The importance of compound risk in the nexus of pandemics, climate change and finance

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Joint with Stefano Battiston and Irene Monasterolo

Monica Billio, Irene Monasterolo, Stefano Battiston | I.S.E.O. Institute - Istituto di studi Economici e per l'Occupazione (istiseo.org)

Battiston, S., Billio, M., and Monasterolo, I. (2020). Pandemics, climate and public finance: how to strengthen socio-economic resilience across policy domains. Edizioni Ca' Foscari, 259-268. ISBN 978-88-6969-442-4

World Bank's Learning Week on Disaster Risk Finance
Connecting World Bank – Ca' Foscari University

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Compounding Risks

- **Definition:**
- Compound risk as joint materialization of different risk sources (e.g. several hazards + pandemics + geopolitical events + economic and financial shocks)

- **Background:**
- Awareness of decision makers that resilience to compound risk is key for many organizations due to non-linear increase in total exposure, exceeding
- the sum of individual risk sources.

- **Challenges:**
- Need for statistical models of joint distribution of climate-related hazards (see Battiston ea 2025) and models of compounding risks especially in terms of their volatility co-movements (see Baltodano ea 2025).

- **Importance:**
- Help in understanding how economic growth and financial stability are affected and policy responses.

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Pandemics, climate change, geopolitics and policy responses

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1. **Climate change, economic competitiveness and financial stability:**
   - Climate as a new type of risk: deep uncertainty, non-linearity, endogeneity
   - Financial institutions are highly exposed to climate risks (Battiston ea 2025), and losses potentially amplified by interconnectedness (Billio ea 2012)

2. **Compouding pandemics and climate risks (<u>and other risks</u>) could lead to losses amplification**:
   - Implications for pace of recovery and private/sovereign debt sustainability. Need to evaluate how **pandemic risk interacts with climate and finance**
   - Thus, assessing compound risk is key to **(i)** inform climate-aligned **pandemics recovery policies**, **(ii)** avoid unnecessary **trade-offs** between funding priorities, **(iii) build back better**

3. **A macro-financial approach to compound risk assessment:**
   - Assessing climate macrofinancial impacts requires to analyse how risk generates in agents' balance sheets, risk transmission channels and drivers of feedbacks
   - Added value of Stock-Flow Consistent behavioral models and applications with international financial institutions (EIRIN, Monasterolo and Raberto 2018, 2019; Dunz ea 2023)

4. **A financial modelling of compounding risks**

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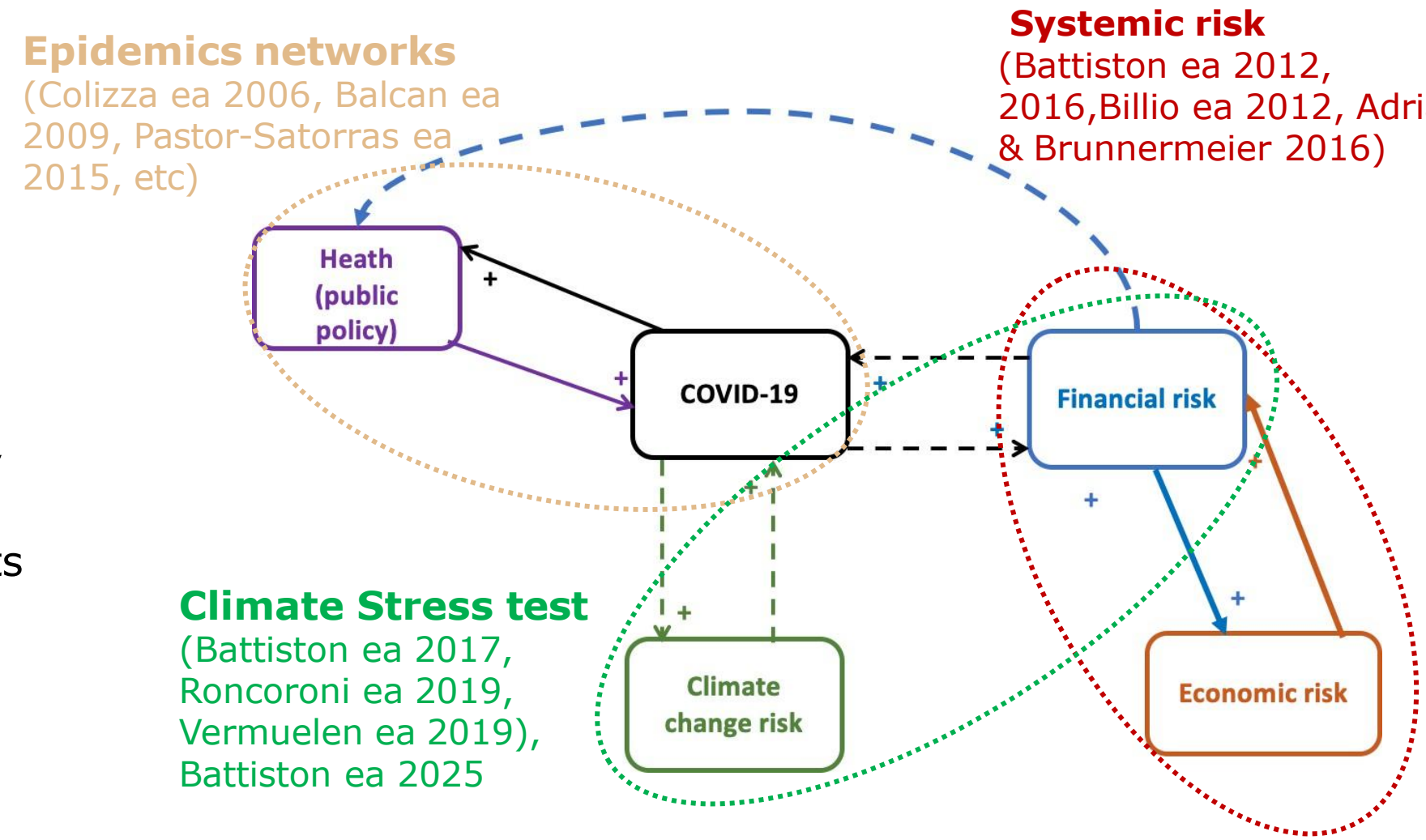
Nexus of pandemic, climate and financial risks

