Position Paper Series – SUR Lab
ISSN 2974-7937

Financing instruments for climate-neutral and resilient urban regeneration

Edoardo Croci (scientific supervisor)
Marta Ambrosio
Antonio Ashtari Tafti
Benedetta Lucchitta
Tania Molteni

Università Bocconi
SUR Lab
Sustainable Urban Regeneration Lab

Via Röntgen 1 | 20136 Milano – Italia
surlab@unibocconi.it | www.surlab.unibocconi.eu

Table of contents

List of tables

List of figures

1. Introduction

Urbanisation is a key contemporary trend which is deemed to continue in the following decades (UN, 2025). Cities are not only relevant areas for population growth, they are also critical players in the climate change transition. Currently home to 55% of the global population and producing over 80% of global GDP, they are responsible for approximately 70% of global greenhouse gas emissions and two-thirds of energy consumption (OECD, 2019). On the other hand, cities are also extremely vulnerable to climate change impacts like heatwaves, flooding, water scarcity and reductions in water quality, the spread of infectious disease-carrying vectors, storms, wildfires, landslides, and coastal flooding, due to their dense infrastructure and population (EEA, 2024). The number of extreme events has risen in frequency and intensity in the last years globally, and cities have been increasingly impacted, highlighting a more than ever urgent need for adaptation and improving urban resilience while also keeping on with emission reductions (WMO, 2024; Surminski et al., 2023).

Urban regeneration offers a strategic opportunity to address the dual challenge of climate change - mitigation and adaptation- by reducing emissions and enhancing climate resilience across critical sectors such as the built environment, mobility, green spaces, and energy and water management. As a transformative process targeting underutilized or degraded areas, urban regeneration can be steered towards climate neutrality and resilience objectives. Well-designed urban regeneration projects include low-carbon infrastructures and building solutions, to avoid the transition risk linked to the evolution of energy regulations and decrease the possibility of vacancy and obsolescence. Furthermore, they tend to have a stronger adaptation capacity, as they are planned with a long-term horizon and foresee flexible designs and solutions to cope with climate impacts (Systemiq, 2024). Indeed, addressing climate change mitigation and adaptation has become a key objective for any urban transformation project, due to regulatory drivers and an increasing market demand for sustainable and resilient assets (UN-Habitat, 2024).

Low-carbon urban development can be advanced through regeneration projects that promote compact, mixed-use neighbourhoods, retrofit existing buildings, integrate green spaces, install smart grids, and deploy sustainable mobility systems. Achieving climate neutrality, however, requires a whole-life carbon approach that considers both operational and embodied emissions from construction materials and processes, which are significant contributors to the built environment's lifecycle carbon footprint (OECD, 2024). On the resilience side, urban regeneration can reduce vulnerability to climate hazards- such as extreme heat, flooding, and drought- by redesigning public spaces and embedding innovative technological and nature-based solutions in the urban fabric. These measures enhance the resilience of people, infrastructure, and ecosystems, strengthening local adaptive capacity.

The integration of ambitious climate objectives and measures into urban regeneration projects can bring about higher investment costs compared to business-as-usual solutions, but can also provide opportunities for investors and generate a range of societal benefits (Taranu, 2024). For example, the realization of low carbon buildings compared to conventional buildings entails incremental capital cost in the range of 1% to 5%, but payback periods are in the range of 2.3 years to 4.9 years, showing the financial case for such investments (IFC, 2023). Furthermore, low-carbon investments are typically less exposed to transition risks as they anticipate future regulations about energy performance and GHG emissions, reducing the probability of being subject to write-offs and early retirement from the market (UNEP FI &IIÖ, 2022). Considering adaptation, the implementation of adaptation measures usually entails large upfront costs or additional expenses over the lifecycle of an operation (WEF, 2025a). At the same time, rising climate change impacts and associated damages can generate relevant costs to asset owners and managers, highlighting the potential savings and the economic case for including adaptation solutions in regeneration projects (Surminski et al., 2023).

Urban regeneration projects are usually complex, multi-functional and span across several years, therefore their implementation requires adequate financial resources and financial planning, relying on different sources of capital (Amirtahmasebi et al., 2016). Several financing instruments are available for public authorities and private developers engaged in urban regeneration to mobilize funding and finance needed for effective climate-neutrality and resilience-oriented projects. By means of a structured approach, this research aims to identify, categorize and analyse available financing instruments for climate-neutral and resilient urban regeneration measures, to provide stakeholders a comprehensive overview of available options and their main characteristics. Financing instruments are analysed based on key elements, including: i) main climate objectives targeted (mitigation and/or adaptation); ii) financing mechanism, considering the instrument's governance, the financial flows between different actors, the instrument repayment and revenue generation of financed measures, and the role of climate data on financial conditions. Key enablers and barriers to the adoption and diffusion of these instruments are also identified. The final aim is to develop practical insights for stakeholders involved in urban regeneration, highlighting opportunities to support and deliver resilient, climate-neutral urban transformations through effective instruments aligned with ambitious climate targets.

The paper is structured as follows: Chapter 1 (Introduction) illustrates the background, the rationale and objectives of the research; Chapter 2 (Methodology) defines the research scope and describes the analytical framework to map, categorize and analyse financing instruments for climate-neutral and resilient urban regeneration; Chapter 3 (Overview of financing instruments) provides a comprehensive mapping and categorization of financing instruments; Chapter 4 (Financing instruments selection and analysis) describes selected instruments and practical examples of projects where these instruments have been implemented; Chapter 5 (Enabling conditions and barriers to financing instruments' use and replication) discusses the main enabling and hampering factors for the use, diffusion and replication of instruments; and Chapter 6 (Conclusions and policy recommendations) draws the final considerations about the implementation of instruments in city contexts to support climate neutral and resilient urban regeneration, developing a set of recommendations tailored to different types of stakeholders.

2. Methodology

2.1. Literature review

A review of literature on funding and financing approaches for climate mitigation and adaptation at the urban level was performed, focusing on relevant reports published by international organizations, EU institutions and agencies, national bodies and national technical agencies addressing climate finance in cities. In the context of this research, urban climate finance refers to the mobilization and use of financial resources to support actions that reduce or avoid CO_2 emissions generated within urban areas or resulting from activities taking place within cities, and/or reduce the vulnerability of urban systems to the impacts of climate change and climate-related risks, by maintaining or increasing adaptive capacity and resilience. Specifically, financing instruments are defined as instruments to mobilize, structure, and channel financial resources from several sources (public, private, blended) toward investments in climate-related projects (based on WB&UNCDF, 2024; CCFLA, 2024; UN-Habitat, 2024; Deuskar et al., 2025; OECD, 2025).

Based on the literature analysis, a long list of financing instruments for urban climate mitigation and adaptation measures was compiled. The list was later screened to select only financing instruments that can be applied to urban regeneration projects, and specifically to support measures in key sectors that contribute to climate neutrality and improve climate resilience of areas and neighbourhoods undergoing a regeneration process, including the built environment, transport, green infrastructures and NBS, energy systems, water and waste. The analysis therefore focuses on financing instruments that provide or mobilize financial resources to support the realization of physical, technical or management measures targeting the reduction of GHG emissions and/or the reduction of risks driven by climate-related hazards, exposure, and vulnerabilities (e.g. development of high energy-performance districts, energy efficiency retrofits of existing buildings, integration of nature-based solutions, sustainable mobility measures, etc.). Furthermore, risk management schemes are also considered, which typically compensate for losses due to extreme events and support recovery when a disaster strikes (Brandon et al., 2025). An illustrative list of measures to integrate climate neutrality and resilience improvement into urban regeneration projects is provided in Table 1:

Built environment	Transport	Green infrastructure and NBS	Energy systems	Water and wastewater	Waste
Energy efficient building envelopes	Cleaner/efficient vehicles	Urban reforestation	Hydroelectric power	Energy efficiency in water services	Waste prevention and reduction
Renewable energy for space heating and hot water	Electric vehicles (including infrastructure)	Tree planting	Wind power	Water efficiency	Material recovery
Energy efficiency in space heating and hot water	Car sharing/pooling	Sustainable Urban Drainage Systems (SUDS)	Photovoltaics	Water reuse	Low carbon waste treatment
Energy efficient lighting systems	Improvement of public transport supply	Depaving	Biomass power plant	Stormwater management	Efficient waste logistics
Energy efficient electrical appliances	Climate proofing of transport infrastructures/vehicles	Green roofs/walls	Combined Heat and Power	Water storage	
Flood- and heat-proofing of buildings	Improvement of logistics and urban freight transport	Ecosystems restoration	Smart grids	Flood management/protection infrastructure	
Passive and active cooling systems	Bike/pedestrian lanes realization/optimization/maintenance/repair	Urban parks	Combined Heat and Power	Drainage system optimization	
Climate-proofing of open spaces/areas	Road network realization/optimization/maintenance/repair/climate proofing	Urban orchards	District heating/cooling plant	Sewer system optimization	
Post-disaster and recovery			District heating/cooling network (new, expansion, refurbishment)		
			Improved electricity interconnections		

Table 1: List of measures to integrate climate neutrality and resilience improvement in urban regeneration projects (own elaboration based on NZC, 2025; Bednar-Friedl et al., 2022; EEA, 2024)

2.2. Analytical framework

A tailored analytical framework was defined consistently with the research objectives, to categorize the financing instruments and define their underlying financing mechanism.

The framework comprises the following elements:

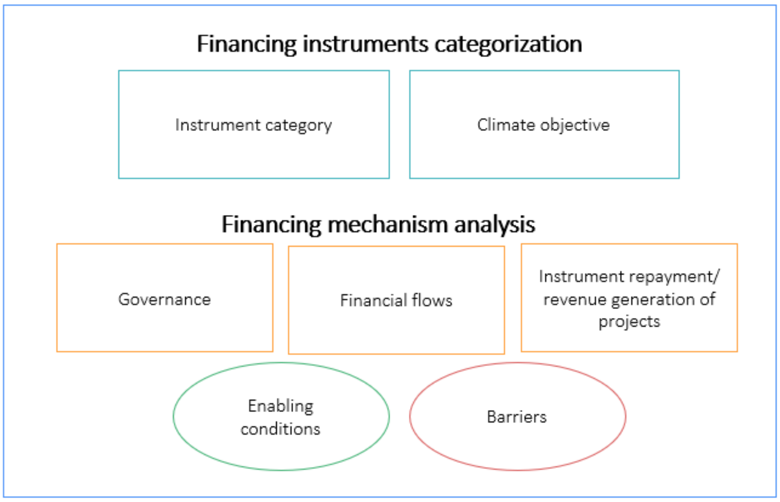

Figure 1: Analytical framework for financing instruments

- **Financing instruments categorization**, which comprises the following elements:
    - **Instrument category:** identifies the main instrument category, among the following ones identified in the literature: Transfers and grants, Fiscal instruments, Debt, Equity, Revolving funds, Third-party financing, Risk mitigation, Payment for Ecosystem Services, Credits.

        - **Climate objective:** identifies if the financing instrument mainly supports investments or projects targeted to reduce GHG emissions (mitigation), to reduce climate risks or climate vulnerability of assets and communities (adaptation), or if it targets both climate objectives.
    - **Financing mechanism analysis**, which comprises the following elements:
        - **Governance:** encompasses the institutional arrangements, roles and responsibilities of stakeholders in designing, managing and overseeing the financing instrument.
        - **Financial flows:** describes the financial flows (investments, payments, revenues) between different actors involved, and how climate data are used to define the instrument's financial conditions.
        - **Instrument repayment and revenue generation of financed projects:** describes how income is generated to repay financing, considering the specific types of measures that an instrument is designed to support and their revenue generation potential.
    - **Enabling conditions:** refer to the institutional, economic, legal and technical factors which must be in place for a financing instrument to be effectively implemented in a given context. These include e.g. regulatory frameworks, availability of co-financing, market maturity and access to technical/legal expertise (adapted from CCFLA).
    - **Barriers:** refers to the main structural, financial, institutional and informational obstacles hindering the adoption of specific financing instruments for climate-related projects and investments (adapted from CCFLA).

3. Overview of financing instruments

3.1. Current landscape of financing for climate-neutral and resilient urban development

The scale of investments needed to decarbonise and improve the resilience of urban infrastructure is considered substantial, amounting between USD 4.5 and 5.4 trillion annually (CCFLA, 2024). Furthermore, the International Finance Corporation (IFC, 2018) estimates that urban sustainable investments in six sectors (waste, water, renewable energy, electric vehicles, public transport, green buildings) in emerging markets could attract more than $29.4 trillion in cumulative climate-related investments by 2030. However, considering the average of 2021 and 2022 data, approximately USD 831 billion in annual urban climate finance was actually mobilised at global level, highlighting a relevant gap to be filled in to promote urban climate neutrality and resilience in cities. Public actors alone cannot meet these needs, making the mobilisation of private capital essential (WEF, 2025a).

Capital for urban climate finance can indeed come from various sources and providers which can be public or private, national or international (WB&UNCDF, 2024). Public financing is allocated from resources by national governments, multilateral, regional, and national development banks, global and national climate funds, bilateral financing through partner countries, and municipal own source revenues (OSR). Private financing is provided in exchange for financial returns, e.g. from debt markets, commercial banks and financial institutions, philanthropic foundations, and private investors (see Table 2).

	Public	*Private*
Domestic	• National Development banks • National climate funds • Government transfers • Municipal own revenue	• Local commercial banks • Debt market (bonds) • Local institutional investors & insurance • Private investors / companies • Local impact investors • Local foundations
International	• Global climate funds • Multilateral development banks • Bilateral country financing	• Debt market (bonds) • Commercial banks • Institutional investors • Private investors / companies • Impact investors • NGOs & foundations

Table 2: Climate finance sources (Source: WB&UNCDF, 2024)

Considering the estimates of urban climate finance mobilised at global level in 2021-22 (USD 831 billion), almost the totality (USD 814 billion, 98% of the total) targeted mitigation efforts, while only USD 10 billion was allocated to adaptation, and USD 7 billion to projects with multiple objectives (CCFLA, 2024).

Within mitigation, transport emerged as the leading investment sector, absorbing USD 424 billion (over 50% of total mitigation finance), driven largely by electric vehicle adoption and mass transit infrastructure. This was followed by buildings and infrastructure, which attracted USD 237 billion in urban climate finance (29% of the total). A significant share of these investments was directed toward retrofit interventions (USD 68 billion) and new construction (USD 29 billion), classified as energy efficiency measures. Additional funding supported the deployment of efficient appliances and lighting (USD 58 billion), the electrification of heat pumps (USD 40 billion), and the installation of solar thermal water heaters (USD 10 billion), alongside other building-related upgrades. Energy systems—primarily solar photovoltaic installations—received USD 152 billion, representing approximately 19% of total mitigation flows. Within adaptation, water and wastewater management accounted for the majority of investments, receiving 68% of total urban adaptation finance (USD 7 billion). Within this sector, wastewater treatment attracted USD 2.42 billion, while water supply and sanitation initiatives received USD 1.13 billion.

In terms of capital providers, private actors played a dominant role, contributing nearly USD 404 billion, or 49% of total urban climate finance. Within this category, households and individuals were the largest subgroup, accounting for USD 187 billion. Corporations contributed an additional USD 67 billion, while commercial financial institutions provided USD 99 billion. Public sources contributed to a lesser extent, accounting for 22% of total finance (USD 183 billion), led by governments (USD 66 billion), national development finance institutions (USD 29 billion), and multilateral institutions (USD 21 billion).

In terms of mechanisms, urban climate finance was delivered through a range of financing instruments. The largest share was provided through balance sheet equity financing, which reached USD 303 billion. This was followed by project-level market rate debt (USD 145 billion), grants (USD 49 billion), and balance sheet debt (USD 47 billion). Project-level equity and low-cost project debt accounted for USD 9 billion and USD 30 billion, respectively.

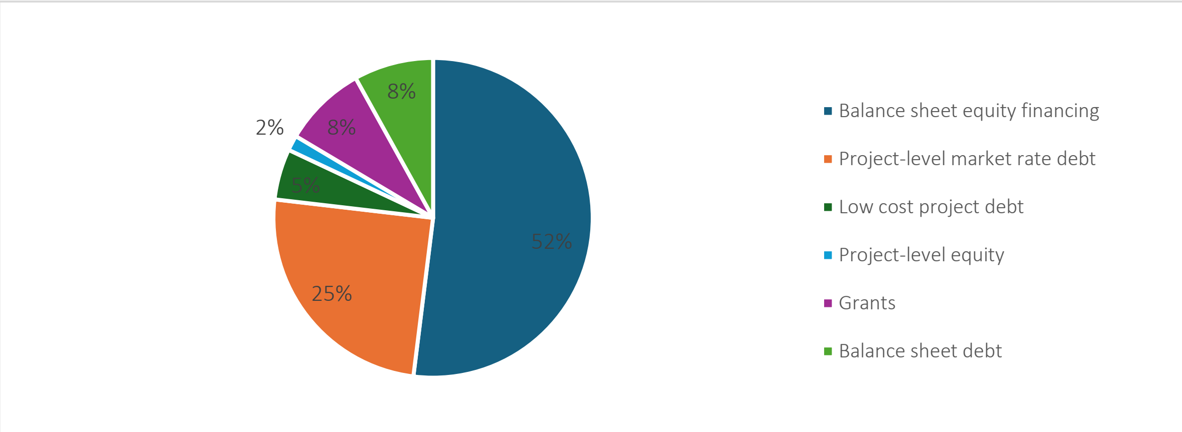

Figure 2: % share of urban climate resources delivered per instrument (mitigation and adaptation) - year 2021/2022 (Source: CCFLA, 2024)

Mitigation projects accounted for a higher share of equity instruments (38%) compared to debt (26%), whereas adaptation finance was predominantly delivered through debt (69%) and grants (8%) (ibid).

As the involvement of private investors is influenced by the risk-return profile of investment opportunities, a greater uptake of risk-sharing and innovative instruments is widely regarded as necessary to attract private capital, diversify funding sources, and enable cities to move beyond the limits of conventional public budgets. Fostering collaboration across public, private, and civil society actors, as well as approaches like blended finance- combining public and private funding sources- will prove essential at this purpose (Interreg Central Europe, 2024).

3.2. Mapping and categorization of financing instruments

Instruments to support urban regeneration projects can be broadly divided into financial and policy instruments. Financial instruments involve the direct exchange of financial resources for an urban regeneration project, including the generation of resources through non-capital markets instruments and through access to capital markets (Amirtahmasebi et al., 2016). On the other side, policy instruments defined by government bodies at different levels contribute to creating a favorable environment for investments, provide incentives for the private sector to engage in urban regeneration (e.g. zoning tools, use of building rights) or disincentives for carbon-emitting activities (CCFLA, 2023).

Several instruments can be used by governments, financial institutions and real estate players to orientate and shift investments towards building projects with high performances in terms of climate-neutrality (LaSalle, 2022). These include both "traditional" instruments as well as more innovative ones, specifically developed to support the implementation of lower-carbon buildings, appliances, and construction, and adaptation oriented-projects (ibid). For example, CCFLA (2023) performed a global mapping of available instruments, detecting 31 policy instruments and 44 financial instruments that have been proposed, tested or implemented to drive investments in low carbon-buildings, a strategic component of climate-neutral urban regeneration projects.

Focusing on financing instruments as key topic of this study, several taxonomies have been developed to identify the main types of financing instruments and their key features. The most frequent categories used in the literature distinguish between transfers/grants, fiscal instruments, equity, debt, risk mitigation, third party financing and other innovative instruments (CCFLA, 2023; GGGI, 2024).

- ***Transfer and grants*** refer to the sharing of financial resources between levels of government for public spending and service provision, and they are frequently used by higher tiers of government to incentivize local governments to focus on climate action (WB&UNCDF, 2024). Public authorities may also channel grants directly to private actors — for example, to support individuals undertaking retrofit and energy efficiency measures. These instruments usual target projects and measures that lack commercial viability, and they can take the form of technical assistance or results-based programs (CCFLA, 2023).
- ***Fiscal instruments*** gather several instruments, through which national and subnational public bodies can collect financial resources to be invested for diverse purposes including climate mitigation and adaptation. Among them:
  - *Taxes and levies:* they represent major sources of revenues for local governments. They provide interest free capital for local governments' climate projects. Moreover, the future beneficiaries share the burden of the project. At the same time, disadvantages of using taxes can be the inherent risk that the projected tax revenues are not met and that citizens show resistance to the higher taxes (NZC, 2024).
  - *Charges and fees:* Charges and fees are payments set and collected at the local level by municipal authorities for the provision or use of a specific public service, facility, permit, or municipal asset (e.g. waste collection, water and sewer services, parking, building permits). They represent a form of own-source revenue and can be designed to reflect local service costs, usage patterns, and policy objectives (WB&UNCDF, 2024; OECD, 2023).
  - *Land value capture:* Financial instruments that enable governments to recover and reinvest land value increases that result from public decisions (OECD, 2022).
- ***Debt*** instruments are financial liabilities requiring the payment of principal and/or interest by the debtor to the creditor. Considering debt instruments targeted to climate objectives, they tend to focus on energy

efficiency and on-site renewable energy measures, while adaptation-specific debt instruments remain scarce (CCFLA, 2023). They include several types of instruments such as:

  - *Bonds*: a form of debt financing issued through an underwriter and sold in domestic or international capital markets (WB&UNCDF, 2024).
  - *Loans:* they are provided by public or private financial institutions to fund investment projects or large-scale investment programs. (WB&UNCDF, 2024).

