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Luciano Lavecchia, Jacopo Appodia, Paolo Cantatore, Rita Cappariello, Stefano Di Virgilio, Alberto Felettigh, Danilo Liberati, Giorgio Meucci, Stefano Piermattei and Federico Schimperna,
Bank of Italy

Katia Specchia,
IVASS

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Abstract

Monitoring climate-related and environmental financial risks requires access to high-quality, highly granular data. However, such data remain scarce and are typically available only for a limited number of counterparty firms. This paper updates the previous work by Lavecchia et al. (2022), providing new evidence on the sustainable data gap in Italy. First, we take stock of the data needs arising from firms' transition plans, net-zero commitments, and financial analyses, as well as from international, European, and national regulations and supervisory requirements. Second, we map the existing data sources related to energy use, greenhouse gas (GHG) emissions, climate indicators, physical and transition risks, and climate scenarios, among others. Finally, we identify the areas where further research is most needed.

Keywords: Sustainable data gap · Climate change · Sustainable finance · Physical risk · Transition risk · Italy · GHG emissions · Energy

JEL classification: C81, Q54, Q48.

Contents

1. Introduction[1]

In the decade following the adoption of the Paris Agreement, global climate commitments and policy actions have proven sufficient to avert the worst-case scenario of a 4°C temperature increase relative to pre-industrial levels. The most recent assessments indicate that the world is currently on a trajectory consistent with an approximate 2.8°C rise by 2100 (UNEP, 2025). Notably, for the first time, the United Nations Framework Convention on Climate Change (UNFCCC) has projected an absolute decline in total global greenhouse gas (GHG) emissions by 2035, estimating a 10% reduction relative to 2019 levels.

Between 2014 and 2024, cumulative global investments in clean energy technologies—including renewable energy, electrification, and energy efficiency—exceeded USD 10 trillion. These sectors now account for slightly more than two-thirds of total energy investments worldwide (IEA, 2025). Despite this significant capital reallocation, current mitigation efforts remain insufficient to achieve the temperature targets established under the Paris Agreement. In 2024, global GHG emissions increased by 2.3%, reaching 57.7 $GtCO_2e$. This growth rate is approximately four times the average annual rate observed over the previous fifteen years and mirrors levels characteristic of the early 2000s (UNEP, 2025).

The underlying drivers of these emissions rebound remain uncertain but are likely multifaceted, encompassing both shortcomings in the design and implementation of climate policies and a potential decline in the effectiveness of natural carbon sinks. Furthermore, the second withdrawal of the United States from the Paris Agreement, coupled with the collapse of a long-negotiated international accord to reduce shipping-sector emissions, underscores the growing fragmentation of global climate governance.

Such developments point toward an increasingly disorderly transition, characterized by asymmetric regional trajectories—where some economies accelerate decarbonization due to technological or economic advantages, while others remain dependent on fossil fuel–based growth models. This emerging divergence has led some observers to describe the situation as an "ecological cold war[2]", reflecting the geopolitical tensions surrounding the global energy transition.

Overall, these dynamics suggest that both physical and transition-related climate risks are likely to intensify, with significant implications for economic systems, financial stability, and corporate strategy over the coming decades.

Several institutional investors have devoted substantial resources to assessing the exposure of their portfolios to physical climate risks[3]. While both demand and supply for asset-level climate risk data have expanded in recent years, these developments remain insufficient to support comprehensive risk evaluation. Investors frequently report that, despite the increased availability of data, determining the materiality of specific assets to overall portfolio risk remains difficult. Persistent information gaps—especially concerning climate vulnerability across value chains and the effectiveness of existing adaptation measures—continue to constrain robust analysis.

Lavecchia et al. (2022) define the deficiencies in the availability, usability, accessibility, and reliability of information relevant to climate change and sustainable finance analysis as the *sustainable data gap*. Legislative initiatives aimed at expanding sustainability reporting are expected to mitigate this gap; however, a recent global retrenchment has been observed, largely due to concerns regarding increased compliance costs. At the same time, commercial data providers continue to invest in this area

[1] The views expressed are those of the authors and do not involve the responsibility of the institutions to which they belong. Corresponding author: Luciano Lavecchia (luciano.lavecchia@bancaditalia.it).

[2] The Coming Ecological Cold War, Foreign Policy, 1 September 2025.

[3] Physical climate risk data: The more you learn, the less you know, Responsible investor, 5 November 2025.

by exploiting new analytical techniques and datasets. Nevertheless, as previously noted, substantial progress remains necessary.

Enhancing the global climate data architecture has therefore become a critical priority. Achieving this objective requires (1) the provision of reliable, comparable, and high-quality data, and (2) the development of harmonized information disclosure standards for climate risks that are as uniform as possible at the global level.