- **Pointed lines: connections already assessed**
- The directionality of the relation is represented by the signs (+/-) of the arrow, where + represents a **reinforcing feedback** while - represents a balancing feedback.



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Why compound risk matters for economic policies to build back better

- Initial fiscal and monetary policies in the EU countries promoted a *'business as usual' recovery*. Necessary short-term strategy to avoid firms to immediately die but may jeopardise the mid-to-long-term environmental sustainability and financial stability objectives.
- **A short-term response to the COVID-19 that does not consider climate issues are more costly and less effective than tackling these issues together.**
- Strengthening the socio-economic resilience against future pandemics, as well as other future shocks, calls **for recovery measures that are fully aligned to the objectives of the EU Green Deal**.
- Tackling these objectives together is more cost effective than addressing the pandemic crisis with short-term measures. To account the interconnectedness among climate risk, pandemic risk and financial risk may be actually the only feasible way to build resilience to future crises.
- **Doing more and better does not cost more: policy complementarity is a matter of understanding and management.**

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Take home messages

- **Compounding** pandemic and climate risks **introduces new challenges for fiscal and financial risk management**, requiring adaptation of macro-financial tools
- When pandemics and climate risks compound, they trigger **non-linear dynamics** that amplify economic shocks and persistence (hysteresis)
- **Risk transmission channels** are shock-specific, and so are the **drivers** of reinforcing feedbacks in the economic and financial systems
- **Neglecting compounding risk** can lead to misunderstand the risk transmission channels and to **underestimate** magnitude of impacts in the economy and financial markets
- Thus, in turn, **limits the effectiveness of policy** responses

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Macroeconomic and Financial Impacts of Compounding Pandemics and Climate Risks

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The analytical framework for assessing compound risks is based on the framework developed jointly with the **World Bank** under the **Crisis Risk Analytics project of the Global Risk Financing Facility: "COVID-19 Pandemic, Financial Shock and Natural Disasters: Assessing compound risks in emerging countries"**

Dunz, N., Mazzocchetti, A., Monasterolo, I., Essenfelder, A. H., & Raberto, M. (2023). Compounding COVID-19 and climate risks: the interplay of banks' lending and government's policy in the shock recovery. Journal of Banking & Finance

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Analyses for emerging countries

Understand how pandemics and climate change (physical) risk interact and affect a country's socio-economic development and financial stability (debt sustainability):

- Assess direct/ indirect impacts of compound COVID-19 and climate physical risks in the economy and finance, accounting for fiscal and monetary policy response to shocks
- **risk transmission channels** across sectors to identify drivers of **reinforcing feedbacks** (amplification effects)
- Focus on **tourism, remittances, export** (i.e. pandemics most hit sectors)
- **Compound risk indicator** to assess non-linear impacts on GDP

Results to support development finance institutions in the design of COVID recovery measures to build resilience to future complex crises, aligning to the climate targets

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The EIRIN macrofinancial model of the open economy

- **Heterogeneous agents/sectors** (parsimonious in complexity) represented as a network of interconnected balance sheets:
  - **Non-Financial** (energy, agric., tourism, services, manufacturing); **Financial** (banks, OFI, central bank), **Government, Foreign sector, Households**
  - Interactions through set of markets: labour, energy, cons/capital goods, trade, financial market (stock/bond/credit market)
  - Consumption/production goods characteristed by energy intensity (**emissions**) and raw material intensity (**biodiversity**)
- **Stock-Flow Consistent**: each agent/sector is represented by its balance sheet entries and interconnected (capital/current accounts) to other agents
- **Leontief** production function (Capital, Labor, Raw Material, Energy)
- Uncertainty about climate impacts and policies translates in financial **agents' climate sentiments** (adaptive expectations in portfolio risk management)

Monasterolo, I., Raberto, M (2018). The EIRIN flow-of-funds behavioral model of green fiscal policies and green sovereign bonds. Ecological Economics, 144, 228-243.