- ***Revolving funds:*** funds set up for a specific purpose. They are revolving in the sense that they self-replenish, utilising interest and principal payments on old loans to issue financing for new projects (CCFLA, 2024).
- ***Equity*** are financial instruments representing an ownership interest in an entity, such as shares of a company, where holders participate in the residual value and profits of that entity. Unlike debt, equity does not entail a contractual obligation to repay principal or interest, but entitles the holder to a share of ownership and any resulting returns. Equity instruments cover private and public equity and tend to focus on mitigation (CCFLA, 2023).
- ***Third-party*** financing in urban climate action refers to leveraging external sources of funding, beyond traditional public budgets, to support projects aimed at reducing greenhouse gas emissions and adapting to climate change impacts in cities (Cities Alliance, 2024).
- ***Risk mitigation*** instruments are used to lower the risk profiles of investments. They include:
  - *Insurance*: they are designed to reduce or transfer specific risks associated with urban infrastructure projects- such as political, commercial, or environmental risks - in order to improve their credit profile and attract private investment (CCFLA).
  - *Credit enhancement mechanisms* (e.g., guarantees): they can be used to support local government's access to repayable finance, to compensate their lack of creditworthiness and reduce the perceived risk of lending to municipalities (WB&UNCDF, 2024).

Other types of instruments include:

- ***PES***: A transaction mechanism through which one or more ecosystem service (ES) buyers compensate one or more ES providers for securing the provision of a clearly defined environmental service, subject to the condition that the service is effectively delivered (conditionality) (OECD, 2023).
- ***Credits***: tradeable instruments that attribute monetary value to verified environmental benefits by quantifying and certifying reductions in greenhouse gas (GHG) emissions or units of biodiversity restored or preserved (OECD, 2023; IAPBC, 2024).

A further instrument- frequently used in urban regeneration projects- are Public-Private Partnerships (PPPs), contractual agreements between public authorities and private entities to deliver public assets or services. These arrangements typically involve the private party assuming management responsibilities, with compensation mechanisms linked to performance outcomes (Aili et al, 2025). Remuneration may be derived from user fees, public funds, or a combination of the two, depending on the allocation of responsibilities and the accounting treatment within the municipality's balance sheet. PPPs are not only a financing instrument but also a risk-sharing mechanism. They are structured to allocate specific risks- financial, operational, or technical - to the parties best positioned to manage them, thus improving cost-efficiency and service delivery (Global Infrastructure Hub, 2019).

3.3. Non-repayable funding and repayable financing instruments

A key criterion to differentiate financing instruments is between non-repayable and repayable. Instruments that do not imply obligations for future repayment are considered to be non-repayable (e.g. intergovernmental fiscal transfers, some types of grants). Instead, any instrument that creates future repayment obligations is -

by definition- repayable (e.g. commercial debt) (WB&UNCDF, 2024). Repayable financing instruments require a stable and recurrent flow of revenue streams to cover the costs of raising financial resources (ibid). By generating revenues, the financed project can offset costs and cover the initial investment. Revenues are produced when an entity, such as an individual end user, private company, or government, pays for the benefit of a project (ibid) or when the project developer directly benefits from monetary savings enabled by the implemented measures.

Climate mitigation and adaptation measures are chacterized by different revenue generation potential, and this is reflected also in the financing instruments that can be used to support their implementation (WEF, 2025a; IISD, 2023). Investments in decarbonisation and climate mitigation generate predictable savings or revenues that can service repayable finance, through the creation of revenue-generating assets or activities (e.g., renewable energy power plants or energy efficiency projects) (WB&UNCDF, 2024), while they also deliver co-benefits such as improved public health from better air quality, economic growth, and energy security (CCFLA, 2023)

On the other side, adaptation projects usually entail large upfront costs or additional expenses over their lifecycle, and may require longer time to generate measurable results. Additionally, they often have uncertain financial returns, and their co-benefits- such as risk reduction, economic development, and ecosystem services provision- are spread among several stakeholders (WEF, 2025a). This makes difficult for private investors to assess the financial viability of adaptation projects (IISD, 2023).

For these reasons, the design of financing mechanisms for many adaptation investments typically assumes there is no direct repayment, so they usually require public support or risk-sharing arrangements (WB&UNCDF, 2024). However, some adaptation-oriented instruments are able to monetize risk reduction benefits of resilience investments.

4. Financing instruments selection and analysis

4.1. Instruments selection

The list of financing instruments identified from the literature was screened to select only those involving capital repayment obligations, suitable to support climate neutral and resilient measures within urban regeneration projects. Furthermore, also revenue-generating instruments like credits or PES are considered, as they represent an innovative approach to support the financing model of climate-neutral or resilience measures by leveraging their positive impact on mitigation/adaptation or other environmental positive externalities. Finally, PPPs are also included, for their potential application to climate neutrality and resilience measures at the urban level. Non-repayable instruments – such as intergovernmental transfers, non-repayable grants, and fiscal instruments, were excluded from the analysis. This research focus is motivated by some considerations. The use of repayable instruments for climate projects is particularly interesting for its potential to stimulate private sector's participation, which contributes to build local financial markets for climate investments. A growth in the use of repayable instruments can support the development of self-sustaining ecosystems, reducing the use of public subsidies and the pressures on public budgets in the context of tight spending constraints. Furthermore, several climate measures that can be implemented in urban regeneration projects are suitable to generate revenues or activate new revenue streams (e.g. building energy retrofits, renewable energy production, sustainable mobility services), that can support repayment of capital (WEF, 2025a; IISD, 2023). Finally, non-repayable instruments are widely analysed and considered in the literature, therefore the focus on repayable instruments provides an opportunity to enrich urban climate finance studies and deep dive into a set of complex governance and implementation challenges.

The decision to focus this research on repayable instruments does not imply that non-repayable ones should be overlooked or disregarded in the implementation of climate-neutral and resilient urban regeneration projects. Transfers and grants have traditionally been the instrument most heavily used to implement climate-related activities (WB&UNCDF, 2024). Land Value Capture instruments offer relevant opportunities to generate financial resources for climate investments in the context of urban regeneration projects, due to their applicability at the district scale.

A key point is the selection of the most suitable financing instrument (or mix of instruments) for each project and its context (IISD, 2023). Such selection should take into account the investment scale, investment needs, targeted measures, their revenue generation potential, risk profile, stakeholders which could be potentially involved, and the enabling context, including the different types of available instruments.

With these premises, the sample retained for the analysis focuses on 18 instruments, displayed in Table 3 by category and climate objective:

Macro-category	Category	Mitigation	Both	Adaptation
Debt	Bonds		• Green/climate bonds	• Resilience bonds
	Loans		• Green loans	
Revolving funds	Revolving funds		• Revolving funds	
Third-party financing	Third-party financing	• Energy Performance Contracts (EPCs) • Property Assessed Clean Energy (PACE) • On-bill financing	• Crowdfunding or citizen investment schemes	
Risk mitigation	Insurance			• Catastrophe bonds • Parametric insurance • Forecast-based financing • Weather derivatives
	Credit enhancement mechanisms		• Guarantees	
Other	Payment for ecosystem services (PES)		• Payment for ecosystem services (PES)	
	Credits	• Carbon credits • Green and white certificates	• Biodiversity credits	
	Public Private Partnership (PPPs)		• PPPs	

Table 3: Financing instruments selected for the analysis

Of these, 5 instruments target mainly mitigation objectives, 5 instruments mainly adaptation, whereas 8 can target both climate objectives depending on the specific design and implementation of the instrument.

Credit enhancement mechanisms such as guarantees have been included in the analysis as they can complement the use of debt instruments. By limiting investors' exposure to credit risk, such mechanisms facilitate the provision of commercial financing at acceptable costs (WB&UNCDF, 2024).

Financing instruments to support climate-related investments can cover different investor needs and project types (GGGI, 2024). Overall, there is no single financial instrument that can cover all the needs of climate-neutral and resilient investments in urban regeneration, also considering that urban regeneration projects are complex in nature and comprise the implementation of measures in many sectors (e.g. different building types, energy systems, transportation, green areas, open spaces, other infrastructures, etc.).

Selected instruments are described in brief in the next section, divided by instrument category. The description delves into the instrument's financing mechanism, considering the instrument's governance, the financial flows between different actors, the instrument repayment and the revenue generation of financed measures, and the role of climate data on financial conditions.

For each instrument category, a real case study from urban regeneration projects and measures related to climate neutrality/resilience is provided, to describe how innovative instruments have been put in practice, the implemented measures, stakeholders involved, achieved climate impacts and co-benefits, and main enabling factors/barriers.

4.2. Bonds

Bonds are a form of debt financing issued through an underwriter and sold in domestic or international capital markets. As fixed-income instruments, bonds allow issuers to raise capital for financing or refinancing specific projects or assets. In return, bondholders receive regular fixed interest (coupon) payments over the bond's term and are repaid the bond's principal (face value) at maturity. Thematic bonds relevant for the scope of this analysis include green/climate bonds and resilience bonds.

Green bonds typically finance projects targeting environment-related investments and benefits, such as low carbon solutions and energy efficiency. A subset of green bonds that meet specific climate eligibility criteria can be labelled as "climate bonds" under the Climate Bonds Initiative (OECD, 2019). Climate bonds can support both mitigation projects, such as low-carbon buildings, energy efficiency, waste and pollution control, low-carbon transport, informational technologies, as well as adaptation ones- such as nature-based assets and climate-responsive water investments (ibid).

Green/climate bonds are issued and managed under capital market rules, with governance frameworks relying on prospectus-based disclosure requirements, oversight by underwriters, and supervision by financial regulators. Green bonds can be structured as general obligation bonds, revenue bonds, or a combination of both, depending on the issuer's financial structure, project type, and investor preferences (Deuskar et al., 2025).

The bond issuer (e.g. municipality, public agency, utility company, private company, Special Purpose Vehicle) places a bond via an underwriter (e.g. investment bank, commercial bank, development bank). Bond holders provide capital to the issuer. The bond proceeds must be used exclusively for projects that generate environmental/climate benefits, including CO_2 reduction or/and improved resilience, and their use should be reported and communicated to investors. The achievement of environmental/climate performance targets is subject to a third-party MRV auditor's verification. The issuer allocates proceeds to interventions, reports on the use of proceeds and repays bond holders according to the bond terms. The payment of regular coupon and repayment of principals at maturity are covered by the issuer's general revenues or the project's cash flows.

Overall, the contribution of financed projects to green/climate objectives is an eligibility criterion for financing, but the bond structure and financial conditions are not tied to the magnitude of these achieved benefits.

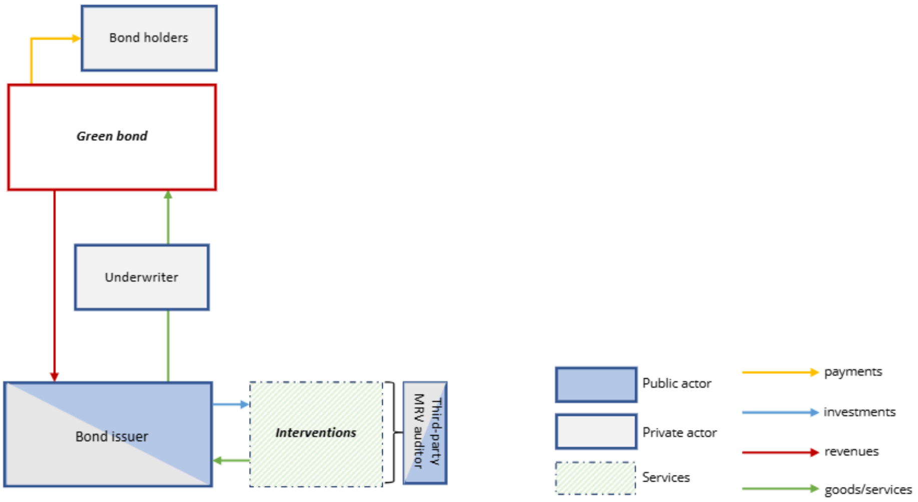

Figure 3: Model and financial flows of green bonds

General Obligation Bond – Miami Forever Bond (Florida, USA) Launched in 2017, the Miami Forever Bond is a US$400 million General Obligation Bond (GO Bond) programme financing infrastructure investments to enhance climate resilience, housing access, and quality of life across the City of Miami. The bond supports projects in five categories: Sea-Level Rise and Flood Prevention, Roadways, Parks and Cultural Facilities, Public Safety, and Affordable Housing. Issued without raising tax rates, the programme is implemented in tranches and guided by a citizen oversight board to ensure transparency and impact monitoring. **Implemented measures**: i) Launched over 100 priority projects in the first tranche (US$58.7M) ii) Delivered infrastructure upgrades in roadways, drainage, parks, and public safety iii) Initiated affordable housing development and planning efforts under a specific tranche allocated to housing affordability and resilience. **Relevant stakeholders:** *City of Miami* • Issuer of the General Obligation Bond • Oversees planning, procurement, and project delivery across tranches *Citizens' Bond Oversight Board* • Appointed by City Commission to review performance and ensure transparency *Local contractors* • Support project implementation across infrastructure and housing domains **Impacts and co-benefits**: i) Reduced risk to natural and climate hazards, promoting better access to living areas ii) Promoted social cohesion and enhanced the attractiveness of the urban environment iii) Improved the response capacity to hazards through drainage and green infrastructure iv) Raised green awareness, promoting behavioural change and more attractive lifestyles. **Barriers and enabling factors**: Coordinating multiple project types across city departments and bond categories required consistent planning, risk management, and procurement oversight. Enabling factors included phased implementation, a structured project selection model, and the establishment of dedicated monitoring and community engagement mechanisms. **Source**: City of Miami, 2018.

Resilience bonds are issued to raise capital for climate-resilient investment. Their structure links financial conditions - such as reduced premiums or improved payout terms - to the demonstrable reduction of expected losses achieved through preventive measures (e.g. flood defences, stormwater management, or green infrastructure) (Hermann et al., 2016). Governance focuses on the definition of the targeted risk, the modelling-based quantification of risk reduction, and the legal structuring of the premium rebate mechanism. The bond issuer (e.g. municipality, public agency, utility company, private company, resilience Special Purpose Vehicle) places a bond, usually with institutional investors through investment banks acting as underwriters. Bond holders provide capital to the issuer. Resilience bonds offer payouts after predefined events, but with the added feature that part of the premium is reinvested in resilience-building measures, potentially lowering long-term costs. If the issuer meets or exceeds the agreed resilience targets, they may benefit from more favorable financial terms (e.g. a lower coupon rate). Conversely, if the targets are missed, the issuer may face a financial penalty such as a higher coupon. Indeed, resilience bonds monetize avoided losses from resilience investments by quantifying the difference in expected losses between a business-as-usual scenario and one with a risk-reducing intervention. This difference is translated into the insurance premium rebate, which flows back to the issuer, therefore supporting the project.

Resilience bonds increasingly rely on the use of project-level KPIs to assess climate risks and measure the impact of financed interventions. Examples include hectares of land protected (e.g., wetlands restoration), percentage reductions in infrastructure downtime, or the number of people with improved access to resilient systems. These indicators are often verified by third parties to ensure robustness and credibility. While there is no universal framework yet, guidance is emerging from organizations such as ICMA to adapt existing green/social bond standards to the specific context of resilience finance (NAP Global Network, 2024).

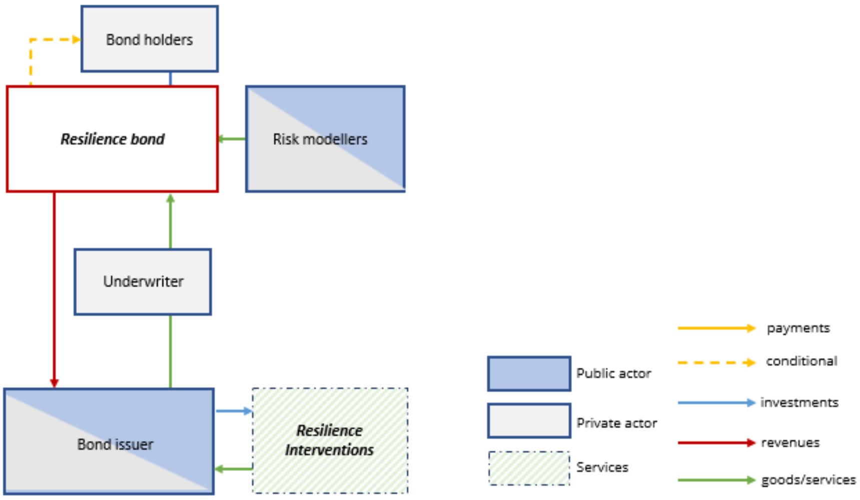

Figure 4: Model and financial flows of resilience bonds

4.3. Loans

Loans are resources provided by public or private financial institutions to fund investment projects or large-scale programmes. ***Green loans'*** proceeds can be exclusively used to fund projects with significant environmental benefits. To access green loan financing, borrowers must demonstrate that the loan structure complies with the Green Loan Principles, including internationally recognised standards for asset verification, governance, use of proceeds, project evaluation and selection, monitoring, reporting, and adherence to relevant certifications. Green loans are structured and administered by financial institutions, with governance frameworks based on agreed sustainability criteria, and reporting practices aligned with recognised frameworks.

A financial institution (public or private) provides a green loan to the borrower (public or private), which allocates proceeds to eligible interventions (single or multi-project programme). Environmental benefits must be clearly defined, measurable, and reported by the borrower. Use of proceeds is subject to a third-party MRV auditor's verification. The borrower repays the loan to the financial institution. Recurring cash flows- from utility savings, tenant charges, or operating cost reductions- can be used to repay capital over time. The financing terms are generally fixed and not tied to environmental performance metrics. However, as described above, access to a green loan typically depends on the borrower demonstrating that the use of proceeds aligns with accepted green categories (e.g. low-carbon transport, clean energy, and potentially also improved urban resilience), often following taxonomies or third-party certifications.

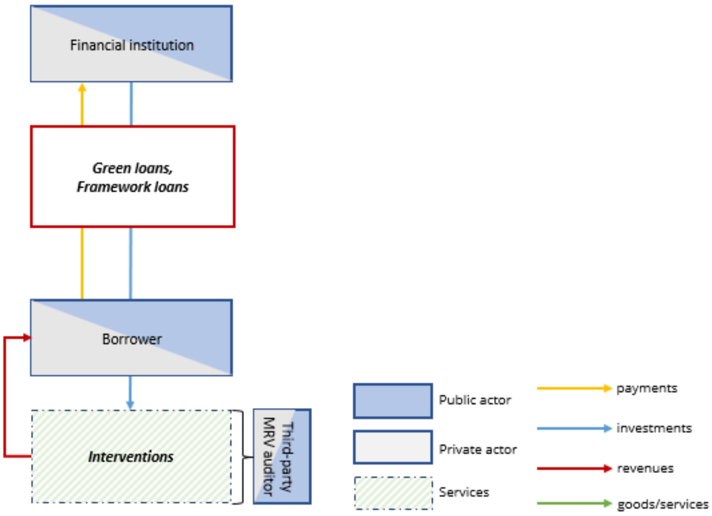

Figure 5: Model and financial flows of green loans

Publicly guaranteed loan – Riverfront Urban Renewal District (Eugene, Oregon, USA)
The Riverfront Urban Renewal District is a large-scale regeneration initiative transforming a post-industrial site along the Willamette River into a mixed-use, low-carbon urban neighbourhood. Led by the City of Eugene through its Urban Renewal Agency Board, the project combines a publicly guaranteed loan, value-capture mechanisms, and public-private co-investment to deliver public infrastructure, affordable housing, ecological restoration, and commercial development. The publicly guaranteed loan, known as the Riverfront Renewal Loan, is managed by the city authority and used by a private developer to finance project components such as sidewalk construction and improvements to the riverfront natural area. The redevelopment advances long-term climate and liveability objectives, while enhancing economic resilience and tax revenues for local jurisdictions.

