entirely a grant. First-loss capital and mission-driven investment placed at the right point in a project's capital stack can unlock financing that would not otherwise be available.
- **Start with risk ownership, not the funding tool:** All practitioners should treat risk ownership as the starting question for any funding or financing decision, not an afterthought. Asking who bears the cost, who benefits from risk reduction, and who can actually influence the risk — before asking which funding tool to use — is what turns a laundry list of options into a decision.

Climate risk is not going to stop accumulating while the tools to pay for reducing it catch up. But the tools already exist, in greater number and sophistication than most practitioners or policymakers currently put to use. What has been missing is a shared way to organize them. Starting from risk ownership, who holds it, and for how long, is that organizing idea, and it is available to use today.

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