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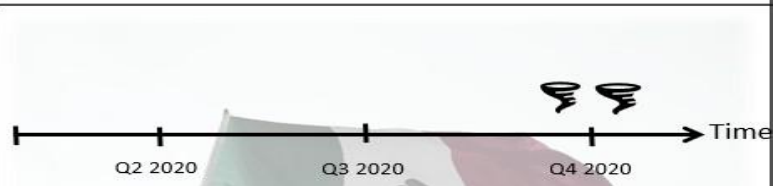
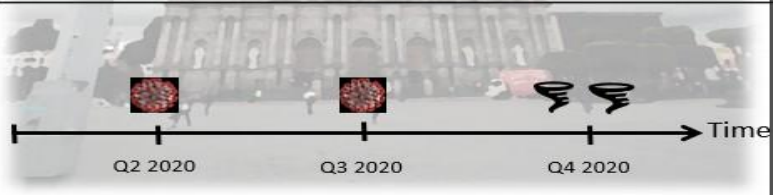
Compound pandemics and climate risk scenarios Mexico application

- 4 Scenarios to compare the macro-financial impacts of hurricanes only, COVID-19 only, compound COVID-19 and hurricanes, considering different **severity** (**mild/strong**)

Scenario No	COVID-19 Lockdown and Policy-response measures	Natural Hazard Occurrence	Graphical Representation
1 Strong hazard	No	Timing: Q4 2020 Impact Size: ς_H = 2.92%	
2 COVID-19 emergency	**Impact from RoW:** • Remittances: **-19.3%** (World Bank & KNOMAD) • Tourism: **-50%** YTD (June 2020) UNWTO • Exports: **-9.19%** (OECD Economic Outlook Double Hit Scenario September 2020) • FDI: **-30-45%** (UNCTAD, World Investment Report 2020) **Impact from domestic economy:** • Private consumption: -**8.26%** (OECD Economic Outlook Double Hit Scenario September 2020) **Gov response measures** (IMF) : *Fiscal:* • Government support increase: **1.2%** of 2019 GDP *Monetary* • Policy rate reduction by **250bps** • Measures to support the financial system: **3.3%** of 2019 GDP	No	
3 Compound COVID-19 and mild hazard		Timing: Q4 2020 Impact Size: ς_L = 1.11%	
4 Compound COVID-19 and strong hazard		Timing: Q4 2020 Impact Size: ς_H = 2.92%	

Hurricane season in Mexico lasts from End of June until End of November. *Source: Dunz ea (2023)*

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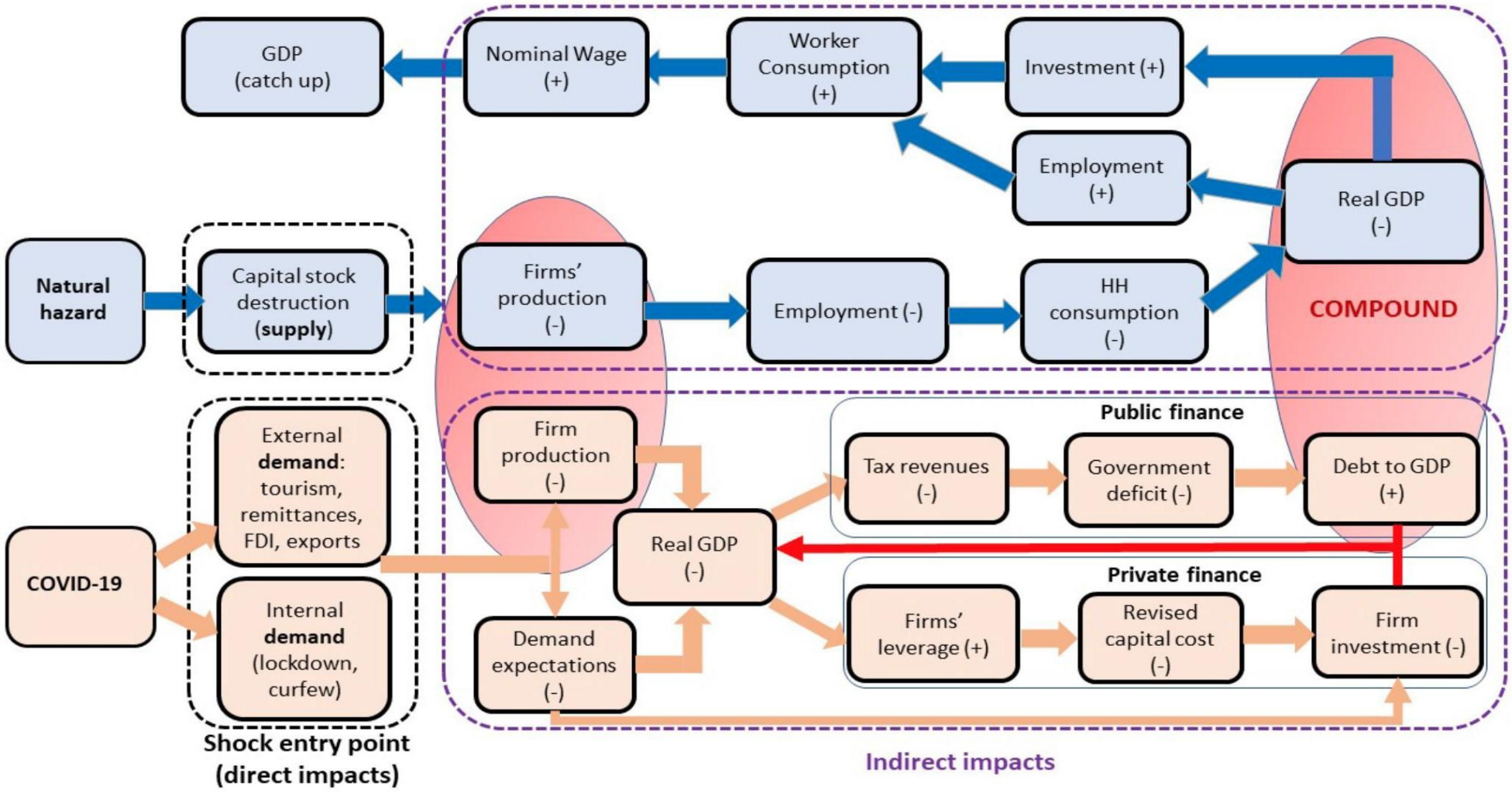
Compound risk transmission channels