Implemented measures:
i) Delivered public infrastructure, including Riverfront Park, Viaduct Park, and the Quiet Zone railway upgrade
ii) Facilitated private development of 617 housing units, a hotel, and retail space
iii) Launched the redevelopment of the historic Steam Plant — a 1930s industrial building formerly used for power generation and district heating — into a cultural and entrepreneurial hub
iv) Integrated climate mitigation and adaptation measures, including soil remediation, green construction practices aligned with LEED certification standards (e.g. high energy efficiency, sustainable building materials, and stormwater management systems), as well as provisions for active mobility and reduced car dependency within the district
v) Enabled construction of 75 affordable housing units through targeted subsidy.

Relevant stakeholders:

City of Eugene – Urban Renewal Agency Board
- Led project coordination and public investment
- Applied TIF and managed capital improvement programmes

Atkins Dame Inc.
- Main private developer for residential and commercial components
- Invested ~$113 million, including land acquisition and infrastructure co-financing

Dream Plant LLC
- Led the redevelopment of the historic Steam Plant
- Received loan support for asbestos abatement and site revitalisation

Lane Liveability Consortium
- Provided capacity-building and strategic alignment across local agencies

Homes for Good
- Partnered on affordable housing delivery and long-term affordability commitments

Impacts and co-benefits:
i) Increased employment rate and jobs (+1200 in the construction sector),and boosted local business
ii) Enhanced attractiveness of the city, and promoted healthier lifestyles
iii) Reduced risk to natural and climate hazards
iv) Enhanced social cohesion and increased property values

Barriers and enabling factors:
Coordinating multiple funding streams and private development phases required sustained administrative capacity and long-term planning. Enabling factors included continuity in local leadership, cross-departmental coordination, and the ability to align public investments with phased private development.

Source: Rowell Brokaw Architects, 2010; City of Eugene n.d.; Eugene Water & Electric Board, 2023; Daily Emerald, 2024; The River District Eugene, n.d.; McDonald, 2021.

4.4. Revolving funds

A ***revolving fund*** is a self-replenishing pool of capital used to finance projects through loans or, in some cases, grants. As projects generate savings or revenues, repayments flow back into the fund, which are then used to support new initiatives. Revolving funds are suitable to ensure sustained financing availability and reduce dependency on external or uncertain funding sources by recycling repaid capital into new projects.

Governance arrangements vary by context and may involve management by internal municipal departments—such as energy or finance departments—or administration by private financial institutions, including commercial banks.

Revolving funds usually begin with seed capital from public or private sources and create a sustainable cycle of financing that can support long-term urban regeneration projects (UNDP, 2024). An entity (public or private) establishes and capitalizes a dedicated fund under the oversight of a steering or coordinating body, with financial and technical management functions. The revolving fund provides upfront financing for interventions, which are implemented either by an internal technical agency or by an external technical agency. Investments flow from the fund to the interventions, generating revenues or cost savings linked to project performance. These revenues return to the revolving fund, replenishing its capital and enabling the continuous financing of new interventions over successive cycles.

Revolving funds that support climate-related investments can lead to lower GHG emissions, but emissions reduction is rarely a formal target of the instrument itself. The fund's main purpose is usually to finance energy upgrades or sustainable infrastructure. Therefore, the link between financing terms and climate metrics is usually indirect. Financing decisions are primarily based on projects' technical feasibility, payback periods, or cost savings. Emissions data may be used to screen, prioritise, or report on the performance of funded projects, especially if climate impact is part of the fund's mandate. Nonetheless, an entity designing, implementing and managing a revolving fund may decide to integrate specific rules related to climate performance, in order to support the most impactful project in terms of mitigation and/or adaptation.

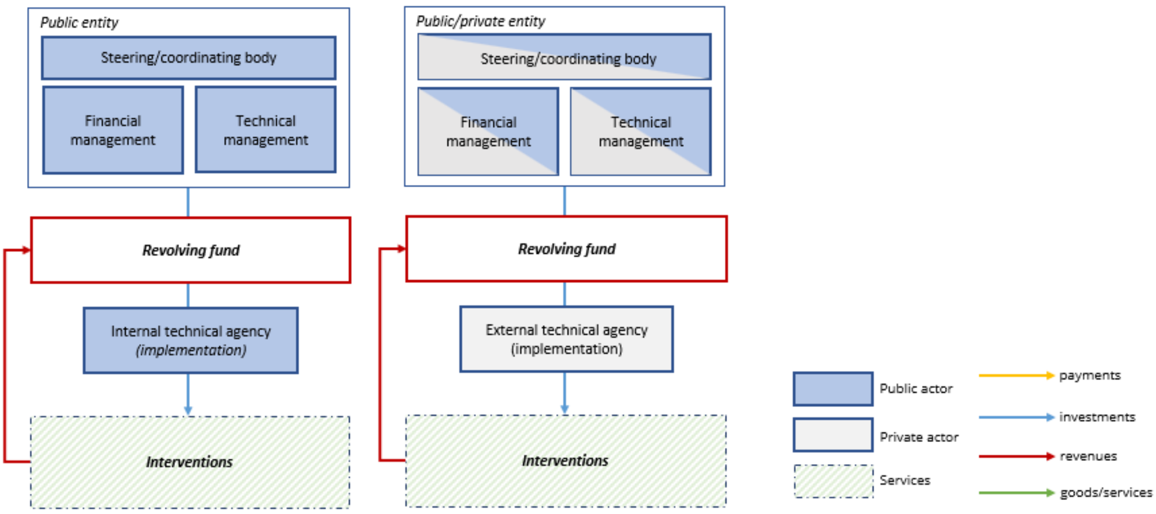

Figure 6: Model and financial flows of revolving funds

Revolving Fund – London Green Fund

Launched under London's ERDF Operational Programme, the London Green Fund is a revolving fund supporting energy efficiency and low-carbon housing projects. It channels over €480 million through three dedicated investment vehicles, combining EU structural funds, public capital from city authorities, loans from the European Investment Bank, and private finance from commercial banks and infrastructure investors. Capital returns are reinvested, enabling long-term project support.

Implemented measures:

i) Operates across energy, housing, and waste sectors

ii) Finances retrofits of public buildings and decentralised energy networks

iii) Supports energy-efficient renovation of social housing blocks

iv) Backs sustainable waste infrastructure, including anaerobic digestion and recycling facilities

Relevant stakeholders:

European Regional Development Fund (ERDF)

- Provided the core public capital base.
- Enabled the use of financial instruments under the JESSICA initiative.

Investment Board

- Comprised the Greater London Authority, the London Waste and Recycling Board, and the European Investment Bank.
- Led governance, managed reinvestment strategy, and ensured fund compliance.

Sector-specific fund managers (Amber Infrastructure, Foresight Group, The Housing Finance Corporation)

- Delivered financing and project oversight.

Housing associations (Gallions, Origin, A2Dominion)

- Implemented retrofitting measures at the project level.

Impacts and co-benefits:

i) Delivered annual CO_2 reductions of approximately 40,000 tons, primarily through retrofitting and renewable energy

ii) Generated energy cost savings and improved air quality

iii) Improved the attractiveness of the urban environment.

Barriers and enabling factors: Implementation was hindered by ERDF regulatory requirements, which required substantial legal adaptation to support repayable instruments. Further delays were caused by the need to build a viable project pipeline from scratch, with many initiatives requiring extensive permitting and technical development before reaching investment readiness. Key enabling conditions included the establishment of an independent Investment Board with decision-making authority and fund managers selected through competitive procedures and equipped with clear mandates.

Source: EIB, 2015.

4.5. Third-party financing

Energy Performance Contracts (EPCs): contractual model in which an Energy Service Company (ESCO) implements efficiency or renewable upgrades and is repaid through the resulting cost savings or additional energy produced. EPCs allow clients to undertake ambitious retrofits without upfront capital and are especially suited for large buildings or infrastructure projects (NZC, 2023A). Governance is established through contractual agreements between the ESCO and the client, requiring a clear definition of performance baselines, savings verification protocols, and dispute resolution mechanisms.

In an EPC, an ESCO finances and delivers energy efficiency interventions under a contract with the property owner, assuming upfront costs and risk. Risk allocation varies by contract type (e.g. guaranteed savings or shared savings). The ESCO is repaid under the contract conditions linked to the intervention's verified performance and energy savings.

While EPCs do not explicitly target GHG reductions, the core mechanism — guaranteeing energy savings over time — leads to a quantifiable reduction in CO_2 emissions. CO_2 reduction estimates can be included for impact reporting or compliance with climate-related goals. Therefore, the link between financial terms and GHG reductions is indirect, as it is related to reduced energy, but formalised, as the payments to the ESCO are contingent upon achieving the agreed energy savings. In some public-sector EPCs, CO_2 indicators may influence project selection or be included in reporting obligations, but financing is primarily based on energy and cost savings, not carbon metrics.

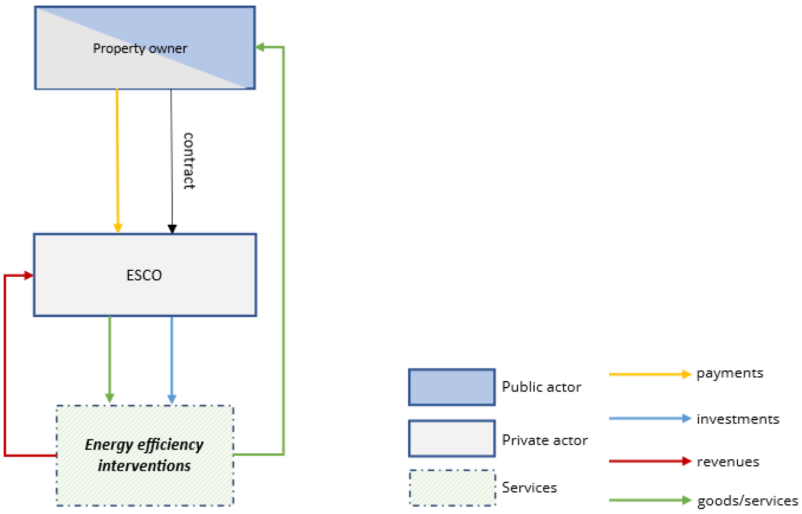

Figure 7: Model and financial flows of an EPC

Property Assessed Clean Energy (PACE): financing model that enables property owners to cover the upfront costs of energy, water, or resilience upgrades through assessments added to their property tax bills. Repayments are tied to the property rather than the owner, meaning obligations transfer if the property is sold. PACE programs are typically capitalised by private lenders or municipalities and rely on local authorities to collect and remit repayments. This structure lowers entry barriers for property owners and facilitates large-scale retrofits and renewable energy adoption (WB&UNCDF, 2024). Furthermore, it reduces financing risk by securing repayment to the property (rather than the individual), lowering default risk and enabling longer loan terms.

PACE schemes are authorised by local or state governments and administered by program operators responsible for managing financing, underwriting, and repayment collection through the property tax system. The municipality also act as guarantor and enables access to financing for property owners through a financial institution that administers the program. The financial institution provides capital to fund interventions, which are usually carried out by certified contractors, ensuring compliance with technical standards and improving project performance reliability. Investments flow toward the interventions on the property, while the property owner repays the financing through a dedicated property tax charge. Payments are collected via the tax mechanism and transferred to the financial institution, generating revenues that service the initial investment.
PACE schemes do not directly target greenhouse gas emissions. Their primary purpose is to finance energy-related upgrades for private property owners — including energy efficiency retrofits and renewable energy installations. CO_2 emissions are indirectly affected through reduced energy consumption, particularly for electricity and heating. Therefore, the link between financing terms and GHG emission reductions is indirect. PACE funding is allocated based on the type of eligible intervention (e.g. insulation, heat pumps, solar PV), not on the quantity of emissions reduced. However, most funded measures lead to CO_2 reductions. Some schemes may require a minimum energy performance improvement, but emissions indicators are not typically a formal condition for financing.

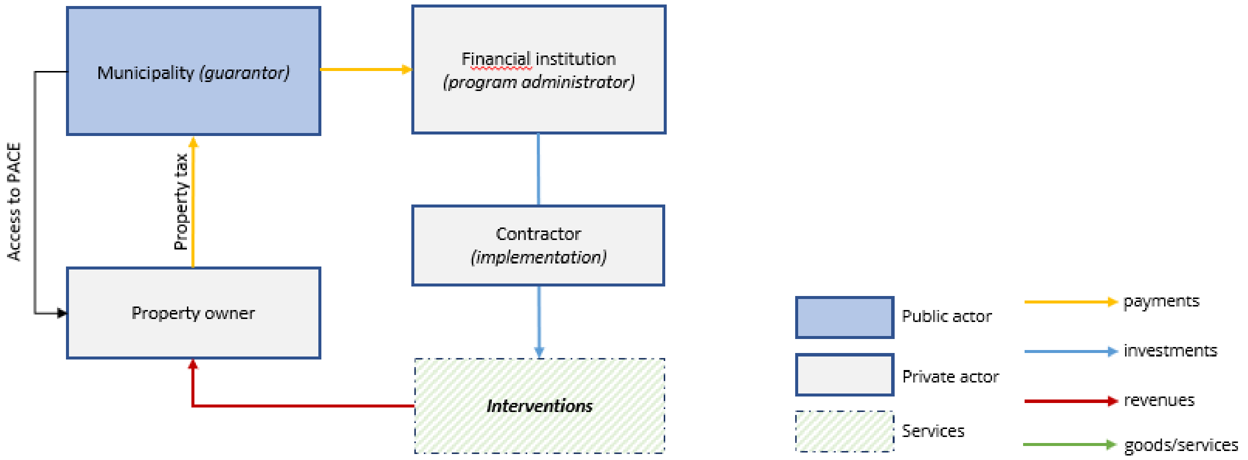

Figure 8: Model and financial flows of PACE schemes

On-bill financing: financing model where loan repayments for energy efficiency or renewable upgrades are integrated directly into utility bills. By using existing billing relationships, this approach lowers collection risks and financing costs, making it easier for households and businesses to access capital for sustainable energy improvements (City Energy, 2018). Its governance typically relies on administration by utilities or program operators, coordination with energy service providers, and regulatory approval for billing system integration.

In an on-bill financing scheme, a utility company finances energy efficiency interventions and invests directly in their implementation. The interventions generate energy savings for participating customers. The cost of the investment is recovered through a tax increment or dedicated charge applied to customers' utility bills. Customers make payments through their regular bills, revenues flow back to the utility company, and the recovered amounts cover the upfront investment in the energy efficiency interventions.

GHG emission reduction is not a primary focus of on-bill financing schemes, as they are usually designed to help consumers finance energy efficiency improvements or small-scale renewable energy systems by repaying the cost through their utility bills. CO_2 emissions are typically reduced as a consequence of lower energy use, but the instrument does not require emissions to be tracked. There is no direct linkage between emissions and the financing terms. Repayments are based on the expected energy cost savings and appear on the customer's utility bill. Emissions data may be calculated to showcase programme impact, but it plays no formal role in disbursement or repayment.

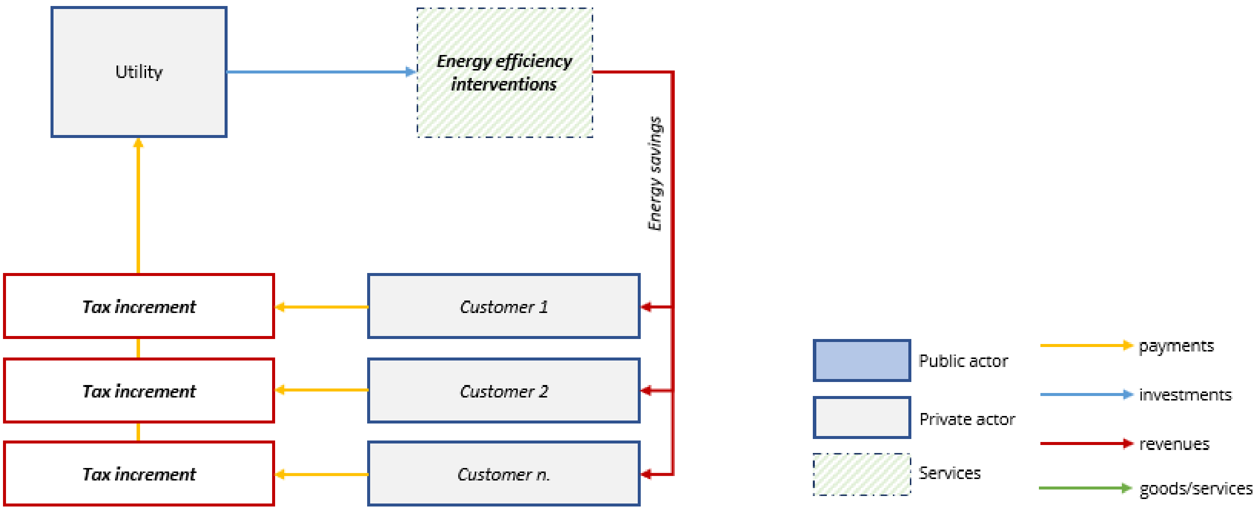

Figure 9: Model and financial flows of on-bill financing

Crowdfunding or citizen investment schemes: A financing model that mobilises small-scale investments from a large number of individuals, typically through online platforms. Investors can expect either interest-based returns or non-financial rewards, depending on the scheme. Crowdfunding is most often suited to smaller-scale projects but can increase community engagement and diversify funding sources for urban regeneration initiatives (Novikova et al., 2017). Implementation is typically managed through online platforms or local intermediaries, with governance arrangements requiring transparent communication, legal compliance, and appropriate safeguards for contributors.

In a crowdfunding scheme, a public/private actor proposes an intervention and collects fundraising through an online platform that connects multiple retail investors to a specific set of interventions. Retail investors provide capital collectively through the platform, and investments flow directly to the interventions. The interventions generate revenues, which are distributed back to the participating investors according to the agreed terms. The platform coordinates the financial flows between investors and project implementation.

Crowdfunding platforms may finance projects with potential GHG reduction impacts — such as solar panel installations, building retrofits, or energy cooperatives — or adaptation initiatives, especially community-led ones, but emissions/improved resilience are not structurally integrated in the instrument, which can finance several types of projects. Whether emissions or resilience are considered depends entirely on the nature of the individual project. In general, there is no formal link between GHG emission or resilience indicators and the amount of funding received. Financing is based on voluntary investors' interest and preferences.

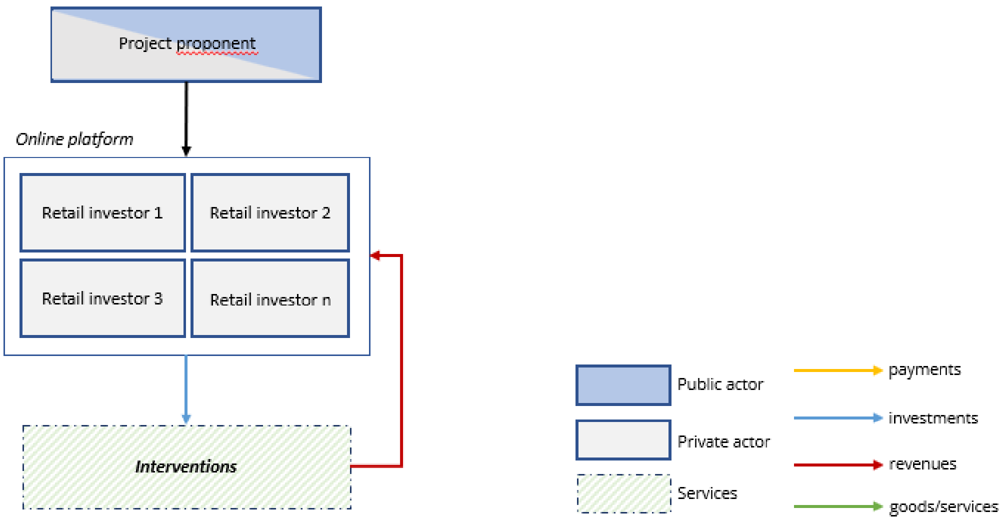

Figure 10: Model and financial flows of crowdfunding schemes

Crowdfunding – Krizevci Green Energy Cooperative
Launched in 2018, the initiative contributes to climate change mitigation and long-term energy transition goals by deploying a crowdfunding model that enables citizens to finance small-scale renewable energy infrastructure. By allowing residents to invest directly in local clean energy projects, it reflects a broader shift toward community-based financing approaches that promote civic engagement.