More specifically, ensuring the quality and comparability of climate-related data will depend on three key actions: (1) the rapid adoption of shared disclosure practices at the global level; (2) the establishment of a basic global taxonomy—or at least a common set of classification principles—for sustainable finance; and (3) the development and application of transparent metrics, certifications, labels, and methodologies.

This paper reviews the data necessary to analyse sustainability risks, with a particular focus on climate-related risks (Sect. 2). It then outlines the data required from banks, insurance companies, and other financial institutions operating in Italy to comply with transparency obligations under the current financial regulatory framework (Sect. 3). Subsequently, it examines the existing datasets that could substantially contribute to narrowing the sustainable data gap in Italy (Sect. 4). The paper concludes with a summary identifying the areas in which data deficiencies are most concentrated.

2. The Data required for the financial and economic analyses of Climate Risks

Climate-related financial risks (CRFRs) are commonly classified into physical and transition risks. Physical risk arises when acute or chronic extreme weather events damage the assets and infrastructure of households and firms or impair their capacity to generate income. These repercussions may also affect the financial system, either directly or indirectly, through multiple transmission channels, as described in the Basel Committee's analysis.

Transition risk, by contrast, refers to the potential devaluation of the production and financial assets of carbon-intensive firms or, more broadly, firms relying on "brown" technologies and products. This risk may stem from the abrupt implementation of policies affecting the cost or use of fossil fuels, disruptive technological innovations, or shifts in investor and consumer preferences, generating stranded assets. Transition-oriented policies generally aim to modify the relative prices of energy inputs, rendering carbon-intensive sources less affordable. In the short to medium term, such measures typically increase costs for firms and households, reflecting the need to finance new investments in green technologies, the introduction of carbon pricing mechanisms, and the write-off of stranded assets—investments whose value cannot be recovered and which might accrue to large sums (Carbon Tracker, 2022).

The economic risk faced by an individual agent or business due to a climate shock — physical or transitional — can be expressed as the product of three factors: (1) the likelihood of an adverse event (hazard), (2) the value of the exposed activities (exposure), and (3) the expected loss per unit exposed (vulnerability).

Hazard denotes the probability that an extreme natural event occurs (in the case of physical risk, e.g., floods or landslides) or that new regulations are introduced (in the case of transition risk). Assessing physical risk requires detailed hazard maps that capture the likelihood of extreme weather events linked to climate change, using data as granular as possible. Current classifications are often limited to the provincial or municipal level, a restrictive approximation assigning uniform hazard levels to broad areas.

Ideally, risk classification grids should reach higher spatial resolution (e.g., address or coordinates at plant level[4]), and firm-level geolocation data should be matched with financial information to accurately link risks and exposures. Furthermore, as climate change increases the probability of certain events relative to historical baselines, forward-looking data are essential; reliance solely on historical records poses the risk of systematic underestimation (FSB, 2021).

For transition risk, hazard analysis is typically conducted at the sectoral level, assessing the probability of exposure to policy and regulatory shifts, such as carbon pricing or technology bans. However, sectoral data alone are insufficient, as firms within the same industry may exhibit markedly different emission profiles, a fact that incidentally also underscores the importance of a comprehensive value-chain analysis.

The second component, exposure, measures the economic value of the activities potentially affected. While banks can generally ascertain the value and location of collateralized property owned by households, estimating firms' exposure is more complex. Business registries often provide only the address of administrative offices, rarely including detailed information on production sites, asset values, or turnover. One proxy for exposure is the distribution of employees across geographic areas or production facilities (Meucci and Rinaldi, 2022). For transition risk, exposure depends on sectoral carbon intensity, technological choices, and firm-specific emissions profiles. Ideally, data should include greenhouse gas (GHG) emissions and the firm's energy mix, to evaluate how changes in energy costs might affect financial performance. Yet only a limited number of firms currently disclose such data (see Paragraph 3). Estimating firm-level emissions remains challenging due to insufficient data on energy consumption, raw material use, and process-specific emission factors, particularly for Scope 3 emissions (Busch et al 2022). Advanced machine learning methods can help estimate ESG indicators, especially for equity portfolios (Lanza et al 2020), though they require high-quality training data. Well-designed surveys may, in some cases, yield more accurate results than large-scale data methods, reflecting the so-called big data paradox (Bradley et al 2021).