Direct impacts (input shock): black dotted boxes; indirect impacts: purple dotted box. Red arrow: reinforcing feedback; shaded red areas: compound effect. Signs (+/-): direction of impact. Source: Dunz ea (2023).

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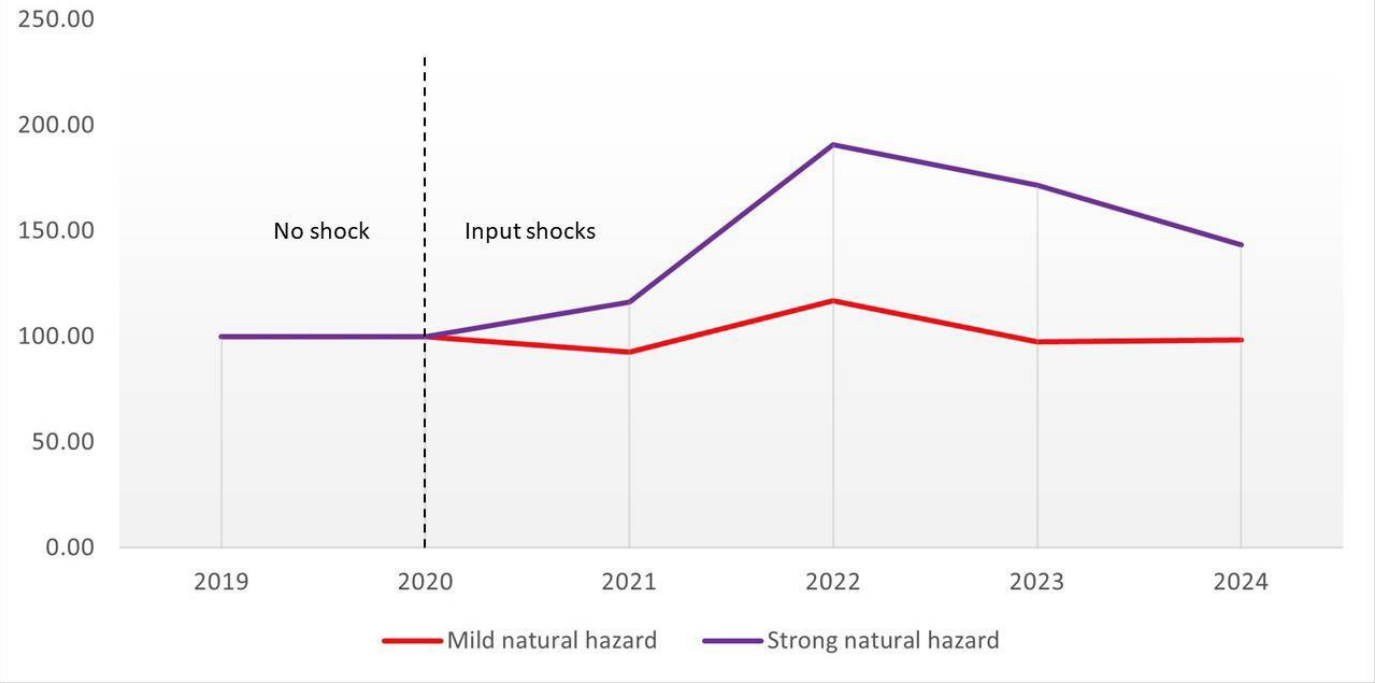
Compound risk indicator: non-linear impacts of compounding

$$\frac{shock_{compound}}{shock_{COVID-19} + shock_{hazard}} * 100$$

- **Compound Risk Index**: Non-linear effect. Greater (>100), smaller (<100), equal (=100) the sum of individual risks

- 2 compound scenarios are considered: (i) **COVID-19 and mild hurricane scenario** (red line) and (ii) **COVID-19 and strong hurricane scenario** (purple line).



Compound risk indicator: *non-linear amplification effects resulting from compounding of COVID-19 and climate shocks happening in 2020.*
x-axis: timeline of the simulation until 2024 on an annual basis.
y-axis: value of compound risk indicator indexed against the sum of the singular event scenarios of hurricane only and COVID-19 only, at 100. Dunz ea (2023)

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A role for policy complementarity?

- Governments does not have to choose between financing COVID-19 response, crucial long-term investments to promote climate and financial stability

- Important to align COVID-19 recovery with countries climate and energy strategy (in the EU, with the EU Green Deal program and the green conditioning of the Next Generation EU)

- **Need and opportunity for complementarities** across fiscal and monetary policies, programs and financial instruments:
  - Immediate COVID-19 response, resilience to future pandemics, and "build back better" coherently with climate objectives
  - In low- and middle income countries, development finance institutions should target recovery support (conditional lending, debt guarantees) to long term programming for climate alignment

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Compounding risks in financial modelling: covolatility

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Baltodano, Billio, Casarin and Costola (2025), Compounding Political and Energy Risks: A clustered stochastic multi–COVOL model, submitted.