Implemented measures:
i) Rooftop installation of solar panels on the local Development Center and Technology Park
ii) System designed for self-consumption to reduce direct building-level emissions
iii) Promotion of decentralized, locally generated renewable energy.

Relevant stakeholders:
Green Energy Cooperative

- Designed the crowdfunding-based financing model
- Coordinated citizen investments through individual loan contracts
- Managed procurement and installation of the solar panels

City of Križevci

- Provided political support and rooftop access for the installation
- Committed to a fixed monthly energy-saving fee as part of the repayment structure.

Regional actors (REA North, Greenpeace Croatia, ACT Group)

- Supported outreach and replication through technical assistance.
- Facilitated knowledge sharing via EU-level platforms and networks.

Impacts and co-benefits:
i) Estimated annual reduction of 39 tons of CO_2 emissions
ii) Lower energy bills for the municipality
iii) Greater civic engagement and public participation in clean energy projects
iv) Financial returns for residents acting as micro-investors

Barriers and enabling factors: barriers included limited municipal capacity to manage citizen-financed models and national regulatory requirements on micro-lending. Key enablers included strong political support, integration into the City's Sustainable Energy Action Plan, and the financial attractiveness of the citizen investment scheme. Digital tools facilitated investor engagement and transparency. Successful replication depends on legal clarity, local institutional capacity, and alignment with broader energy planning frameworks.

Source: NetZeroCities, n.d.

4.6. Insurance

Catastrophe bonds are released as insurance to catastrophic events. They are designed to transfer the financial risk of catastrophic events (such as floods, hurricanes, or earthquakes) from the issuing entity to investors. In exchange for bearing this risk, investors receive a yield. However, if a predefined disaster occurs, all or part of the principal is diverted to cover the associated losses rather than being repaid (Allendorf et al., 2025).

While catastrophe bonds are not always identifiable as green or climate bonds, they can align with climate adaptation objectives when they address climate-risk and disaster resilience, and focus on reducing risks of exposure (Chatry et al., 2025).

Catastrophe bonds are typically structured through a dedicated legal entity that issues the bond and manages the proceeds (usually a Special Purpose Vehicle), with governance frameworks requiring a clear definition of trigger events and payout rules. The bond sponsor can be an insurer or reinsurer, but also public authorities or corporations. capital is raised from investors who purchase the bonds (bondholders). The structure is coupon-paying with a default depending on the occurrence of a trigger event (Hofer et al., 2023). In case the trigger event occurs, the principal is used to to cover the insurer's catastrophe-related claims obligations. If no trigger event occurs in the bond's term, the principal is returned to the investors at maturity and coupons are also paid as counterweight to the assumed risk. In this way, catastrophe bonds contribute to systemic resilience by providing insurers with contingent capital in the event of extreme losses. This reduces the likelihood of insurer insolvency and supports timely claims payments, which ultimately benefits insured parties (the sponsor) affected by the catastrophe.

Some catastrophe bonds integrate climate risk indicators directly into their trigger mechanisms. For example, payout conditions may be based on the intensity or frequency of climate-related hazards such as hurricanes or flooding. In other cases, triggers may be tied to broader economic loss thresholds rather than climate metrics, highlighting variation in the extent to which climate risk is explicitly embedded in the assessment process (Cbonds).

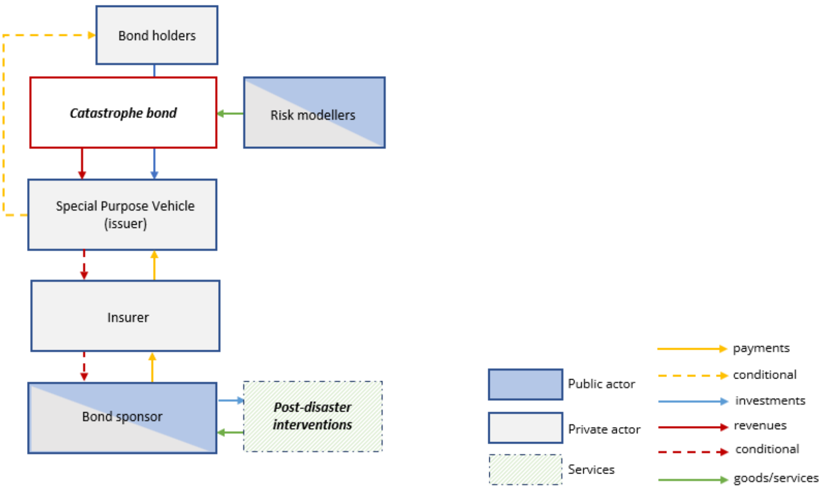

Figure 11: Model and financial flows in catastrophe bonds

Parametric Catastrophe Bond – MetroCat Re Ltd. (New York MTA)

In 2012, Hurricane Sandy caused extensive damage to New York City's transport infrastructure, leaving the Metropolitan Transportation Authority (MTA) with billions in losses and limited options for insurance coverage. Hence, in 2013, the MTA launched MetroCat Re, a dedicated catastrophe bond programme designed to provide multi-year financial protection against climate-related hazards, with a primary focus on storm surge events. The programme allows the MTA to transfer risk to capital markets through parametric insurance mechanisms, reducing its dependence on traditional insurers. Now in its fourth issuance, MetroCat Re has enabled the MTA to secure over US$200 million in total coverage.

The most recent transaction, MetroCat Re 2023-1, provided US$100 million in coverage specifically against named storm-induced storm surge. Issued via a Bermuda-based special purpose insurer established by the MTA's captive insurance company, the bond features binary payout triggers linked to water-level measurements at selected tidal gauges known to correlate with flooding in the subway system. Unlike the two previous issuances, which also included coverage for earthquake risk, the 2023 structure reverted to focusing solely on storm surge events. By relying on parametric triggers rather than indemnity-based assessments, the programme ensures faster payouts following qualifying events and reinforces the MTA's financial resilience in the face of escalating climate risks.

Implemented measures:

The parametric structure was designed to ensure rapid access to liquidity in the event of a qualifying storm surge. In such a scenario, proceeds would be channelled through the MTA's captive insurer to support emergency response and the restoration of critical infrastructure, such as the clearance of flooded subway tunnels and the repair of damaged transport assets.

Relevant stakeholders:

New York MTA

- Beneficiary of the storm surge insurance coverage
- Designed the coverage structure via its captive insurer

First Mutual Transportation Assurance Co.

- Captive insurance vehicle of MTA
- Entered reinsurance agreement with MetroCat Re Ltd.

MetroCat Re Ltd.

- Bermuda-based special purpose insurer
- Issued the cat bond and transferred risk to investors

GC Securities

- Sole structuring agent and bookrunner

EQECAT Inc.

- Risk modeling and calculation agent

Impacts and co-benefits:

i) Enhanced financial resilience to climate shocks
ii) Reduced reliance on traditional insurance markets

iii) Promoted innovation in public sector climate risk transfer
iv) Maintained operational continuity of critical transport infrastructure.
Barriers and enabling factors:
While technical complexity and basis risk posed challenges, the MTA benefited from experience with previous issuances, a mature captive structure, and investor familiarity with parametric products. Simplifying the scope to storm surge only improved investor uptake and pricing efficiency.
Source: Swiss Re, 2020; Evans, 2023; Braun and Kousky, 2021.

Parametric insurance: A class of insurance instruments that disburse predetermined payouts upon the occurrence of a specific, objectively verifiable parameter (for example, rainfall above a defined threshold, temperature anomalies beyond an agreed range, or air quality indices exceeding a benchmark). Unlike traditional indemnity-based products, compensation is not contingent on the ex-post assessment of actual damages but on the fulfilment of ex-ante contractual conditions, thereby reducing basis risk, lowering transaction costs, and enabling faster disbursement of funds (WEF, 2025b). Implementation relies on contractual agreements between the insured and the insurer, with governance frameworks defining the hazard index, trigger thresholds, payout amounts, and verification mechanisms, often involving third-party data providers.
The insurance provider enters into a parametric insurance contract with a risk holder (e.g., a municipality, public authority, or project developer). The risk holder pays periodic premiums to the insurer in exchange for predefined coverage. Payouts are triggered automatically when a predefined parameter- such as rainfall depth, wind speed, or flood levels- exceeds an agreed threshold, as measured by independent data sources. Such parameters are often selected based on historical climate data and hazard modeling to reflect the specific vulnerability of the insured asset or area.
Payouts are triggered automatically when a specified climate threshold is exceeded. For example, if water depth recorded by on-site sensors during a flood exceeds a predetermined level, the agreed sum is disbursed regardless of the actual damage.
If no triggering event occurs, the insurer retains the premiums. The payout can be used by the risk holder to cover emergency costs, stabilize finances, or finance recovery and resilience measures.

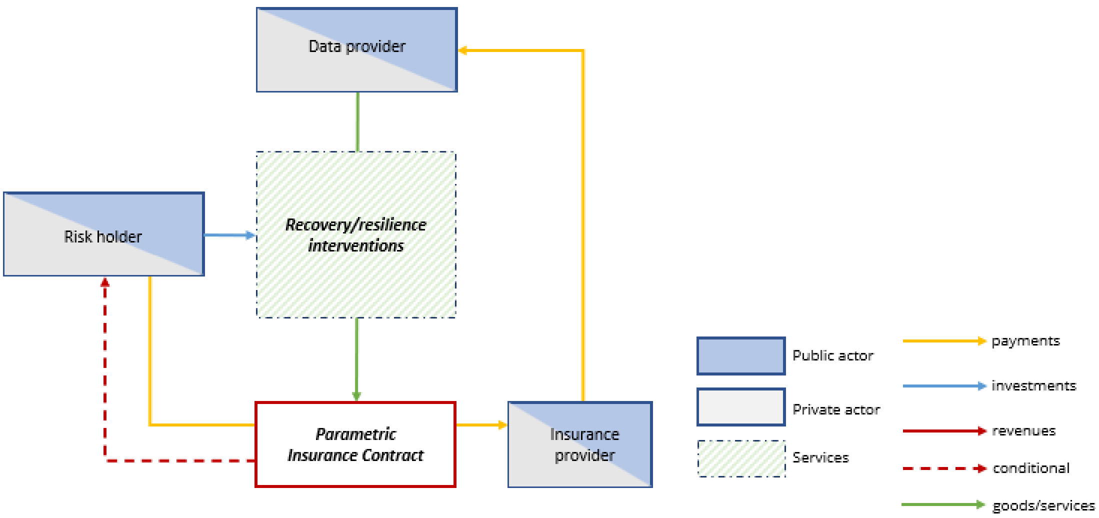

Figure 12: Model and financial flows of parametric insurance

Forecast-based financing: An anticipatory financing mechanism that releases funds automatically based on predefined triggers such as weather forecasts, risk models, or early warning systems. The objective is to make resources available before disasters occur, enabling preventive actions such as reinforcing infrastructure, protecting vulnerable assets, or mobilizing emergency response capacity. By linking financing to forecast information, it shifts resources from reactive disaster relief to proactive preparedness (Allendorf et al., 2025), allowing for planned interventions and avoiding costlier reactive responses. Implementation is typically managed through agreements among humanitarian agencies, meteorological services, and funding organizations, with governance frameworks defining forecast thresholds, pre-approved early action protocols, and transparent mechanisms for the release and accounting of funds, often supported by independent monitoring and evaluation.

The financing entity (e.g., a donor, government agency, development bank, or humanitarian fund) commits predefined funding to a forecast-based financing mechanism linked to specific early warning triggers. Capital is allocated in advance and held within a dedicated fund or budget line. When a predefined forecast threshold (such as projected rainfall, river levels, heatwaves, or storm intensity) is reached, verified through agreed meteorological or risk models, funds are automatically released to the implementing entity. The released funds are used to implement pre-agreed early actions aimed at reducing anticipated impacts, such as strengthening embankments or distributing supplies. If the forecast trigger is not reached during the defined period, the allocated funds remain available for future activation or are rolled over according to the governing arrangements.

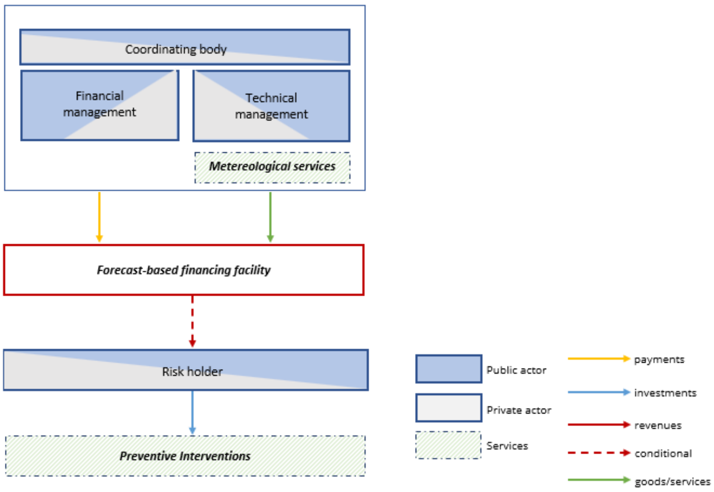

Figure 13: Model and financial flows of Forecast-based financing

Weather derivatives: Financial contracts whose payoff is linked to a weather index such as temperature, rainfall, or wind speed. Unlike traditional insurance, they do not require proof of damage but only that the index reaches a predefined threshold. This makes them suitable for hedging against climate variability, such as excess rainfall delaying construction or extreme heat increasing energy demand. They provide a flexible tool to stabilize revenues and manage weather-related risks (Hermann et al., 2016). These contracts are negotiated bilaterally or traded on specialised markets, with governance arrangements requiring a clear definition of weather indices, trigger thresholds, and payout formulas.

The derivative provider (e.g., a financial institution, insurer, or specialized risk intermediary) enters into a weather derivative contract with the risk holder (such as a municipality, utility, or project developer). The risk holder agrees to pay a premium or fixed fee to the provider in exchange for financial protection against predefined weather-related risks. The contract specifies an objective weather index measured over a defined period and location using independent meteorological data. If the weather index deviates from the agreed threshold or range during the contract term, the provider makes a payout to the counterparty based on a predefined calculation formula. Payments are tied to the deviation. For example, if average monthly rainfall falls below a specified contractual level, triggering a drought clause, the derivative contract releases the agreed compensation. The payout is entirely index-based and does not depend on actual damages. If the trigger conditions are not met, the provider retains the premium.

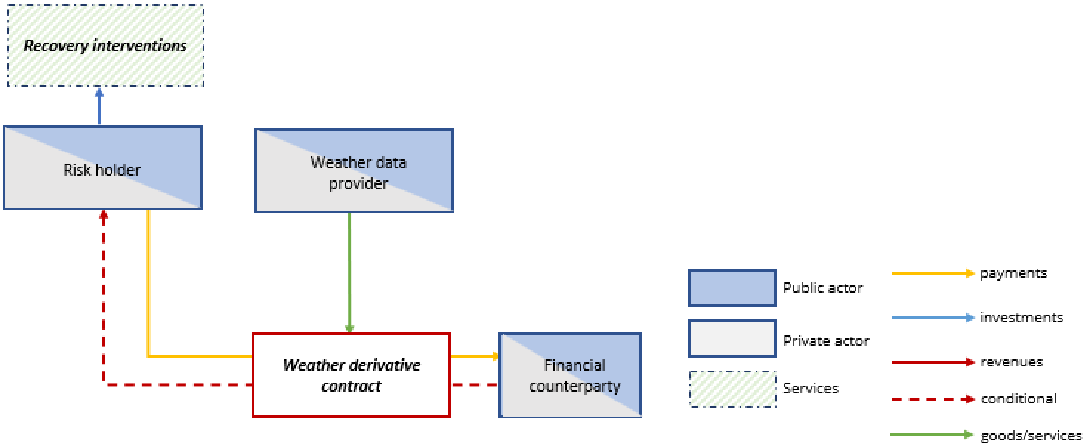

Figure 14: Model and financial flows of weather derivatives

Parametric Flood Insurance – Asheville (North Carolina, USA)

To improve resilience against urban flooding, the City of Asheville adopted Descartes Underwriting's Flood-at-Location parametric insurance solution. Triggered by real-time on-site sensors, the instrument provides rapid payouts based on flood depth, enabling municipalities to recover from both direct and indirect impacts. The solution offers an alternative to traditional insurance, addressing service disruptions, emergency response costs, and financial delays linked to natural disasters.

Implemented measures:

i) Deployed no-contact flood sensors across critical locations
ii) Structured parametric triggers based on flood depth (e.g., 3.9 feet)
iii) Defined payout schedule based on severity and site-specific thresholds
iv) Enabled immediate use of funds for both physical damage and indirect costs

Relevant stakeholders

City of Asheville

- Policyholder and initiator of the parametric coverage
- Identified shortcomings in traditional insurance coverage following Hurricane Helene

Descartes Underwriting

- Designed and provided the Flood-at-Location insurance solution
- Installed and calibrated real-time sensor network

Brokers and advisors

- Facilitated policy customization to fit municipal risk and budget profile

Impacts and co-benefits:

i) Accelerated financial recovery from flood events
ii) Covered indirect losses (e.g., service disruption, emergency costs)
iii) Increased budget predictability and financial resilience
iv) Enhanced data availability and local risk awareness.

Barriers and enabling factors:

Implementation required a reliable network of sensors and robust local data infrastructure to ensure accurate calibration of triggers. As with all parametric instruments, clear communication and technical understanding were key to addressing potential concerns about payout conditions. Enabling factors included high sensor precision, transparency of contract terms, and the speed of disbursement mechanisms.

Source: Descartes Underwriting, n.d.

4.7. Credit enhancement mechanisms

Guarantees: Instruments that reduce the perceived risk of lending and improve access to repayable finance. They provide direct risk mitigation by partially covering losses in case of borrower default, thereby encouraging private investment in higher-risk or underserved sectors. Guarantees can be provided by public or private entities and are designed to support borrowers with limited creditworthiness, thereby enabling investment in climate-aligned projects (WB&UNCDF, 2024). These instruments are typically managed by public financial institutions, guarantee funds, or development banks, with governance frameworks defining coverage rules, credit risk assessment procedures, and the administration of claims in the event of default.

In a credit guarantee scheme, a guarantor provides a guarantee to a financial institution covering part of the credit risk associated with a loan. Based on this risk mitigation, the financial institution extends a loan to the borrower, who uses the funds to finance specific interventions. The borrower repays the loan to the financial institution through scheduled payments. In case of default, the guarantor compensates the financial institution according to the terms of the guarantee.

Within this instrument, there is no direct correlation between climate indicators and financial terms of the guarantee. The mechanism is driven by financial risk metrics, not climate risk metrics. The decision to provide credit enhancement may consider climate impact as part of a broader due diligence process, but this is neither required nor standardized across cases. Brandon et al. (2025) report that guarantees have been applied to projects addressing climate risks such as storms (17%), floods (17%), heatwaves (17%), and broader resilience objectives (50%).

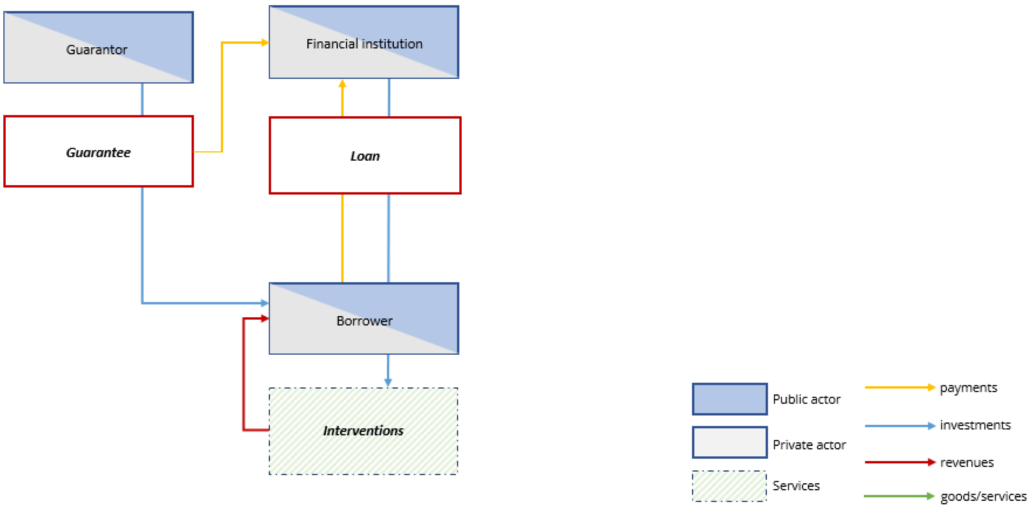

Figure 15: Model and financial flows of guarantees

Credit Guarantees – Belfius Smart Cities (PF4EE Instrument)

Implemented as part of the EU LIFE-funded Private Finance for Energy Efficiency initiative, this financing mechanism supports private-sector investments in energy efficiency across Belgium. It targets businesses and energy service companies (ESCOs) undertaking retrofits and energy upgrades, addressing market barriers through concessional loans combined with an EIB-backed credit guarantee covering up to 80% of potential losses. Delivered through Belfius Bank, the initiative aims to de-risk lending and accelerate the uptake of energy efficiency measures.

Implemented measures:

i) Focused primarily on building retrofits and energy efficiency upgrades

ii) Supported thermal insulation, replacement of inefficient heating and cooling systems, and installation of modern lighting technologies

iii) Integrated solar panels into building systems

iv) Improved building automation and energy monitoring systems

Relevant stakeholders:

European Investment Bank

- Provided the credit guarantee and concessional capital through the PF4EE facility.

Belfius Bank

- Acted as the national financial intermediary.
- Managed client engagement, loan disbursement, and project screening.

Private-sector actors (SMEs, building owners, ESCOs)

- Developed and implemented eligible investments.

Impacts and co-benefits:

i) Contributed to lower carbon emissions by improving energy performance in buildings

ii) Reduced energy costs

iii) Increased attractiveness of the urban environment

iv) Increased investor confidence in energy efficiency projects

v) Supported the development of a commercial ecosystem for energy performance contracting.

Barriers and enabling factors: key barriers include administrative fragmentation and the limited technical capacity of smaller firms to structure bankable projects. Embedding this model in local planning requires alignment with municipal energy goals and dedicated advisory services to support project preparation and uptake. The initiative's effectiveness stems from its integrated design, combining long-term concessional finance with credit risk mitigation. Belfius' established local presence and EIB's implementation capacity created strong synergies.

Source: Todeschi et al., 2025.

4.8. PES

Payment for ecosystem services (PES): Mechanism in which buyers compensate providers for delivering clearly defined ecosystem services, with payments conditional on verified outcomes. It can reduce financial risk for project developers or landowners by providing a predictable revenue stream tied to environmental performance, provided that the project is able to generate ecosystem services and that they are assessed and verified. PES can involve private buyers, public authorities charging user fees, or government-financed schemes acting on behalf of beneficiaries (OECD, 2023). Implementation may be coordinated by public agencies, environmental NGOs, or specialised intermediaries—such as watershed agencies, land trusts, or conservation funds—with governance frameworks based on contractual arrangements between payers and providers that define service metrics, verification procedures, and dispute resolution mechanisms.

Looking at the financial flows, an ecosystem services buyer enters into an agreement with an ecosystem services provider and transfers payments to the provider. The provider invests in and implements defined interventions aimed at generating ecosystem services. A third-party monitoring, reporting, and verification entity may assess the implementation and outcomes of these interventions. Payments are contract-based and are typically tied to the delivery of ecosystem services, such as water regulation, biodiversity, or climate regulation, which may include carbon sequestration as a valued service. GHG emissions are not directly targeted in most PES schemes, but certain services — such as carbon sequestration and storage in forests, peatlands, or marine ecosystems — are associated with reduced atmospheric carbon levels. The focus is typically on CO_2, though in some cases the carbon stock includes other forms of stored carbon (e.g. in soils or dead biomass). Emissions reductions are considered as co-benefits of maintaining or enhancing ecosystem integrity, rather than the primary objective.

When structured to support interventions such as forest conservation, wetland restoration, and water harvesting, PES can directly address climate risks including droughts, floods, and land and ecosystem degradation. These schemes channel resources into activities that increase natural resilience and buffering capacity, and their design enables alignment with adaptation priorities in sectors such as agriculture, water management, and biodiversity protection (NAP Global Network, 2024).

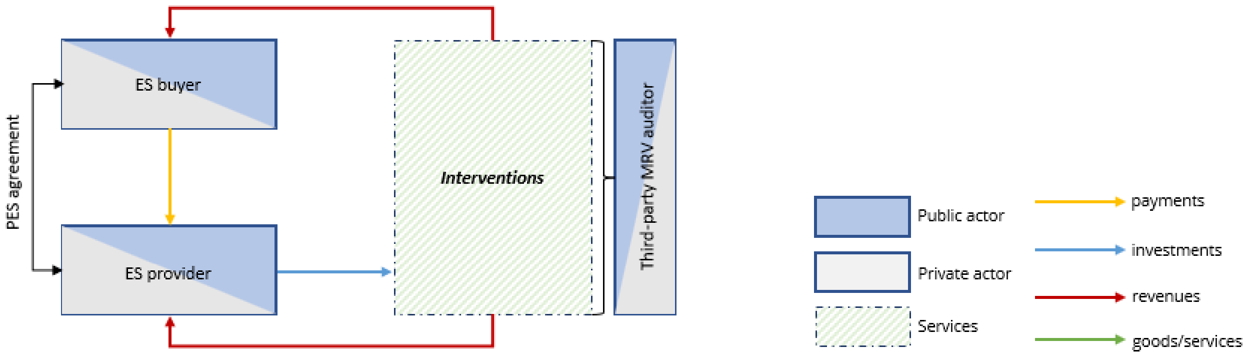

Figure 16: Model and financial flows of PES

Payment for Ecosystem Services, Groenfonds Midden-Delfland – Netherlands

Groenfonds Midden-Delfland is a long-term Payment for Ecosystem Services (PES) mechanism financing landscape preservation through structured contributions linked to real estate development. Launched in 2005 by three municipalities, the initiative channels one-off public contributions and recurring developer payments into a professionally managed investment fund. The fund adopts a defensive investment strategy aimed at preserving capital while generating stable annual returns. These returns are used to provide regular payments to farmers and landowners in exchange for the delivery of ecological services, supporting the long-term conservation and management of the Midden-Delfland landscape. The mechanism aligns urban expansion with rural stewardship by linking development-related financial flows to the ongoing provision of ecosystem services.

Implemented measures:

i) meadow bird management
ii) pollard tree upkeep
iii) maintenance of herb-rich grasslands
Iv) integration of educational and recreational activities.

Relevant stakeholders:

Municipalities and private developers (capital providers)

- Municipalities contributed initial capital through one-time endowments.
- Developers provide recurring contributions linked to real estate expansion.

Asset manager

- Invests pooled capital to preserve value and generate stable returns.
- Manages financial flows and allocates returns to fund ecosystem services.

Landowners and farmers

- Receive annual payments for delivering and maintaining green services.
- Manage ecological features such as grasslands, hedgerows, and pollard trees under contract.

Impacts and co-benefits: i) Maintenance of 927 hectares of herb-rich grasslands, mowed during ecological periods; ii) Conservation of over 3,700 pollard willows, along with hedgerows and tree rows that enhance habitat diversity; iii) Preservation of 153 historic farm buildings, reinforcing the region's ecological and cultural heritage; iii) Support for biodiversity, water retention, and long-term landscape resilience through multifunctional land management.

Barriers and enabling factors: barriers include the legal and institutional complexity of structuring and operating such a fund, as well as the need to establish robust procedures for monitoring and verifying ecosystem service delivery. Key enabling factors included a clearly defined operational model linking development-related contributions to environmental financing, and the use of a defensive investment strategy that integrates financial and ecological objectives. The model's long-term viability depends on stable fund management and predictable returns.

Source: Machiels et al., 2024.

4.9. Credits

Carbon credits: market-based instruments that assign monetary value to verified reductions in greenhouse gas emissions. Each credit represents a standardized unit of avoided, reduced, or removed emissions and can be traded in domestic or international markets. By pricing carbon, these instruments create financial incentives for mitigation efforts and direct resources toward climate-aligned projects (OECD, 2025). Carbon credits can potentially be issued from the implementation of urban regeneration projects under the Paris Agreement Crediting mechanism, provided that UNFCCC approved methodologies are used to assess emission reductions obtained from the project and other aspects (i.e. baseline definition, additionality assessment, etc); or they can generate credits to be used under voluntary carbon markets. Governance is defined by national or international market standards and typically involves independent third-party verification bodies to ensure environmental integrity and compliance.

A project developer implements a CO_2 reduction intervention that is certified by a scheme administrator and verified by a third-party monitoring, reporting, and verification entity. Following certification, carbon credits are issued and transferred to credit buyers. Credit buyers provide payments in exchange for the credits, generating revenues for the project developer. Depending on the type of measures implemented and the amount of credits generated, the revenues can contribute to different extents to the initial investment in low-carbon and resilience measures within the urban regeneration project and overall to its financing approach

Carbon credit mechanisms are explicitly designed to quantify and trade reductions in greenhouse gas emissions. While CO_2 is the main focus, most systems also account for other gases such as methane (CH_4) and nitrous oxide (N_2O), expressed in CO_2 equivalent (CO_2eq). For instance, the California Cap-and-Trade Program and Québec's Cap-and-Trade System include also methane (CH_4), nitrous oxide (N_2O), and several fluorinated gases such as SF_6, HFCs, PFCs, and NF_3.

Emissions reductions from carbon credits are quantified through standardised methodologies approved by third-party registries (e.g., Verra, Gold Standard). These typically involve ex-ante baselines and ex-post monitoring and verification processes. Projects must demonstrate additionality and provide verified emission reductions or certified emission reductions expressed in tonnes of CO2eq.

There is a direct and proportional relationship between the quantity of verified emissions reductions and the financial value generated. Each tonne of CO_2eq avoided or removed translates into one carbon credit, which can be sold on voluntary or compliance markets. Revenue is thus explicitly tied to emissions performance.

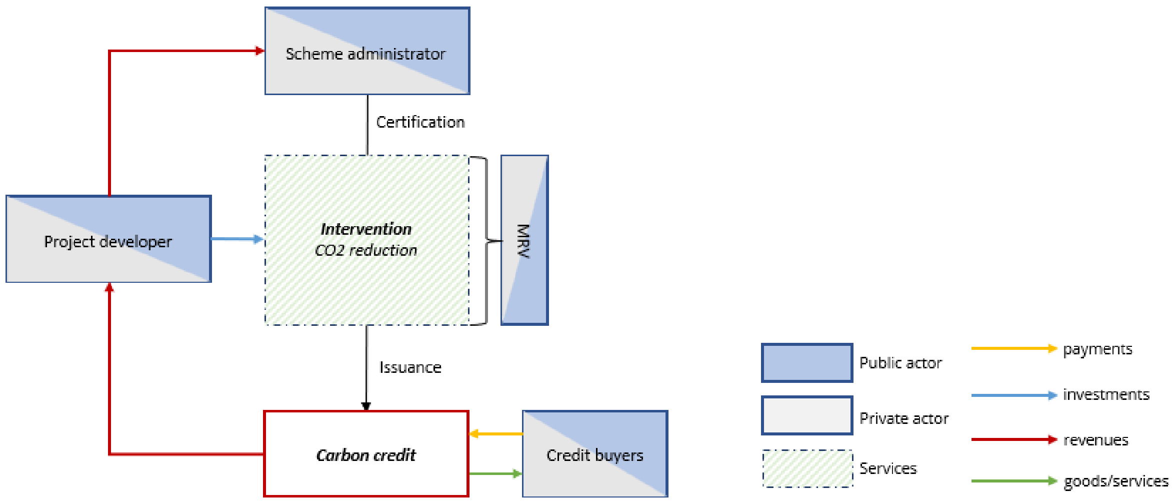

Figure 17: Model and financial flows of carbon credits

Green and white certificates tradable certificates used to verify either renewable energy generation (green certificates) or energy savings (white certificates). Green certificates certify electricity produced from renewable sources, while white certificates certify verified reductions in energy consumption. Both can be exchanged among obligated entities to help meet efficiency or renewable targets without requiring direct investment in infrastructure (Todeschi et al., 2025). By monetising verified energy savings and emission reduction, they create a funding stream from climate projects. Revenues from certificates trading can contribute to support the generating project or be reinvested in other sustainable urban regeneration measures, such as building retrofits or urban greening. The approach incentivises both emission reductions and climate-aligned investment. Governance is typically established under national compliance frameworks, with oversight by energy regulatory authorities and certification and verification procedures carried out by accredited third parties.

Within green certificate schemes, the certificate issuer (typically a regulatory authority or designated registry) grants certificates to electricity producers or project developers for each verified unit of renewable energy generated. These certificates are issued in addition to the revenue obtained from selling electricity on the market. Energy suppliers or other obligated parties are required to purchase a certain number of green certificates to comply with renewable energy targets. They acquire certificates either directly from producers or through certificate trading platforms.

In green certificates, there is a direct and proportional relationship between the quantity of renewable energy produced— and, by extension, the emissions saved — and the issuance of certificates, therefore the financial incentive is directly tied to the mitigation performance.

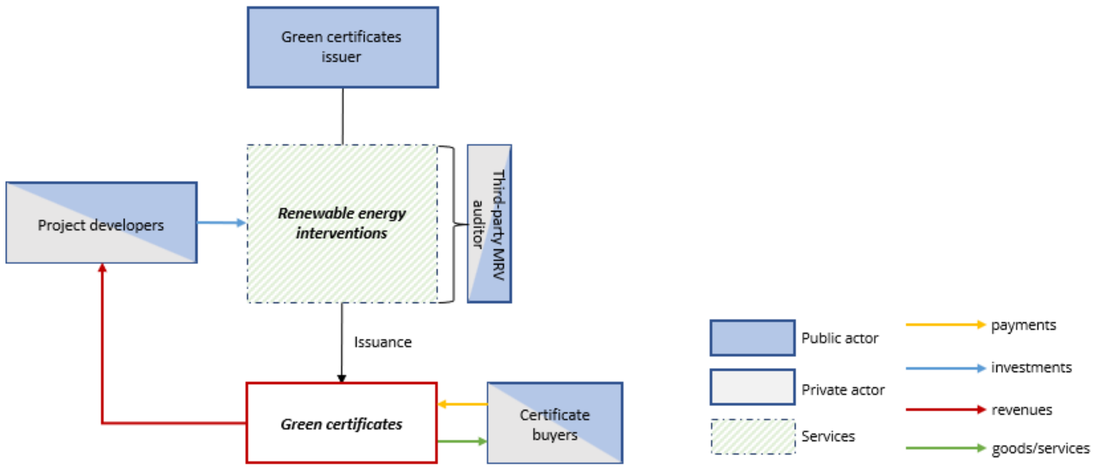

Figure 18: Model and financial flows of green certificates

Within white certificate systems, the certificate issuer (usually a regulatory authority or designated agency) awards certificates to energy service companies, utilities, or project developers for each verified unit of energy savings achieved through approved energy efficiency measures. Obligated parties, typically energy suppliers or distributors, are required to achieve specified energy savings targets. They can meet these obligations either by implementing efficiency measures themselves or by purchasing white certificates from other certified entities through bilateral agreements or trading platforms.

In white certificates, there is a direct and proportional relationship between the quantity of energy savings- and, by extension, saved emissions saved — and the issuance of certificates, therefore the financial incentive is directly tied to the mitigation performance.

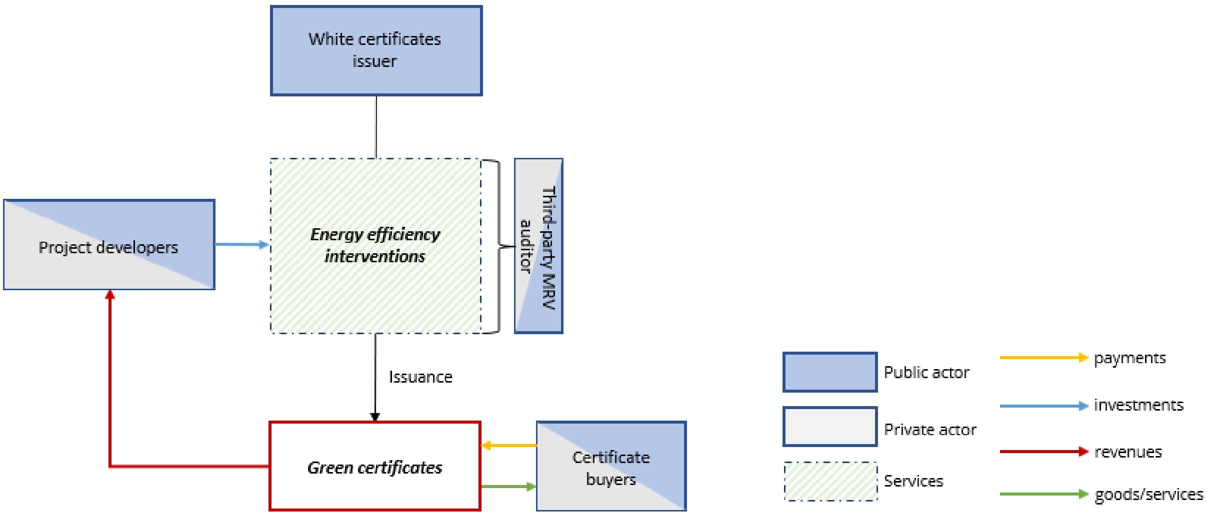

Figure 19: Model and financial flows of white certificates

Biodiversity credits: Tradable units representing verifiable biodiversity restoration or preservation outcomes achieved over a defined period. Credits can be structured as bundled, where multiple ecosystem benefits are combined into a single product, or stacked, where different services are quantified separately and sold to distinct buyers. These instruments assign financial value to nature-positive outcomes and can channel investment into ecological regeneration (WEF, 2024). Governance may be established under national biodiversity offset regulations or voluntary market schemes and typically includes third-party certification or monitoring to ensure the credibility and integrity of claimed outcomes.

Looking at how the instrument operates, a project developer implements a biodiversity restoration intervention that is certified by a scheme administrator and assessed by a third-party monitoring, reporting, and verification entity. Following certification, biodiversity credits are issued and transferred to credit buyers. Credit buyers provide payments in exchange for the credits, generating revenues for the project developer.

Biodiversity credits may indirectly address certain climate risks—such as floods, heatwaves, land and ecosystem degradation, and broader resilience—when restoration activities enhance natural buffering capacity, regulate local temperatures, or support ecosystem stability, but climate risk assessment is usually not formally integrated into these systems. Credit pricing is based on biodiversity offset units, not tied to climate risk metrics.

Considering mitigation, certain projects (e.g., forest preservation) may generate co-benefits in terms of carbon sequestration, but GHG emissions are usually not measured in the context of biodiversity credit schemes. The financial value of biodiversity credits is tied to the quantified increase in biodiversity, not to any emissions-related outcome. If a project generates carbon co-benefits, these may enhance its attractiveness or create eligibility for parallel funding, but they are not part of the core crediting mechanism.