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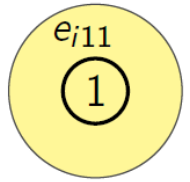
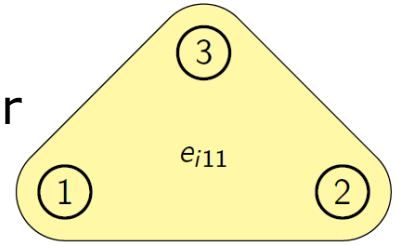
Different compounding schemes with three sources of risk

Possible configurations are

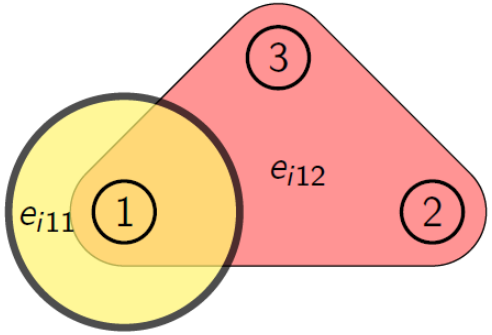
- Absence of Compounding: Only individual risks



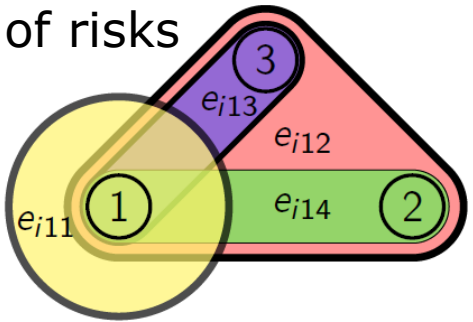
- Global Compounding: All risks are compounded into a single global factor



- Conditional Global Compounding: Both individual risks and a global compounding risk



- Full Compounding: All possible combinations of risks



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Compounding energy and geopolitical risks

26 countries including Australia, Belgium, Brazil, Canada, China, Germany, France, India, Italy, Japan, Netherlands, South Korea, Spain, UK and the US.

Three types of risk:

- Energy Price Risk
- Energy-Related Uncertainty Index
- Geopolitical Risk

Individual and
Global compounding risk

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How Finance can help? Some hints from the WaterLANDS project

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Joint with Enrico Ambrogi

WaterLANDS: Water-based solutions for carbon storage, people and wilderness
WaterLANDS is a €23.6 million, 5-year EU-funded project that will restore wetland sites across Europe and lay the foundations for scalable protection across much wider areas.

https://waterlands.eu/

WaterLANDS

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Finance for mitigation and, particularly, adaptation is still well below what is necessary to tackle the impacts of climate changes, mostly in developing countries which are especially vulnerable to climate change and less financially ready.

Key actions:

1. Developing detailed **funding strategies at national level** and encompassing them in the budget.
2. Scaling up transparency in financial disclosures, **aligning private and public incentives**
3. Assessing the consistency, qualitative and quantitative, of ***international providers' spending plans with climate finance goals***;
4. **leveraging public and blended finance to mobilise private investment (corporate, philanthropic etc).**

WaterLANDS

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Hurdles

- **Short.termism/behavioral attitude**
- Benefits and impact of adaptation investments are often detected and only during extreme climate events and/or over longer time periods. This holds back action by decision makers, often driven by a short-term perspective.
- **Asimmetries :** countries/regions with the highest adaptation needs usually have limited resources due to the economy size and level of development.
- **Externalities**
  Adaptation/mitigation projects may create both positive and negative externalities, which call for effective management of negative impacts while monetising positive effects at societal and environmental level
- **Inconsistent use of (scarce) public resources:** such circumstance does limit the catalytic effect of public funds (i.e.: allowing investments to take place that would not otherwise happen)
- **Know-how** Mostly at developing countries level (public side, NGOs etc), limited professional attitude in designing adaptation projects suitable to attract investors (technical assistance is needed)

Leveraging public and blended finance to mobilise private investment.

1. **The public role.** Adaptation finance is still mostly embodied by public funders, with private roles remaining marginal and/or fragmented (awareness needed).

2. **Enabling environment** Creating a suitable and enabling environment for climate adaptation investments requires aligning policy actions across a number of policy areas to ensure that funding from all sources is mobilised, including public, **corporate and financial sectors**, climate funds and development co-operation (national development bank, international financial institutions, multilateral organizations etc)

3. **Credit enhancement with public funds** Debt, equity and guarantees provided under market conditions (concessional and usually public) are meant to actually determine credit enhancement in order to expand the financial firepower to back investment in adaptation (by triggering "commercial" or "quasi-commercial" investors, i.e. corporate, financial, insurers, *via* risk mitigation and/or return enhancement).