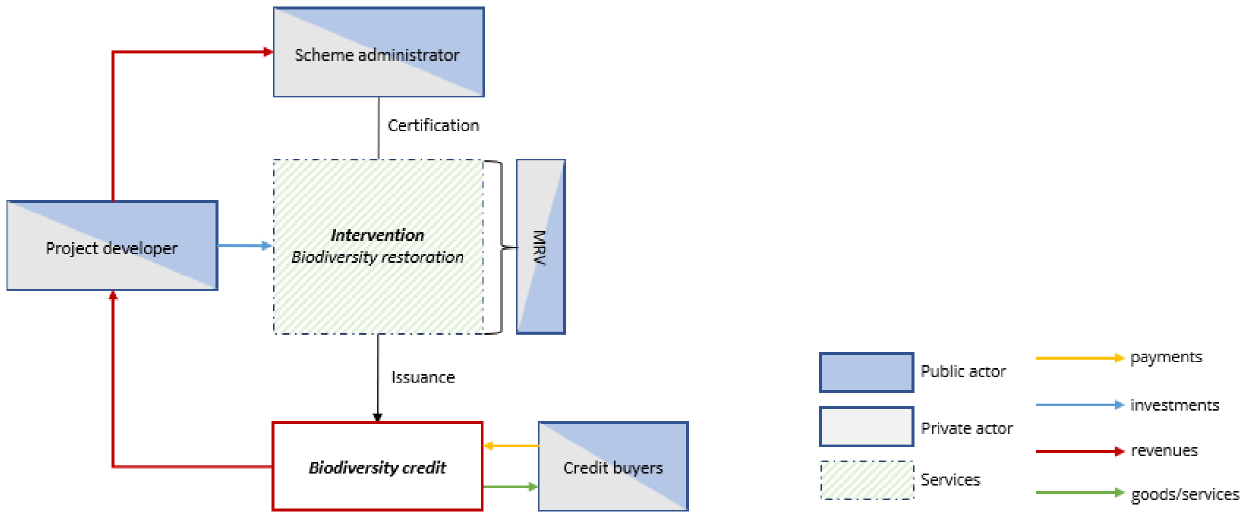

Figure 20: Model and financial flows of biodiversity credits

4.10. PPPs

Public–Private Partnerships (PPPs) are contractual agreements between public authorities and private entities to deliver public assets or services. These arrangements typically involve the private party assuming management responsibilities, with compensation mechanisms linked to performance outcomes. Remuneration may be derived from user fees, public funds, or a combination of the two, depending on the allocation of responsibilities and the accounting treatment within the municipality's balance sheet.
PPPs serve not only as a financing tool but also as a risk-sharing mechanism. They are structured to allocate specific risks—financial, operational, or technical—to the parties best positioned to manage them, thus improving cost-efficiency and service delivery. A range of contractual models can be employed:

- *Build–Own–Operate–Transfer:* the public authority grants a private entity the right to finance, design, construct, and operate a facility for a specified concession period, typically involving a new infrastructure asset. The private operator — often structured as a special purpose vehicle — owns the asset during the project period, operating it commercially, and ultimately transfers the asset to the public authority at the end of the term. Revenue streams are typically secured via long-term offtake agreements with a single purchaser, such as a utility or government body, rather than through direct user fees (WB, 2026a);
- *Design-Build-Finance-Maintain*: a private consortium is responsible for designing, constructing, financing, and maintaining a public infrastructure asset over a long-term contract, typically lasting 20 to 30 years. Throughout the contract period, ownership of the asset remains with the public sector. These projects are typically financed through debt backed by dedicated revenue streams, most commonly user fees such as tolls. These anticipated revenues are used to raise capital via bonds or other debt instruments. Public sector contributions—either in cash or in-kind assets like land access—often supplement the financing, while private partners are generally required to invest equity as part of the funding structure. In some cases, the private partner is compensated through availability payments—regular instalments made over the contract term rather than a lump sum at completion. Since the private entity remains responsible for maintaining the facility for 20 to 30 years, this structure creates strong incentives to prioritize high-quality, durable construction that minimizes future maintenance needs (Center for Innovative Finance Support, n.d.);

- *Build-Transfer-Operate*: the private sector partner is responsible for designing, financing, and constructing the infrastructure asset, but unlike in a BOT model, legal ownership is transferred to the public authority immediately upon completion of construction. The private entity then operates the facility for a defined concession period under a separate operating agreement. While the transfer of ownership occurs early, operational control and commercial risk during the service phase remain with the private partner. This model distinguishes itself by separating asset ownership from operational responsibility, which has implications for how asset handover, depreciation, and public sector oversight are managed throughout the contract term (WB, 2026b).

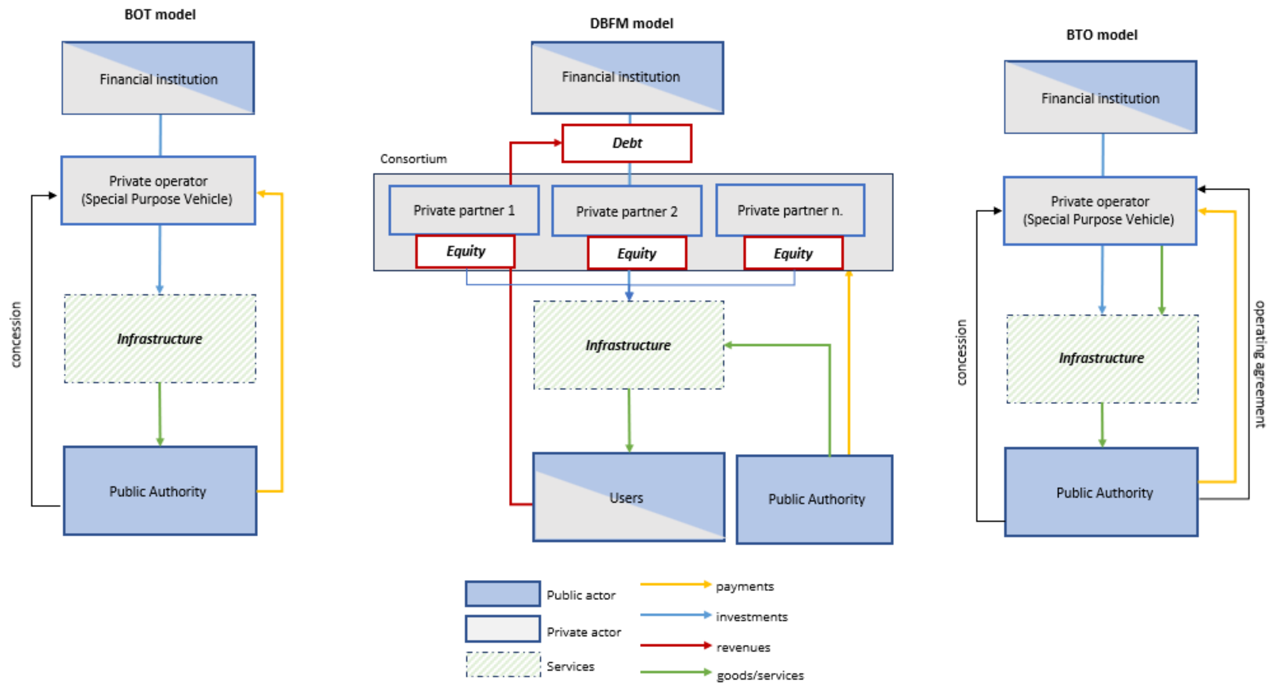

Figure 21: Model and financial flows in PPPs

In the context of climate action, PPPs allow local governments to leverage private capital and technical expertise, provided they possess sufficient fiscal autonomy and institutional capacity. While the success factors of climate-related PPPs mirror those of traditional ones — including clear risk allocation, enforceable contracts, and viable project structures — their application in the climate space is most evident in certain project types.

In the field of mitigation, PPPs have frequently supported municipal energy efficiency projects, particularly in areas such as public lighting retrofits, building renovation, and low-carbon district energy systems. These initiatives typically combine long-term performance contracts with private investment in infrastructure upgrades, enabling municipalities to reduce operational costs while lowering emissions (Novikova et al., 2017). More complex PPPs have also been used in urban regeneration projects that integrate climate goals into land-use planning, building codes, and energy standards (Climate Adapt (a), n.d.).

In the domain of adaptation, some projects have leveraged private sector participation in the delivery of urban flood protection measures, such as green-blue infrastructure, elevation of land in vulnerable zones, and integrated stormwater systems. These interventions often form part of larger urban development schemes where public and private interests align, particularly when the adaptation component is embedded in the value of real estate development or long-term infrastructure resilience (Climate Adapt (b), n.d.).

Considering the role of climate data within the design and implementation of this instrument, GHG emissions are not embedded in the PPP structure itself, but can be considered at the project appraisal or procurement stage. When environmental criteria are integrated into PPP tenders or performance contracts, emissions may be estimated using life-cycle assessments, energy performance models, or environmental impact studies. However, such assessments are not a core requirement of the PPP instrument, and their use varies widely depending on the contracting authority, sector, and region. There is usually no direct financial linkage between emissions data and the structure of a PPP. In some cases, minimum environmental performance standards may be set as part of the tender (e.g. energy class of buildings, vehicle emissions standards), and failure to meet them may affect contract eligibility or trigger penalties.

Looking at adaptation, PPPs are not structurally designed to address specific climate risks, but they can be applied to urban adaptation projects. Climate risk considerations vary depending on the project. While some infrastructure PPPs may include climate vulnerability assessments (especially in flood-prone or heat-exposed areas), there is no standardized requirement or methodology to implement them. Financial flows are not typically tied to climate indicators.

5. Enabling conditions and barriers to financing instruments' use and replication

5.1. Enabling conditions

Enabling conditions can be defined as those essential factors which must be in place for a financing instrument to be implemented in a given context, and therefore allow the replication of successful cases and experiences in further contexts or projects (adapted from CCFLA). For the purposes of this analysis, enabling factors have been divided between three types - institutional, economic and technical - which refer respectively to: i) institutional, regulatory and legal factors, which determine whether instruments are legally permissible, administratively feasible, and institutionally credible; ii) economic and financial factors, which determine if instruments can be initiated and scaled up; and iii) technical factors, pertaining the different phases of urban regeneration project development and of financing instrument implementation to support the project. While some enabling factors might belong to more than one type, such classification can be useful to identify which domains should be checked and considered to assess instruments' replicability potential.

Institutional

Institutional enabling factors shape the legal, procedural, and organizational conditions under which financing instruments for climate-related investments can be established and operated.

For several instruments, a key precondition is the presence of **enabling legislation**. This is true for example for PACE schemes, that require legislation for local governments to attach repayments to property tax systems (EPA). For instruments whose financial viability depends on long-term commitments, such as EPCs, legal capacity to enter **multi-year contracts** is essential (US Department of Energy). For catastrophe bonds, legal and regulatory frameworks must allow the structuring of parametric or indemnity-based payout mechanisms (CCFLA).

In the case of nature-based solutions, a clear legal framework enabling PES contracts is necessary to ensure enforceability, legal remedies, and long-term credibility (Greiber, 2011). For instruments based on credits' trading, a legal or voluntary framework that allows **credit issuance and selling** is indispensable (GHG, SEI), as **green or white certificates** need a regulatory obligation that creates demand, by requiring regulated entities to acquire a certain amount of certificates. Across all instruments, a **stable and transparent legal framework** reduces regulatory uncertainty, lowers perceived risk, and supports investor confidence.

Beyond formal legality, institutional capacity is also reflected in the design of **application and approval procedures**. Fast and clear application and approval processes reduce administrative barriers, accelerate deployment, and increase uptake, particularly for instruments targeting a large number of relatively small-scale projects or end users (e.g. on-bill financing) (Johnson et al., 2016).

Institutional effectiveness is also influenced by **coordination between funders and implementers**, as in the case of Forecast-Based Financing (IFRC). Clear institutional arrangements that align the roles, responsibilities, and incentives of public authorities, financial intermediaries, project developers, and service providers reduce fragmentation and transaction costs. Such coordination is particularly important in blended finance structures and performance-based instruments, where multiple actors must collaborate over extended time horizons.

Finally, **political support** constitutes a crucial institutional enabling factor. Sustained political commitment signals long-term policy stability, legitimizes the use of innovative financial instruments, and reassures private investors and implementing agencies. Political support is especially important for PPPs where first-of-a-kind projects or instruments that involve user charges, fiscal exposure, or novel risk-sharing arrangements are implemented (PPIAF, 2009).

Economic

Economic-type enabling factors are central to determining whether climate-related financial instruments can be initiated, sustained, and scaled over time.

For instruments that rely on reinvestment approaches, such as revolving funds, internal contracting schemes, or pilot impact-based instruments, a key precondition is the **availability of initial capital for the first investment cycle** Initial capitalization enables the first set of investments to be executed, generating financial returns or savings that can subsequently be recycled, thereby establishing financial credibility and operational momentum (Cicmanova et al. 2017). For revolving funds, another key element is the **prioritization of short payback and technically robust investments**, particularly in the early stages of implementation. Investments with predictable cash flows and limited technical complexity reduce financial risk, accelerate capital turnover, and help demonstrate the viability of the instrument to public authorities, financiers, and other stakeholders.

Fund size and access to co-financing options further shape the effectiveness of these instruments. Fund size should be adequate in relation to expected payback periods, and co-financing options should be explored to accelerate reinvestment (ibid).

Economic viability of instruments is also influenced by **project scale**. Large building portfolios with significant untapped energy efficiency potential facilitate aggregation, reduce transaction costs, and enhance the financial viability of standardized contractual and financing arrangements, as in the case of EPCs (US Department of Energy). Furthermore, the technical standardisation and replicability of building upgrades facilitate portfolio-based approaches, enabling scaling through public or blended finance programs. For instance, in Stuttgart, the expansion of the revolving fund was closely linked to the approval of a major school renovation programme in 2009. As standard renovation works were rolled out across multiple schools, the fund was increased in parallel to finance the energy retrofits (Cicmanova et al., 2017).

The **availability of quick financing post-disaster or to prevent damages** is another key enabler, especially for instruments designed to respond to time-sensitive risks or opportunities. Flexible financing allows resources to be deployed quickly and adapted to evolving conditions, which is critical in contexts such as forecast-based financing, emergency resilience measures, or early-stage project development (IFRC).

From a lender and investor perspective, the **bankability of underlying projects** remains a central topic. Projects that are close to bankability- requiring only partial de-risking rather than full risk absorption- are far more likely to attract private capital. Since guarantees are held in full on the guarantor's balance sheet and offer limited fees or collateral, they are best used selectively for projects with clear repayment prospects and well-defined risks (NAP, 2024).

Finally, **strong repayment prospects** underpin the sustainability of revolving mechanisms. Predictable revenue streams, reliable cost savings, or stable fiscal backing increase confidence among lenders and investors, reduce financing costs, and support long-term continuity. The presence of a pipeline of projects capable of delivering measurable and reliable savings is particularly important for instruments such as EPCs, performance contracts, and revolving funds.

Technical

The effectiveness and scalability of climate-related financing instruments for urban regeneration depend on a set of interrelated enabling factors that span across project design, data and methodological robustness, technical capacity, and governance arrangements. Among these, the availability of **screening criteria for project selection** plays a foundational role. Clear frameworks for identifying eligible green projects and ex ante screening criteria for assessing contributions to climate resilience are essential to ensure that financial resources are directed toward interventions that deliver verifiable environmental outcomes. Such criteria underpin investor confidence, regulatory compliance, and alignment with sustainability objectives, particularly in instruments like bonds, loans, and performance-based finance. For example, issuing a credible resilience bond requires ex ante screening criteria to assess whether the intervention makes a substantial contribution to climate resilience, based on output-level indicators that can be directly attributed to the investment (Climate Bonds Initiative, 2024).

A critical cross-cutting enabler across nearly all instruments is **data availability**. Sophisticated risk modelling and access to reliable underlying data are prerequisites for instruments targeting physical climate risks, such as catastrophe bonds, parametric insurance, and weather derivatives (CCFLA). High-frequency climate and weather data, context-specific climate forecasts, and reliable meteorological data sources are required to define triggers, price risks, and operationalize forecast-based or parametric mechanisms (Generali, 2023; IFRC, n.d.). In nature-based and biodiversity-related instruments, the availability of reliable ecological data and biodiversity metrics is equally essential to quantify impacts, support credit issuance, and ensure environmental integrity (WEF, 2024).

Data availability alone, however, is insufficient without **standardized methodologies**. Frameworks to assess and verify resilience impacts, approved methodologies for emissions reduction estimation, and standardized savings calculation approaches provide methodological consistency and comparability across projects and jurisdictions. These methodologies reduce uncertainty, lower transaction costs, and enable the aggregation of projects into portfolios suitable for capital market instruments or large-scale public–private financing schemes. For carbon credits specifically, the availability of approved methodologies for estimating emission reductions, their validation and certification by a third party and project developers' capacity to measure emissions over time and submit reports to a recognized registry is essential for the functioning of the mechanism (GHG, SEI). For credits instruments, like carbon credits and green/white certificates,also the availability and effective functioning of trading platforms is a precondition.

Underlying these structural elements is the **availability of technical capacity to define targets, set baselines, and assess savings potentials**. The capacity to assess baseline energy consumption and identify savings opportunities is a prerequisite for performance-based instruments, while technical expertise for baseline setting and verification ensures the credibility of reported outcomes. These capacities are often embedded within public authorities, utilities, or specialized intermediaries and are critical to maintaining trust among financiers and stakeholders. This is the case of revolving funds for energy saving and for EPCs, that require the ability to assess current energy consumption and identify measures with clear saving potential (Cicmanova et al., 2017; US Department of Energy).

The deployment of financial instruments is further facilitated by the **availability of standardized processes**, particularly for **contracting and procurement.** Standardized contractual arrangements and procurement procedures support efficiency, legal certainty, and replicability, especially in contexts where public authorities engage repeatedly with private actors or financial intermediaries. Such processes are particularly relevant for

PPPs and EPCs. Instead, the capacity to define and enforce **contracts with pre-agreed thresholds and indemnity values** is critical for parametric-based insurance (Generali, 2023).

Equally important is the **definition of climate objectives**. Clearly articulated climate and resilience objectives, impact metrics, and measurable performance targets provide strategic direction and operational clarity. Defined Key Performance Indicators (KPIs) and targets are central to green/climate bonds and loans, where reporting how proceeds are used and oriented towards climate projects is a key aspect. . Green bonds require a robust framework for identifying and financing eligible green projects with measurable environmental benefits. The issuer must define clear sustainability objectives, assess environmental impacts, and disclose how projects are selected and managed, including procedures for handling environmental and social risks (Green Bonds Principles & ICMA, 2025). For biodiversity credits, targets and performance tracking systems should be in place to manage progress over time (WEF, 2024).

Certain instruments further require **specialized technical capacity to price weather-related risks**, particularly in the case of weather derivatives, parametric insurance, and catastrophe bonds. This capacity depends on advanced modelling expertise and the ability to translate probabilistic climate data into financial pricing structures that are acceptable to market participants.

Once instruments are operational, the **availability of technical capacity to calculate, monitor, report, and disclose impacts** becomes decisive. Capacity for impact verification and reporting supports accountability and ensures that claimed environmental benefits are substantiated over time. These capacities are reinforced by robust **disclosure and reporting mechanisms**, including regular reporting on environmental impacts and ongoing disclosure obligations that apply throughout the lifecycle of bonds, loans, or crediting schemes (LMA, ICMA, 2024). In crowdfunding, for example, transparency and credibility are critical: contributors must have access to clear project information and regular updates, and trust that funds will be used as promised (CCFLA).

Effective implementation further depends on the existence of **systems for monitoring, compliance, and fund management**. Governance systems for monitoring and compliance ensure that financial and environmental commitments are respected over time, while defined governance and fund management rules support transparency, accountability, and proper use of resources. A clear governance and oversight framework is especially critical where funds are pooled, earmarked, or recycled, as in revolving funds, credit schemes, or bond-financed programs.

Instruments involving capital markets or earmarked finance additionally require transparent **tracking of bond or loan proceeds**, typically through dedicated sub-accounts or internal tracking systems. This ensures that funds are allocated as intended and supports compliance with investor expectations and regulatory standards. For green bonds, proceeds must be tracked through dedicated sub-accounts or sub-portfolios, and regular reports must be published until full allocation. These reports should detail how funds have been used, which projects were financed, and what environmental impacts are expected (Green Bond Principles & ICMA, 2025).

Closely related is the **alignment with climate taxonomies and disclosure standards**, such as those established at regional or international level, which enhances comparability, credibility, and market acceptance.

Finally, robust systems of **independent monitoring, oversight, and accredited third-party validation and verification** play a central role in safeguarding environmental integrity and financial credibility. Independent oversight mechanisms reduce conflicts of interest, strengthen governance, and are particularly critical in instruments reliant on performance-based payments, credit issuance, or outcome-linked returns.

5.2. Barriers

Barriers refer to structural, financial, institutional, technical, and cultural obstacles that may hinder the implementation of financing instruments for climate-related projects and investments. As with enabling factors, barriers have been grouped into three types - institutional, economic, and technical - while acknowledging that some barriers might belong to more than one type. In addition, a fourth category of "cultural" barriers has emerged from the literature, referring to social, behavioral, and perception-related factors that may limit the uptake of specific financing instruments by different actors.

Institutional

Mirroring enabling factors, institutional barriers relate to regulatory frameworks, legal provisions, and administrative processes that may constrain the activation and effective operation of financing instruments.

The **absence of specific regulation** can represent a major barrier, particularly for instruments that rely on existing systems. For example, the implementation of PACE schemes depends on the integration of repayment mechanisms into property tax systems; where such regulation is lacking, activation becomes difficult or impossible (Sustainability Directory). Similarly, crowdfunding schemes may face obstacles where regulatory frameworks do not clearly recognize or allow financial returns to small-scale investors (CCFLA).

Even where enabling legislation exists, **regulatory uncertainty** - arising from unclear provisions or rapidly evolving legal frameworks - can undermine adoption. This challenge is especially pronounced for innovative resilience-related instruments, which often operate in regulatory environments that are still under development (Generali, 2023). Regulatory uncertainty also remains a significant barrier for carbon credits, as national and international frameworks continue to evolve, creating ambiguity around compliance requirements and future market integration (GHG, SEI).

Regulatory and administrative complexity can further constrain implementation. In the case of PPPs, complex regulatory requirements may increase project timelines and transaction costs, reducing overall attractiveness (PPIAF, 2009). Similarly, for guarantees and credit enhancement mechanisms, complex administrative procedures related to claims management can represent a substantial barrier (NAP, 2024).

Institutional barriers also arise from the **interaction between public and private actors**. In PPPs, insufficient mutual understanding of public-sector and private-sector rules, incentives, and constraints can hinder project development and delivery. In addition, negative public or stakeholder perceptions – in particular the resistance to perceived privatization- may create further obstacles (PPIAF, 2009).

More broadly, **weaknesses in governance frameworks** constitute a critical issue. When governance arrangements are insufficiently defined, concerns may emerge regarding market integrity and the risk of greenwashing. This issue is particularly relevant for emerging instruments such as biodiversity credits, where robust governance is essential to ensure credibility and environmental integrity (BASE, 2025).

Cultural

Cultural barriers identified in the literature largely relate to **limited awareness, understanding, knowledge or trust** among potential users regarding financing instruments, their operational mechanisms, and associated opportunities. This is the case for parametric insurance and weather derivatives, which remain relatively less known compared to more traditional resilience financing approaches (Generali, 2023; ENEL). Similar challenges affect PACE schemes, which require a sufficient level of homeowner awareness and trust in the repayment mechanism (Sustainability Directory). In addition, PACE schemes may face **resistance from mortgage lenders**, particularly concerning the priority of repayments in relation to existing mortgage claims, further constraining uptake (Sustainability Directory).

Economic

Economic barriers relate to financial viability, capital availability, cost structures, and market conditions that influence the feasibility and scalability of financing instruments.

Securing sufficient upfront capitalization is a central challenge for revolving funds, as the absence of initial capital can prevent the first investment cycle from being launched (Cicmanova et al., 2017).

For innovative instruments such as on-bill financing, **reluctance among utilities to commit capital** represents a significant barrier. This reluctance is driven by concerns over credit risk, potential repayment defaults, and the perceived administrative burden of managing loan programs. In many cases, utilities see on-bill financing as blurring the boundary between their core service provision role and that of a financial institution, which discourages adoption (FSC, 2015).

Some instruments, such as forecast-based financing, are **structurally dependent on donor funding**, which may constrain long-term sustainability and limit opportunities for scaling (IFRC).

High transaction costs constitute another major economic barrier across several instruments, such as credit-based instruments. Carbon credit schemes face high transaction costs linked to project certification, third-party verification, and legal due diligence, which can discourage participation by smaller actors (GHG, SEI). Similarly, biodiversity credits face high monitoring and verification costs due to the site-specific and technically demanding nature of biodiversity assessments. Combined with small project sizes, long implementation timelines, and relatively low financial returns, these factors limit the attractiveness of biodiversity credits for mainstream investors (BASE, 2025).

A further barrier affecting guarantee mechanisms is the **limited availability of public resources to provide guarantee backing**, which constrains the scale at which such instruments can be deployed (NAP, 2024).

Market access and liquidity constraints also play an important role. For green bonds, limited market access and low liquidity - particularly for smaller or emerging-market issuers - reduce participation and overall attractiveness (Jena & Vuppuluri, 2025). In contrast, biodiversity credit markets are constrained by fragmentation and limited tradability across regions, as credits are highly location-specific, which further reduces liquidity and discourages private investment (BASE, 2025).

Finally, in the case of EPCs, a barrier that spans economic and technical dimensions is the **difficulty of bundling small-scale projects** into portfolios that are financially attractive for service providers (Smart Impulse).

Technical

Technical barriers relate to data availability, methodological robustness, standardization, and technical complexity.

Limited access to high-quality, localized data represents a major challenge for many instruments. For example, insufficient availability of reliable local data undermines the implementation of parametric insurance (Generali, 2023). Weather derivatives face similar challenges, particularly in accurately modelling localized weather impacts (ENEL).

A **lack of standardization** is another key technical barrier affecting several financing instruments, particularly bonds, loans, and credit-based mechanisms where the allocation of financial resources depends directly on assessed sustainability outcomes. For green bonds, the absence of universally accepted definitions and certification frameworks increases the risk of greenwashing, undermining investor confidence and market integrity (Jena & Vuppuluri, 2025). Similar challenges arise for green oans, where the lack of standardized sustainability metrics complicates performance assessment (ICMA, 2024).

For EPCs, the **absence of standardized contract templates** increases legal and administrative burdens for participating actors, reducing uptake (Smart Impulse). Weather derivatives face comparable challenges due to the lack of standardized contract structures (ENEL).

In carbon credit markets, the absence of clear, transparent, and credible frameworks for measuring and verifying emissions reductions has raised concerns about the actual climate impact of certain schemes. This lack of consistency and trust makes it difficult for buyers to assess credit quality and limits the scalability of carbon markets as effective mitigation tools (GHG, SEI). Biodiversity credits face similar challenges, as the

absence of standardized metrics and methodologies hampers comparability and quality assurance across projects (BASE, 2025).
Beyond standardization issues, many instruments are characterized by **inherent technical complexity** in applying methodologies for assessing, verifying, and reporting sustainability outcomes. For green bonds, verification and reporting requirements can be complex and costly, posing particular challenges for smaller issuers (Jena & Vuppuluri, 2025). Outcome definition, measurement, and attribution remain critical challenges for PES mechanisms (Greiber, 2011). Resilience bonds require quantifiable and modelled risk reductions, as well as alignment between infrastructure delivery timelines and bond issuance (Climate Bonds Initiative, 2024). Catastrophe bonds are complex to price and depend on specialized expertise in climate modelling and disaster risk assessment (Bocconi University, 2025). Forecast-based financing involves technical challenges related to the definition of forecast thresholds and early action protocols (IFRC). In EPCs, technical complexity is closely linked to the legal and operational challenges of structuring performance-based contracts (Smart Impulse).
A specific technical barrier affecting several instruments is **basis risk,** defined as the mismatch between actual losses and predefined trigger conditions. This issue is particularly relevant for catastrophe bonds, parametric insurance, and forecast-based financing, where basis risk can leave issuers insufficiently compensated following an adverse event, thereby undermining confidence in the instrument (Bocconi University, 2025; Generali, 2023). In forecast-based financing, basis risk is closely linked to inherent forecast uncertainty (IFRC).

6. Conclusions and policy recommendations

This study aimed to provide a comprehensive analysis of financing instruments that can be leveraged to integrate climate mitigation and climate adaptation measures into urban regeneration projects, consistently with the impelling need to consider such dimensions within urban transformations. The analysis focused on repayable instruments, with capital repayment obligations and/or revenue-generating instruments like credits or PES. Non-repayable instruments – such as intergovernmental transfers, non-repayable grants, and government-revenue instruments, were excluded. Overall, the sample retained for the analysis included 18 instruments, covering debt, risk mitigation, third party financing, revolving funds, PES credits, and PPPs.
The study provided a structured analysis highlighting: the instruments' governance; the underlying financing mechanism and financial flows of each instrument; revenue and repayment models, considering how repayment is covered or a return on investment is created for the project developer; the role of climate data in defining financial conditions; key enabling factors and barriers to an effective utilisation and diffusion of such instruments.
Main results on governance arrangements show that, while climate-neutral and resilience-oriented urban finance instruments differ substantially in form and scale, their governance mechanisms converge around a set of recurring elements: public oversight, contractualization, intermediation, verification, multi-actor coordination and risk management. These shared governance features are critical for ensuring legitimacy, effectiveness and scalability across diverse urban regeneration contexts. Furthermore, financial institutions emerge as relevant players with several diverse roles and responsibilities according to the specific instrument. Their roles vary according to the type and structure of the instrument. They may act as direct providers of capital through instruments such as green loans, channeling private finance into energy efficiency upgrades, renewable energy installations, and climate adaptation measures. In capital market instruments- such as green bonds, climate bonds, or resilience bonds - financial institutions often serve as arrangers and underwriters, structuring the issuance, assessing risk, pricing the instrument, and placing it with investors. In risk-sharing mechanisms, including guarantees, insurance products, and blended finance structures, they may act as providers or managers, helping to de-risk projects and enhance their bankability, particularly where urban regeneration projects face high upfront costs or uncertain returns. Moreover, financial institutions can assume

a more integrated and operational role as programme administrators. For example in PACE schemes, they may administer the programme, provide upfront capital to finance interventions, and recover repayments through property tax-based mechanisms. Through these diverse roles, financial institutions contribute not only financial resources but also risk assessment expertise, market credibility, and the capacity to mobilize additional private investment, thereby enabling scalable climate-neutral and resilient urban transformation.

Different repayment and revenue generation approaches are possible according to the financing instrument and the types of measures they can finance. Measures in the building (e.g. building envelope upgrades, energy-efficient heating systems) and energy sectors (e.g. photovoltaics, district heating networks, smart grids) often have the capacity to generate substantial and relatively predictable energy savings. This makes them compatible with financing instruments that need recurring cash flows to repay capital over time (i.e. revolving funds, green loans) and those that rely on future savings for repayment (e.g. EPCs, on-bill financing, PACE). Green infrastructure and nature-based solutions (NBS) - including urban parks, green roofs, tree planting, sustainable urban drainage systems, and ecosystem restoration - primarily deliver ecosystem services such as microclimate regulation, biodiversity increase, flood mitigation, and enhanced liveability. These benefits, while highly valuable from a societal perspective, rarely generate direct revenues and are often diffuse and long-term in nature. Where governments establish regulatory or compliance-based frameworks, instruments such as carbon credits and biodiversity credits can be used to monetise environmental benefits and channel private capital into green interventions. Where the generation of ecosystem-services from these measures can be assessed and verified, PES can monetize them and create a revenue stream from the project.

Resilience measures related to recovery/prevention in several sectors (e.g. building, green infrastructure, water sectors) can also be supported by risk reduction instruments - such as resilience bonds and catastrophe bonds, parametric insurance, weather derivatives and forecast-based financing – which monetize risk reduction effects into their financial conditions. For example, in the case of resilience bonds, NBS may reduce climate risks (e.g. through wetlands, green roofs, floodable parks) and therefore lower insurance premiums. Parametric insurance provides rapid liquidity after extreme events, which can be used to restore built, water and green infrastructure. Forecast based financing act preventively and can support the implementation of NBS, flood protection or other measures before the event occur.

Some financing instruments are, by design, suitable for supporting integrated packages of climate measures rather than single, isolated measures. These instruments can accommodate multiple types of eligible investments within the same financial structure, allowing measures of different sectors to be financed simultaneously. Revolving funds are a clear example, as they can channel capital toward diverse climate-related measures - such as building retrofits, renewable energy systems, or low-carbon infrastructure - while recycling repayments to support additional investments over time. Their programmatic structure enables the financing of different measures under a common governance and eligibility framework. PACE provides another example, as it allows property owners to bundle upgrades - such as energy efficiency improvements, renewable energy systems, and seismic resilience measures - into a single loan repaid through property-linked assessments. Green bonds similarly support integrated approaches, as municipal issuances are often structured to finance multi-sectoral investment programs, covering a range of measures including transport infrastructure, building upgrades, renewable energy deployment, and nature-based solutions within a single bond framework.

Annex 1 shows the potential applicability of analysed financing instruments to mitigation and adaptation measures.

Considering the types of GHG emissions data taken into account in the development and application of instruments, most mainly focus on operational emissions (Scope 1 and Scope 2), while carbon credits are the only instrument where whole-life carbon has been assessed in some cases (see Annex 2 for a detailed overview). GHG emissions data are used in different ways, ranging from the support to projects screening – in order to prioritize financing to those with highest mitigation potential – to core criteria in the allocation of financial resources. While the direct monetisation of emission reductions remains confined to specific instrument types (i.e. carbon credits), a wider range of mechanisms integrate GHG metrics in their assessment logic. Overall, the results show the importance of aligning financial design, governance priorities and policy objectives to ensure that emission reductions are not merely a co-benefit but a central and measurable outcome of climate-neutral urban regeneration finance.

Looking at climate adaptation, analysed instruments demonstrate a range of approaches to climate risk assessment, spanning probabilistic models, forecast systems, historical baselines, and performance monitoring protocols. While the degree of formalisation and the nature of the indicators differ, they all rely on the quantification of climate-related variables as a core mechanism for structuring responses to environmental risks. Some instruments rely on a direct, contractual link between risk and funding, while others incorporate climate considerations more loosely through project screening and prioritisation. Both approaches reflect ongoing efforts to align financial mechanisms with the realities of a changing climate, either through structured disbursement logic or through prioritisation processes that allocate funding based on climate vulnerability or expected resilience benefits.

A set of enabling factors have been identified as crucial for the deployment of analysed instruments in different contexts. These include i) institutional factors, like the availability of enabling, stable and transparent regulations; coordination between actors, in particular funders and implementers; effective procedures; and political support; ii) economic factors, which in particular for revolving funds include initial capital availability and having a set of robust investments with defined payback periods; project scale and the possibility to bundle similar projects to reach scale; strong repayment prospects that ensure the sustainability of revolving instruments; and iii) technical factors, like the availability of screening criteria and data to select projects; presence of standardized methodologies to assess projects; technical capacity to implement instruments, select projects, monitor and assess related climate impacts; the involvement of third-party verification. Also several barriers have been identified which can hamper the operation of these instruments, and can be addressed through several strategies. These include i) institutional barriers, like regulatory uncertainty, regulatory and administrative complexity, lack of cooperation and effective governance mechanisms, limited or inadequate stakeholder involvement; ii) cultural factors, linked to limited awareness, understanding, knowledge or trust in these instruments; iii) economic factors, like high transaction costs, difficulties in securing upfront capitalization, limited availability to commit capital; and finally iv) technical factors, like limited access to high-quality data, lack of standardization, and technical complexities. These results suggest a range of key policy implications that can be considered in the climate-neutrality and resilience agenda in the context of urban regeneration:

- Promote awareness of available financing instruments, how they function and how they could be combined into effective financing packages according to project's characteristics
- Develop standardized contracts to facilitate the uptake of related instruments
- Develop common standards to account and track climate impacts of financed measures, in order to report achievements consistently
- Integrate current accounting and monitoring standards with whole-carbon emissions, in order to provide more comprehensive estimates of carbon impacts associated with new developments and steer finance towards projects that maximise carbon reduction across the whole project lifecycle
- Adopt a portfolio-based approach, combining measures with different revenue generation potentials within the same portfolio, so that financially attractive measures (e.g. low carbon measures, energy efficiency) help to cross-subsidise interventions with lower returns but high public value (e.g. adaptation and resilience-oriented)

- Leverage the co-benefits of low carbon and adaptation measures, in particular those that align with the priority urban policy goals (e.g., poverty reduction, equity and inclusion, ecological integrity, energy security, mobility, air quality and health, city liveability, etc.) to attract further public and private investments.

Future developments of this analysis could benefit from the use of quantitative measures to assess the performances of instruments across several dimensions (e.g. cost effectiveness; climate impacts; social equity). The analysis could also be further enriched by considering a wider sample of real case-studies where these financing instruments have been implemented and analyse results achieved over time.

Bibliography

Aili, F., Alonso, G., Brown, V., Carreira Silva, M., Luque, O., & Salmoral, G. (2025). *Mobilizing local resources for climate adaptation through innovative Public-Private partnerships: A guide for local authorities to leverage private investment for climate-resilient development*. European Commission.

Alexeew, J., Bergset, L., Meyer, K., Petersen, J., Schneider, L., & Unger, C. (2010). An analysis of the relationship between the additionality of CDM projects and their contribution to sustainable development. *International Environmental Agreements: Politics, Law and Economics*, *10*(3), 233–248. https://doi.org/10.1007/s10784-010-9121-y

Allendorf, H., Range, M., Bohl, D. & Wiechers, T. (2025). Climate and disaster risk finance: a mosaic of instruments. Published by GIZ.

Amirtahmasebi, R., Orloff, M., Wahba, S., & Altman, A. (2016). *Regenerating Urban Land: A Practitioner's Guide to Leveraging Private Investment*. World Bank. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/979091467993467764/regenerating-urban-land-a-practitioner-s-guide-to-leveraging-private-investment

Artemis. (2025). *Q4 2025 catastrophe bond & ILS market report*. https://www.artemis.bm/news/artemis-q4-2025-cat-bond-ils-market-report/

BASE. (2025). Financing for biodiversity. A state of the play of biodiversity credits and habitat banks. Available at: https://energy-base.org/news/financing-for-biodiversity-a-state-of-the-play-of-biodiversity-credits-and-habitat-banks/

Bednar-Friedl, B., R. Biesbroek, D.N. Schmidt, P. Alexander, K.Y. Børsheim, J. Carnicer, E. Georgopoulou, M. Haasnoot, G. Le Cozannet, P. Lionello, O. Lipka, C. Möllmann, V. Muccione, T. Mustonen, D. Piepenburg, and L. Whitmarsh, 2022: *Europe*. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 1817–1927, doi:10.1017/9781009325844.015.

Brand, M. W., Seipp, K. Q., Saksa, P., Ulibarri, N., Bomblies, A., Mandle, L., Allaire, M., Wing, O., Tobin-de la Puente, J., Parker, E. A., Nay, J., Sanders, B. F., Rosowsky, D., Lee, J., Johnson, K., Gudino-Elizondo, N., Ajami, N., Wobbrock, N., Adriaens, P., Gibbons, J. P. (2021). Environmental impact bonds: A common framework and looking ahead. *Environmental Research: Infrastructure and Sustainability*, *1*(2), Article 023001. https://doi.org/10.1088/2634-4505/ac0b2c

Brandon, C., A. Aggarwal, B. Kratzer, R. Carter, V. Laxton, & Ross., K. (2025). *From bonds to blended finance: How a diverse range of financial instruments are financing climate adaptation and resilience. Working Paper.* Washington, DC: World Resources Institute. Available online at doi.org/10.46830/wriwp.25.00061.

Braun, A., & Kousky, C. (2021). *Catastrophe bonds*. Wharton Risk Management and Decision Processes Center. https://riskcenter.wharton.upenn.edu/wp-content/uploads/2021/07/Cat-Bond-Primer-July-2021.pdf

CCFLA. (2021). *The State of Cities Climate Finance: Executive Summary*. Cities Climate Finance Leadership Alliance. https://citiesclimatefinance.org/wp-content/uploads/2021/06/2021-State-of-Cities-Finance-Executive-Summary.pdf

CCFLA. (2023). *Net Zero Carbon Buildings in Cities: Interdependencies between Policy and Finance*. Climate Policy Initiative. https://www.climatepolicyinitiative.org/wp-content/uploads/2024/01/Full-Report_Net-Zero-Carbon-Buildings-in-Cities_Interdependencies-between-Policy-and-Finance.pdf

CCFLA. (2024) Financial Instruments Toolkit. Retrieved from citiesclimatefinance.org: https://citiesclimatefinance.org/financial-instruments

CCFLA. (2024). The State of Cities Climate Finance 2024. Cities Climate Finance Leadership Alliance at: https://citiesclimatefinance.org/publications/2024-state-of-cities-climate-finance

Center for Innovative Finance Support. (n.d). *Alternative project delivery defined.* https://www.fhwa.dot.gov/ipd/alternative_project_delivery/defined/new_build_facilities/dbfm.aspx

Chatry, I. et al. (2025). *Mobilising sustainable finance for regions and cities.* OECD Regional Development Papers, No. 132, OECD Publishing, Paris, https://doi.org/10.1787/2af8dadb-en.

Cicmanova, J., Turner, I., van Liefland, S., Kaiser, M., & Ethuin, P. (2017). *Infinite solutions guidebook: Financing the energy renovation of residential buildings through soft loans and third-party investment schemes*. Energy Cities. https://energy-cities.eu/wp-content/uploads/2019/01/PUBLI_infinite_solutions_guidebook_softloans_2017_en.pdf

City of Eugene. (n.d.). *Downtown riverfront*. https://www.eugene-or.gov/3506/Downtown-Riverfront

City of Paris (2020). *Sustainability Bond Reporting 2020: Projects funded by the € 300 million Sustainability Bond issued on November, 2020*. Paris: Ville de Paris.