4. **Explicit and implicit returns.** Still, in order to attract additional financial resources by different classes of stakeholders, explicit and implicit returns of the adaptation action have also to be clearly identied/assessed at project design and negotiation level as well. This actiity is also instrumental to identify additional financial instruments and/or potential revenues stream (e.g.: PES, payment for ecosystem services)

Emscher river renaturation (Germany)

a 30-years strategy combining green bonds issuance, EIB loans, EU fundings, regional and private support for restoring biodiversity and increasing extreme weather events resilience

Context: The Emscher river (85km) located in the Ruhr region, was used as an open wastewater channel up to the beginning of 1990. Due to the local mining activities, it was impossible to build an underground sewer system and thus the river and its tributaries were used for the transport of wastewater and rainwater. Besides the considerable biodiversity destruction, the canalization affected the natural floodplains and increased flood and drought risks. The decline of the mining and heavy industries in favour of the services sector allowed a reconsideration of the affected natural space. In 1992 started a 30-years project, up to 2022, aiming to restore the Emscher valley, its biodiversity, but also to increase its flood retention capacity (through retention basins). Thus, the river and its tributaries have been conversed to semi-natural watercourses, a modern underground sewage system has been developed, rainwater retention basins were created as well as 1.6 million m2 of wetlands.

Public interest of the project: the target was to improve the resilience of the Emscher catchment towards extreme climate events (flood and drought risk), but also to improve in general the life conditions in the region, through biodiversity restoration, modern underground sewage system construction, the creation of recreative areas and a more favourable microclimate. Furthermore, during the whole period of the project more than 1400 directly related jobs per year were created (Climate-ADAPT database, 2023) .

Vehicle and Governance: the project was led by the Emschergenossenschaft (North Rhine-Westphalian water board) including municipalities (19), mining companies (9), commercial and infrastructure companies (170). It is governed by a board of 3 managing directors (elected for 5 years).

Public players involvement: water board, municipalities, regional development bank (North Rhine-Westphalia Bank (NRW)), universities and research facilities.

Private players involvement: companies involved in the regional economy (including coal mining companies), regional, and civil society initiatives (Emscherfreunde (Friends of the Emscher)).

Business model to pursue the conservation goal. The financing received from the NRW was upon the completion of several water engineering works allowing the separation between wastewater and clean water (such as: the construction of 132 pumping stations, 4 sewage treatment plants, a central sewage sludge, 87 rainwater treatment plants), but also the renaturalization of the river and its tributaries, the connection to the Rhine river (for the first time in more than 100 years), the creation of retention basins, wetland areas and the increase of biodiversity (309 species observed in 2022 against 7 in 2006) (NRW.BANK, Sustainability Report, 2022).

Cash flow and/or financial "motivation" and related Financial Instrument/Payment mechanism. The revitalisation of the river is financed through several funding schemes and programmes given the consequent total cost (€5.5 billion) and the long time span. Fundings have been received through the regional development bank (North Rhine-Westphalia Bank) which has emitted several green bonds (around € 445.0 million for the last two in 2022, € 250 million in 2013), the EIB (total loans since 2011, €1.8 billion), but also from EU-funding programs such as: INTERREG, FP7 and HORIZON2020, LIFE+, and national research fundings (KLIMZUG). Also, some support has been received from local businesses and NGOs (like Friends of the Emscher). NRW bank is expected to support the initiative with an additional €1 billion up to mid-2020s dedicated among others to the creation of a water learning site and a water experience area (Climate-ADAPT database, 2023).

Lessons learnt: A successful project relies on an active, well-organised entity centralising and planning the administrative, financial and technical aspects. Besides EU fundings, regional development banks (providing impact bonds in this case) and private financing (companies, civil society) can contribute significantly to its development. The access to green bonds financing is conditioned upon the definition and the fulfilment of measurable criteria that can be easily monitored and that comply with the EU Taxonomy. All benefits from restoration activities should be highlighted: biodiversity conservation, flood/drought control, cooling green areas (microclimate), recreational and educational activities.

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The Ingoldisthorpe Wetland (UK)

Context: The river Ingol is located in Norfolk, one of the fastest growing, but also one of the driest UK regions. It is exposed to considerable ammonia and phosphorus pollution levels, released by the water recycling center of Anglian Water (water treatment company). The Norfolk Rivers Trust is the NGO, responsible for the protection and enhancement of Norfolk's aquatic environments, including the river Ingol. Both entities have found an agreement for a natural solution addressing the pollution issues. Namely, the creation of a natural wetland consisting of 4 interconnected ponds, planted with native species able to remove pollution, combined to an enhanced water treatment facility should allow to improve the water quality in the Ingol river.

Public interest of the venture: Several public benefits can result from the project: 1) reduced phosphorus, ammonia and other chemicals concentration levels (due to plant and equipment improvements at the Water Recycling Center and the construction of the wetland); 2) improved wildlife habitat and ecosystems (resulting from the reduced water pollution); 3) reduced flood risk (resulting from the wetland's construction and the remeandering of the river Ingol); 4) GHG emission reductions (related to improved land and forest management).

Private interest in the project: the project has allowed for a substantial cost reduction for the water company, through water consumption savings, power savings and chemical usage savings (related to the equipment enhancements and the wetlands' construction). The project further contributed to the reduction of the company's carbon footprint. The wetland being constructed on private land, landowners have received a financial compensation exceeding their opportunity cost (i.e the payments/returns they might have obtained if an alternative land utilization was chosen).