City of Miami. (2018, December 13). *Miami Forever Bond: Tranche 1 project list - approved*. https://www.miami.gov/files/assets/public/v/2/document-resources/pdf-docs/miami-forever-bond_tranche-1-approved-projects_12.13.18.pdf

Climate Adapt (a) (n.d.) *Optimization of the mix of private and public funding to realise climate adaptation measures in Malmö. Case study.* https://climate-adapt.eea.europa.eu/en/metadata/case-studies/optimization-of-the-mix-of-private-and-public-funding-to-realise-climate-adaptation-measures-in-malmo

Climate Adapt (b) (n.d.) *Public-private partnership for a new flood proof district in Bilbao, Spain. Case study.* https://climate-adapt.eea.europa.eu/en/metadata/case-studies/public-private-partnership-for-a-new-flood-proof-district-in-bilbao

Climate Bonds Initiative. (2024). *Climate bonds resilience taxonomy methodology*. https://www.climatebonds.net/files/reports/cbi_resilience-methodology_2024.pdf

Community Action Partnership. (2018, July). *Model testimony: Risks of on-bill financing*. https://communityactionpartnership.com/wp-content/uploads/2018/07/Model-Testimony-Risks-of-On-Bill-Financing.pdf

Descartes Underwriting. (n.d.). *Building resilience for US municipalities against flood risk with a sensor-based parametric solution* [Case study]. https://descartesunderwriting.com/case-studies/building-resilience-us-municipalities-against-flood-risk-sensor-based-parametric

Deuskar, C., Murray, S., Leiva Molano, J. S., Khan, I. A., & Maria, A. (2025). *Banking on Cities: Investing in Resilient and Low-Carbon Urbanization*. World Bank Group. https://hdl.handle.net/10986/43183

EEA. (2024). *Urban adaptation in Europe: what works? Implementing climate action in European cities* (EEA Report 14/2023). European Environment Agency. https://www.preventionweb.net/publication/urban-adaptation-europe-what-works-implementing-climate-action-european-cities

Eis, J., & Khatri, A. (2024). *Biodiversity credits: A guide to identify high-integrity projects*. World Economic Forum. https://www.weforum.org/publications/biodiversity-credits-a-guide-to-identify-high-integrity-projects/

ENEL (n.d.) *Weather derivatives.* Available at https://globaltrading.enel.com/financial-products/weather-derivatives

Eugene Water & Electric Board. (2023, July 11). *EWEB and City finalize sale of former riverfront headquarters*. https://www.eweb.org/your-public-utility/news/eweb-and-city-finalize-sale-of-former-riverfront-headquarters

European Investment Bank (EIB). (2015). *London Green Fund – Case Study*. https://www.fi-compass.eu/sites/default/files/publications/case-study_london-green-fund_uk.pdf

Evans, S. (2023, May 12). *MTA secures $100m MetroCat Re cat bond at bottom of price guidance*. Artemis. https://www.artemis.bm/news/mta-secures-100m-metrocat-re-cat-bond-at-bottom-of-price-guidance/

Fisher, Sheehan and Colton (FSC). (2015). Risks of On-bill financing. Weatherization Leveraged Partnerships Project. Available at https://communityactionpartnership.com/wp-content/uploads/2018/07/Model-Testimony-Risks-of-On-Bill-Financing.pdf

Generali Global Corporate & Commercial. (2023). *Parametric insurance: We speak your language*. https://www.generaliglobalcorporate.com/solutions/parametric-insurance.html

GGGI. (2024). *Financing low carbon buildings*. Global Green Growth Institute. https://alcbt.gggi.org/wp-content/uploads/2025/02/4.1-Financing-Low-Carbon-Buildings.pdf

GHG Management Institute & SEI (n.d.). Carbon offset guide. Available at: https://offsetguide.org/

Green Bond Principles & ICMA. (2025). Green Bond Principles Voluntary Process Guidelines for Issuing Green Bonds. https://www.icmagroup.org/assets/documents/Sustainable-finance/2025-updates/Green-Bond-Principles-GBP-June-2025.pdf

Greiber, T. (2011). Enabling conditions and complementary legislative tools for PES. In Payments for ecosystem services and food security (pp. 205–225). Food and Agriculture Organization of the United Nations. https://www.fao.org/4/i2100e/i2100e07.pdf

Hermann, A., Köferl, P., & Mairhöfer, J.P. (2016). *Climate Risk Insurance: New Approaches and Schemes.* Working paper. Allianz.

Hofer, L., Zanini, M. A., Gardoni, P. (2023). *A CAT bond-based coverage scheme proposal for Italy*. Procedia Structural Integrity, Volume 44, Pages 934-941, ISSN 2452-3216. https://doi.org/10.1016/j.prostr.2023.01.121

International Federation of Red Cross and Red Crescent Societies (IFRC) (n.d). *What is Forecast-based Financing?* Available at https://www.forecast-based-financing.org/

International Finance Corporation (IFC). (2018). *Climate investment opportunities in cities—an IFC analysis*. https://www.ifc.org/wps/wcm/connect/875afb8f-de49-460e-a66add2664452840/201811-CIOC-IFC-Analysis.pdf?MOD=AJPERES&CVID=mthPzYg

International Finance Corporation (IFC). (2023). *Building Green: Sustainable Construction in Emerging Markets*. World Bank Group. https://www.ifc.org/content/dam/ifc/doc/2023/building-green-sustainable-construction-in-emerging-markets.pdf

IISD (2023). *Innovative Financial Instruments and Their Potential to Finance Climate Change Adaptation in Developing Countries*.

International Capital Market Association & Loan Market Association. (2024, June). Guidelines for sustainability-linked loans financing bonds. https://www.icmagroup.org/assets/documents/Sustainable-finance/2024-updates/Guidelines-for-Sustainability-Linked-Loans-financing-Bonds-June-2024.pdf

Interreg Central Europe. (2024). *Climate resilience (innovative) funding instruments on the municipal level*. Mission CE Climate. https://www.interreg-central.eu/wp-content/uploads/2024/11/Funding-Instruments-for-Climate-Resilience-at-the-Municipal-Level.pdf

Jena, L. P., & Vuppuluri, V. (2025, July 30). Green bonds: Issues, incentives, and the green premium debate [Briefing note]. Institute for Energy Economics and Financial Analysis (IEEFA). https://ieefa.org/resources/green-bonds-issues-incentives-and-green-premium-debate

Kaminker, C. & Majowski, C. (2018). Green bonds: ecosystem, issuance, process and case studies. Implemented by: developPPP.de, GIZ, Emerging Markets Dialogue on Finance, SEB.

LaSalle, J. M., Micale, V., de Aragão Fernandes, P., Haesra, A., Masale, E., Rosane, P., Wijaya, E., Zeki, M., & Negreiros, P. (2022). *Financing Net Zero Carbon Buildings: A background and scoping paper*. Cities Climate Finance Leadership Alliance. https://www.climatepolicyinitiative.org/publication/financing-net-zero-carbon-buildings/

Machiels, T. (2024). *Dorset Heathlands – Financing heathland mitigation with developer obligations*. University of Antwerp for CLIMATEFIT. https://climatefit-heu.eu/wp-content/uploads/2024/07/12_Dorset-Heathlands.pdf

McDonald, R. (2021, July 2). *Eugene projects receive millions in state funding via American Rescue Plan*. The Register-Guard. https://eu.registerguard.com/story/news/2021/07/02/eugene-oregon-legislature-funding-american-rescue-plan-safe-sleep-riverfront/7821059002/

NAP Global Network (2024). *Climate resilience bonds*. https://napglobalnetwork.org/innovative-financing/climate-resilience-bonds/

Novikova, A., Stelmakh, K., Hessling, M., Emmrich, J., & Stamo, I. (2017). *Guideline on finding a suitable financing model for public lighting investment: Deliverable D.T2.3.3* Best practice guide. Report of the EU funded project "INTERREG Central Europe CE452 Dynamic Light". https://www.ikem.de/wp-content/uploads/2021/07/Dynamic-Light_D.T2.3.3_Novikova-et-al-2017-Best-Practice-Guide-final.pdf

OECD. (2019). *Financing climate objectives in cities and regions to deliver sustainable and inclusive growth* (OECD Environment Policy Paper No. 17). https://doi.org/10.1787/ee3ce00b-en

OECD. (2023). *Financing Cities of Tomorrow: G20/OECD Report for the G20 Infrastructure Working Group under the Indian Presidency*. Paris: OECD Publishing. doi: https://doi.org/10.1787/51bd124a-en

Probst, B. S., Toetzke, M., Kontoleon, A., Anadón, L. D., Minx, J. C., Haya, B. K., Schneider, L., Trotter, P. A., West, T. A. P., Gill-Wiehl, A., & Hoffmann, V. H. (2024). Systematic assessment of the achieved emission reductions of carbon crediting projects. *Nature Communications*, *15*, Article 9562. https://doi.org/10.1038/s41467-024-53645-z

Public-Private Infrastructure Advisory Facility (PPIAF). (2009). Toolkit for public-private partnerships in roads & highways: Module 1: Overview and diagnosis. World Bank. https://www.ppiaf.org/sites/ppiaf.org/files/documents/toolkits/highwaystoolkit/6/pdf-version/1-43.pdf

Quantified Ventures. (2018, October 31). *Sharing risk, rewarding outcomes: The environmental impact bond*. https://www.quantifiedventures.com/blog/what-is-an-environmental-impact-bond

Rowell Brokaw Architects. (2010). *EWEB Riverfront Master Plan: A community-developed design for Eugene's downtown riverfront*. Eugene Water & Electric Board. https://www.eugene-or.gov/DocumentCenter/View/28890/EWEB-Riverfront-Master-Plan?bidId=

Saraf, S., Ostermeyer, Y., Kumar, S. and Hussain, T. (2024). *Carbon Financing For Low-Carbon Buildings*. United Nations Environment Programme. https://globalabc.org/resources/publications/carbon-financing-low-carbon-buildings

Sokolsky, B. (2022, May 1). *Eugene downtown riverfront park development continues*. Daily Emerald. https://dailyemerald.com/151089/city-news/eugene-downtown-riverfront-park-development-continues/

Surminski, S., Barnes, J., Hudson, P., & Thomae, J. (2023). *Staying above water: A systemic response to rising flood risk*. Marsh McLennan. https://www.marshmclennan.com/insights/publications/2023/june/staying-above-water-a-systemic-response-to-rising-flood-risk.html

Sustainability Directory. (n.d.). *What are C-PACE program limitations?* Retrieved October 15, 2025, from https://energy.sustainability-directory.com/question/what-are-c-pace-program-limitations/#academic

Swiss Re. (2020). *Insurance-linked securities market update: Volume XXXIII, August 2020*. https://www.swissre.com/dam/jcr:091f842a-242e-40cf-a4e8-6188bf0594e1/ils-midyear-market-update2020.pdf

Systemiq. (2024). *Urban Regeneration: turning obsolescence into value for society, nature, climate and investors*. Systemiq White Paper. https://www.systemiq.earth/wp-content/uploads/2024/09/Systemiq_Urban_Regeneration_White_Paper.pdf

Taranu, V. (2024). *Sustainable plus energy neighbourhoods: Mainstreaming the neighbourhood approach into EU building policies*. BPIE. https://www.bpie.eu/publication/sustainable-plus-energy-neighbourhoods-mainstreaming-the-neighbourhood-approach-into-eu-building-policies/

The River District Eugene. (n.d.). *The River District*. https://theriverdistricteugene.com/the-river-district/

Thompson, A. (2020, July 2). Environmental impact bonds: Where are they now? *Environmental Finance Blog*. University of North Carolina, School of Government. https://efc.web.unc.edu/2020/07/02/environmental-impact-bonds-where-are-they-now/

Todeschi, V., Bertoldi, P., Hernandez Moral, G., Clementi, E., Treville, A., & Melica, G. (2025). *Financial instruments for mitigation, adaptation and energy poverty actions*. Publications Office of the European Union. https://publications.jrc.ec.europa.eu/repository/handle/JRC142127

United Nations (UN) (2025). World Urbanization Prospects 2025: Summary of Results. UN DESA/POP/2025/TR/ NO. 12. New York: United Nations.

UN Environment Programme – Finance Initiative (UNEP FI) & Institute for Real Estate Economics (IIÖ). (2022). *Managing Transition Risk in Real Estate: Aligning to the Paris Climate Accord*. United Nations Environment Programme Finance Initiative. https://www.unepfi.org/publications/managing-transition-risk-in-real-estate/

UN-Habitat (2024). Cities and climate action. World cities report 2024. https://unhabitat.org/sites/default/files/2024/11/wcr2024_-_full_report.pdf

World Bank (WB). (2023). *Index-based weather derivative*. https://thedocs.worldbank.org/en/doc/29d15a97a9791b5e6cfac1c302d08f08-0340012023/original/product-note-index-based-weather-derivative.pdf

World Bank (WB) (2026a). *Concessions Build-Operate-Transfer (BOT) and Design-Build-Operate (DBO) Projects.* Public-Private Partnerships Resource Center. https://ppp.worldbank.org/agreements/concessions-bots-dbos#BOT%20Projects

World Bank (WB) (2026b). *PPP contract types and terminology*. Public-Private Partnerships Resource Center. https://ppp.worldbank.org/ppp-contract-types-and-terminology

World Bank & United Nations Capital Development Fund (WB&UNCDF). (2024). *Local Governments Climate Finance Instruments - Global Experiences and Prospects in Developing Countries*. World Bank Group. http://documents.worldbank.org/curated/en/099041224090039327

World Economic Forum (WEF). (2025a). *The Resilience Opportunity: Unlocking Climate Resilience through Public-Private Collaboration*. White Paper. https://www.weforum.org/publications/the-resilience-opportunity-unlocking-climate-resilience-through-public-private-collaboration/

World Economic Forum (WEF). (2025b). *Insuring Against Extreme Heat: Navigating Risks in a Warming World.* White Paper. https://www.weforum.org/publications/insuring-against-extreme-heat-navigating-risks-in-a-warming-world/

World Food Programme (WFP). (2019). *Forecast-based Financing (FbF): Anticipatory actions for food security*. https://www.wfp.org/publications/forecast-based-financing-fbf-anticipatory-actions-food-security

World Meteorological Organization (WMO). (2025). *State of the Global Climate 2024* (WMO-No. 1368). https://wmo.int/sites/default/files/2025-03/WMO-1368-2024_en.pdf

Xie, F., Liu, G., & Zhuang, T. (2021). *A Comprehensive Review of Urban Regeneration Governance for Developing Appropriate Governance Arrangements*. Land, 10(5), 545. https://doi.org/10.3390/land10050545

Zelena Energetska Zadruga. (n.d.). *Križevci Solar Roofs*. Retrieved October 15, 2025, from https://www.zez.coop/en/projekt/krizevci-solar-roofs/

Annex 1 – Financing instruments and measures

	Bonds		Loans	Third-party financing				Revolving funds	Insurance				Credit enhancement mechanisms	PES	Credits			PPPs
	Bonds	Resilience Bonds	Green loans	EPCs	Crowdfunding	PACE	On-bill financing	Revolving funds	Catastrophe Bonds	Parametric Insurance	Forecast-based	Weather Derivatives	Guarantees	PES	Carbon credits	Green & white certificates	Biodiversity credits	PPPs
Buildings																		
EE building envelope	■		■	■		■	■	■					■		■	■		■
RE space heating/hot water	■		■			■		■							■	■		
EE space heating/hot water	■		■	■		■	■	■					■		■	■		
EE lighting systems	■		■	■		■	■	■					■			■		
EE electrical appliances	■						■	■								■		
New buildings construction	■							■					■					■
Heat-proofing of buildings	■	■	■			■		■		■	■	■	■					■
Passive & active cooling systems	■	■	■			■		■		■	■	■	■					■
Climate-proofing of open spaces/areas	■	■	■					■		■	■	■	■					■
Post-disaster and recovery	■	■	■		■			■	■	■	■	■						■
Transport																		
Cleaner/efficient vehicles	■		■					■							■			■
EVs (incl. infrastructure)	■					■	■								■			■
Car sharing/pooling	■		■		■			■					■					■
Improve public transport supply	■		■					■					■		■			■
Climate proofing of infr/vehicles	■	■	■					■		■	■	■	■		■			■
Logistics/urb freight improvement	■										■							■
Bike/pedestrian lanes realization/optim	■		■		■			■							■			■
Road network realis/optim/climate proofing	■	■	■					■		■	■	■	■					■
Green infrastructure & NBS																		
Reforestation		■			■			■	■	■				■			■	■
Tree planting	■	■	■		■			■	■				■	■			■	■
SUDS	■	■	■		■			■	■	■	■		■	■			■	■
Depaving	■	■	■		■			■						■			■	■
Green roofs/walls			■		■	■							■	■				
Ecosystems restoration	■	■			■				■					■			■	
Urban parks	■				■									■			■	
Urban orchards					■												■	

	Bonds		Loans	Third-party financing				Revolving funds	Insurance				Credit enhancement mechanisms	PES	Credits			PPPs
	Green/Climate Bonds	Resilience Bonds	Green loans	EPCs	Crowdfunding	PACE	On-bill financing	Revolving funds	Catastrophe Bonds	Parametric Insurance	Forecast-based Financing	Weather Derivatives	Guarantees	PES	Carbon credits	Green & white certificates	Biodiversity credits	PPPs
Energy systems																		
Hydroelectric power																		
Wind power																		
Photovoltaics																		
Biomass power plant																		
Combined Heat and Power																		
Smart grids																		
DH/cooling plant																		
DH/cooling network																		
Improved electricity interconnections																		
Water & Wastewater																		
EE in water services																		
Water efficiency																		
Water reuse																		
Stormwater management																		
Water storage																		
Flood mgt./protection infr.																		
Drainage system optimization																		
Sewer system optimization																		
Waste																		
Waste prevention/reduction																		
Material recovery																		
Low carbon waste treatment																		
Efficient waste logistics																		

Annex 2 – Climate metrics' role within the financing instruments

		Climate mitigation metrics			*Climate adaptation metrics*		
Instrument category	*Financing instrument*	*GHG emissions considered?*	*GHG indicators foreseen?*	*Link GHG emissions-financial conditions?*	*Climate risks considered?*	*Climate risk indicators foreseen?*	*Link climate risk data – financial conditions?*
Bonds	Green/Climate bonds	Yes, project-related, mainly operational emissions	Yes, project-related	Yes, usually not formalized	Yes	No	No link
	Resilience bonds	Yes, project-related, mainly operational emissions	Yes, project-related	No link	Yes	Yes: project-level KPIs, such as hectares of protected land, percentage reductions in infrastructure downtime.	Yes, usually not formalized
Loans	Green loans	Yes, project-related, mainly operational emissions	Yes, project-related	No link	Yes	No	No link
Third-party financing	Energy Performance Contracts (EPCs)	Yes, project-related, mainly operational emissions	Yes, project-related	Yes (linked to energy reduction)	No	No	No link
	PACE	Yes, project-related, mainly operational emissions	Yes, project-related	Yes, usually not formalized	No	No	No link
	On-bill financing	Yes, project-related, mainly operational emissions	Yes, project-related	Yes, usually not formalized	No	No	No link
	Crowdfunding / citizen investment	Yes, project-related, mainly operational emissions	Yes, project-related	Possibly	Yes	Possibly	Possibly
Revolving funds	Revolving fund	Yes, project-related, mainly operational emissions	Yes, project-related	Possibly	Possibly	Possibly	Possibly
Insurance	Catastrophe bonds	Not considered	NA	No link	Yes	Yes: probabilistic hazard models, including event frequency, intensity thresholds, and estimated loss distributions linked	Yes, formalized

						to specific climate-related perils.	
	Parametric insurance	Not considered	NA	No link	Yes	Yes: physical parameters, e.g. rainfall intensity, temperature thresholds, wind speed, or seismic activity.	Yes, formalized
	Forecast-based Financing	Not considered	NA	No link	Yes	Yes: probabilistic forecasts and early-warning systems, including predicted rainfall, temperature extremes, or hazard likelihood thresholds.	Yes, formalized
	Weather derivatives	Not considered	NA	No link	Yes	Yes: weather indices, e.g. heating or cooling degree days, cumulative rainfall levels, or temperature averages.	Yes, formalized
Credit enhancement mechanisms	**Guarantees**	May be considered indirectly where guarantees support low-carbon or green projects	Possibly	Possibly	May be considered indirectly where guarantees support adaptation projects	Possibly	Possibly
Payment for Ecosystem Services (PES)	**PES**	GHG emissions may be considered where ecosystem services relate to carbon sequestration or avoided emissions, although PES schemes are more commonly designed around ecosystem	Project-related	No link	Yes	Yes: hydrological performance, water retention capacity, vegetation cover, or soil stability linked to flood or drought risk reduction.	No link

		conservation and restoration objectives.					
Credits	Carbon credits	Yes, project-related, covering up to Scope 3 emissions	Yes, project-related	Yes, formalized	No	No	No link
	Green & white certificates	Yes, project-related, mainly operational emissions	Yes, project-related	Yes (linked to energy reduction)	No	No	No link
	Biodiversity credits	Usually not considered	Project-related	No link	No	No	No link
Public Private Partnerships (PPP)	PPP	Project-related, mainly operational emissions	Project-related	Possibly	Possibly	Possibly	Possibly

Possibly = not necessarily foreseen by the instrument, but it could be possibly integrated into it according to the instrument design.