Vehicle and Governance: the project was financed via the issuance of a green bond issued by Anglian Water (AW), the latter was also responsible for the facility equipment's' improvement. While the Norfolk Rivers Trust (NRT) took the charge of the prefeasibility study (funding and execution), but also of the construction of the wetland, the lease of the concerned farmland and the maintenance for a 20- year period. Thus, NRT investigated the possible technical improvements adapted to the region and the project's particularities and the AW's strong financial structure, governance and reporting were crucial for investors' confidence and involvement.

Public players involvement: the Environment Agency

Private players involved and degree/nature of their involvement. Norfolk Rivers Trust (NGO) and Anglian Water, landowners, community, local organisations

Business model to pursue the conservation goal. The conservation goal was reached trough infrastructure improvements and the creation of a wetland. These enhancements have allowed the water treatment facility to operate more efficiently, respecting high standards, at lower costs and with a reduced impact on the environment. Indeed, as indicated by Anglian Water, the site naturally cleans 1.4 million water litres per day at low costs. This positive experience has motivated the development of 26 new wetlands by 2030.

Cash flow and/or financial "motivation" and related Financial Instrument/Payment mechanism. The total costs related to the Ingoldisthorpe wetland construction were £500 thousand, half of them were financed through a green bond (the first water utility green bond in Europe), issued by Anglian Water. BNP Paribas, HSBC, ING and JP Morgan participated to the bond's arrangement which was defined with a maturity of eight years and an annual fixed-rate yield of 1.6%.

Lessons: Projects involving the participation of water utility companies might be interested by the present experience, namely the sharing of responsibilities and costs, but also by the financing opportunities provided by green bonds.

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The Buyuk Menderes basin Case (Turkey)

Context: The Buyuk Menderes basin is marked by rich biodiversity, where possible improvements in the private sector's production processes would support and make easier the conservation work that is already underway. The basin hosts 3 well known and internationally relevant wetlands that are home to species endowed with conservation priority. However, water pollution and growing scarcity from the existing upstream textile manufacturers around the city of Denizli is a well known threat for the flora, fauna and the quality of life of local communities. The textile industry in Denizli makes massive use of water from the river and produces over US $1.5 billion worth of textiles. Its industrial process in most cases are source of pollution and need to be made more efficient and environment-friendly.

Public interest of the venture. Despite the economic and social importance of the sector in the Turkish economy, the textile production process asks for huge amounts of water, energy and chemicals which determine a long-lasting impact on the environment and sustainability. This circumstance leads to a loss of habitats and biodiversity as well as creating economic risks for the region (for example, water scarcity).

Private interest in the project. With a growing concern of the Governments in having cleaner and more efficient production, private entities are actually obliged to modify the processes. Implementation of new principles and technologies lead to a reduction in energy, water and chemicals during the production cycle, with resulting advantages in terms of: reduction of costs, efficiency improvement as far as resources use, compliance with environmental rules, increase of brand value and higher economic and financial standing when dealing with national and international financial institutions. But, to do this, companies and in particular SMEs need to have proper and competitive financing mechanisms to fill the investment gap.

Large companies' interests, and multinational in particular, are related to their own strategy concerning ESG and sustainability strategy. In the casa of the Buyuk Menderes Basin, , IKEA Group has partnered with WWF and other private large companies, by setting up a multi-stakeholder platform to develop a Water Stewardship model in the Buyuk Menderes river basin to help in climate change adaptation and building resilience in the farming system.

Vehicle and Governance: Water Basin Management Committee, a multi stakehdolders committee which includes water utilities, municipalities, representative of competent Ministries, Universities and and industrial zone entities. Such a committee was established to develop action plans to tackle the different challenges and issues the basin faces.

Within this wide context,I the WWF initiative with the definite aim to address the investment gap, and the way to finance it, to improve production efficiency and in particular to preserve environmental conditions in the basin.

Public players involvement. As said, Municipalities and the Government have been part in the process, along with state-owned water utilities, all of them represent in the Committee. Th South Agean Development Agency (GEKA) was also part of the WWF iniaitive.

Private players involved and degree/nature of their involvement. Two category of players:

SMEs: textile producers in Denizli produce more than 50% of total exported textile Turkish production. Their involvement in the process was done via stakeholders meetings, design of feasibility studies and financial solutions.

Large/multinational companies such as Ikea, Inditex, H&M Group that, due to possibly different reasons, have been involved in this project (ESG etc).

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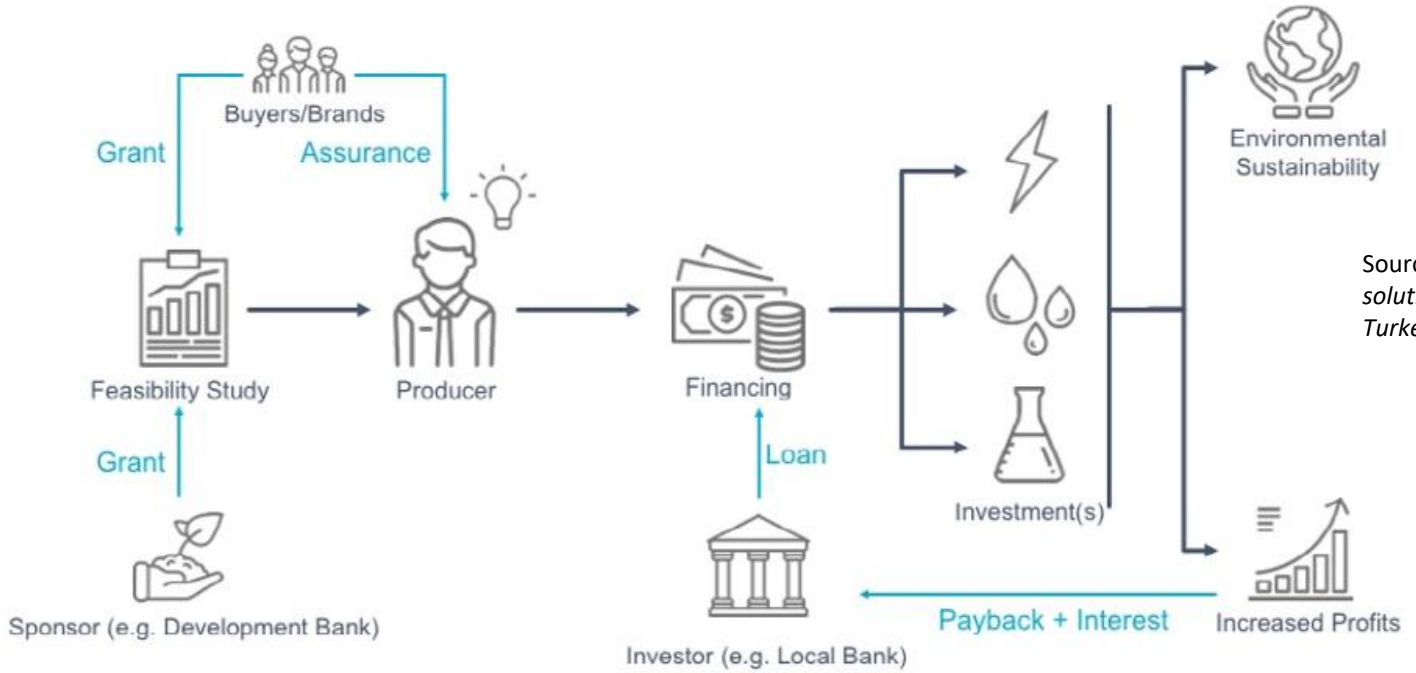
The Buyuk Menderes basin Case (Turkey)

Business model to pursue the conservation goal. The complex mechanism through which the WWF initiative is designed is described below (Figure…). It entails the provision of grants (preliminary phase) and loans (current/investment phase) to the SMEs, whose economic justification for the public side is the habitat and environment protection (in broad sense), while for the private component is the increased expected profit following the efficiency increase (costs saving, brand value) by the textile SMEs.

Cash flow and/or financial "motivation" and related Financial Instrument/Payment mechanism. For the SMEs majority, feasibility studies have concluded that investment payback periods are unlikely to exceed three years, As an approximate average, the size of the investment for each SMEs had an average loan between 90,000 - 200,000 US$. The improved production processes would entail an average cost saving of 200,000 US$ per year per factory. While highly depending on factory type and size, for a target of 50 SMEs a total of US$ 10 million US$ saving in total per year might be estimated across the basin. In 2019 it was reported that seven textile companies had invested €6.5million in efficient production techniques, saving 1.5 million cubic metres of water. This stirred the interest of 12 more additional textile producers to invest in cleaner processes. Other national and international fashion brands joined the Collective Action Committee, pioneered by H&M Group and Inditex (Zara).

Lessons learnt: Industrial sectors are possibly affected by the conservation activity in the area and maybe they are putting at risk the local habitat and environment, making a less than efficient use of natural, scarce resources. There's the need to identify the reasons which might motivate them in changing their processes. Large companies or multinationals could be in principle interested in supporting a conservation project



Sources: WWF (2019). *Financial solutions for improving water quality in Turkey's Buyuk Menderes river basin*.

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Glossary

- **Blended Finance**:The use of (cathalytic) funding from public and philanthropic/donor sources to mobilize additional private sector investment (generally at market rate) to realize the SDGs.
- **SDGs**: Sustainable Development Goals firstly adopted in 2015 by United Nations Member States
- **Short-termism**: the habit of considering mostly the immediate advantages of particular actions, i.e. excessive focus on short-term outcomes, at the expense of long-term goals.
- **Externalities**: indirect effects which have an impact on the consumption and production opportunities of others, where the price of the product does not take those externalities into account. As a result, differences between private returns or costs and the returns or costs to society as a whole. E.g. negative externality: air pollution produced by a private company to the local environment.

Glossary

- **Cathalytic effect:** the ability of the initial, generally public, financing to attract additional investments, leading to a multiplier effect creating greater positive impacts.
- **Credit enhancement**: measures/conditions (e.g. via interest rate, tenure, guarantees etc) that reduce the inherent risks of projects (or improve their financial returns) for the investors or lenders. Usually, these measures are provided by Governments/Multilateral Institutions/Donors at large, pursuing a public interest (societal, environmental etc).
- **Implicit returns** (vs explicit): returns which cannot be easily accounted as cash-flow based. For example: land or other assets appreciation, reduction of greenhouse gas emissions.
- **PES,** payments for ecosystem services: PES are voluntary transactions in which payments are received for the provision of definite ecosystem services. The payment causes the (additional) benefit to occur where it would not have otherwise. PES is an economic instrument that can be used as a tool for managing environments in a way that sustains their ecological services (e.g. for adaptation purposes) in addition to more traditional financial instruments.