The final component, vulnerability, represents the expected loss per unit of exposure and captures the share of value lost after an extreme event has materialized. This measure should account for insurance coverage, which can reduce expected losses for intermediaries but simultaneously increase insurers' exposure, particularly when their portfolios are concentrated in affected areas. Assessing vulnerability thus requires information on the protection gap — the difference between total and insured losses — at both firm and macro levels. Such data are typically unavailable, especially at micro scales (Faiella and Lavecchia, 2025). Moreover, not all assets are equally affected by climate events; for instance, floods may damage only the lower floors of buildings. This level of detail, crucial for accurate vulnerability estimation, remains difficult to obtain.

3. The Data Necessary for Financial Intermediaries to Respond to Requests from Supervisors

The General Framework. The role of the financial system in the ongoing transition process is crucial, both to channel financial flows towards a more sustainable economic system and to prevent and mitigate the related risks. The different authorities involved in the various aspects of climate risk and sustainability

[4] Analyses typically focus on firms' headquarters, yet data on local units are crucial for accurately assessing firms' and lenders' exposure (see Loberto and Russo, 2024, on Italian manufacturing firms' exposure to hydrogeological risk).

regulation are making considerable efforts to align legislation and requests to intermediaries wherever possible.

The ECB has included climate and environmental risks among its supervisory priorities and monitors their impacts on significant banks in the euro area. In its 2020 guide to significant banks, the ECB set out its expectations for sound and prudent management of climate and environmental risks, providing non-prescriptive guidance on how to incorporate such risks into the business model, strategic, governance and risk management processes, as well as in the required disclosures to the public. The guide provides practical examples of how to use the existing regulatory framework to integrate climate risks into intermediaries' management processes.

Sustainable finance is a strategic priority area in EIOPA's action plan[5] for the coming years, aimed, in particular, at (i) integrating ESG risks into the prudential framework of Solvency II [6], (ii) supporting the supervision of ESG risks in micro and macroprudential analyses with a view to financial stability and the convergence of supervisory approaches in the EU[7], (iii) promoting disclosure and sustainable business models, (iv) addressing the climate risk insurance protection gap in Europe and (v) promoting the use of open-source models and data concerning the risks associated with climate change.

Entities subject to authorization and supervision by Banca d'Italia are required to comply with the supervisory expectations on climate and environmental risks, published by Banca d'Italia on 8 April 2022 (Banca d'Italia, 2022), regarding the integration of climate and environmental risks into their business strategies, governance, control and risk management systems, as well as market disclosures. These expectations are quite general, and the formalization of the underlying principles at the operational level is deferred to individual intermediaries, who are therefore required to conduct in-depth analyses and assessments to determine the materiality of their risk exposure. Based on these analyses, intermediaries will be able to apply the principle of proportionality, considering their complexity.

Insurance-Specific Surveys. The insurance undertakings supervised by IVASS are required to comply with the Solvency II framework, the prudential regulation of the insurance sector, and the provisions issued by IVASS on the integration of ESG risks into the governance and risk management system, as well as the control and governance requirements for insurance products qualified as 'sustainable'. In 2022, IVASS launched an annual monitoring on natural catastrophes risks and sustainability addressed to all insurers operating in Italy. The Survey consists of quantitative data (as of the end of the previous financial year) on exposure to physical risks in non-life insurance business and transition risks in investment portfolios; and qualitative information (as of the end of the current year) on governance, risk management and the use of climate risk scenarios analysis within the own risk solvency assessment (ORSA).

The monitoring is aimed at collecting hard evidence for the following purposes: (i) assessing the potential impacts of transition risks and physical risks at micro- and macroprudential level on insurers; (ii) identifying vulnerabilities that could affect financial stability, (iii) monitoring the level of natural catastrophe insurance penetration and the protection gap for residential and commercial properties at nationwide, (iv) verifying consistency between national regulations and European legislation and (v)

[5] EIOPA sets out its strategy for 2023 – 2026 (link) to contribute to building up sustainable insurance and pensions, including by addressing protection gaps, for the benefit of citizens and businesses.

[6] See, EIOPA Consultation paper on the proposal for Regulatory Technical Standards (RTS) on management of sustainability risks including sustainability risk plans (December 2024). The Solvency II Directive requires undertakings to implement specific plans to address the financial risks from sustainability factors and mandates EIOPA to specify the elements of the sustainability risks plans (link).

[7] See, EIOPA Opinion on the supervision on the use of climate change risk scenario in own risk solvency assessment (ORSA), (2021) and the Application guidance on how to reflect climate change in aimed mainly at small and medium-sized insurers (2022).

supporting sustainable finance initiative at national and international level. The main results of the survey are published annually (IVASS, 2025).

Disclosure Requirements. Filling the sustainable data gap requires not only an improvement in the statistical coverage of phenomena affecting sustainability and climate risks, but also common and well-defined reporting standards (for further details see Loizzo and Schimperna, 2022). This requires improving transparency and reporting (disclosure), i.e., the dissemination by companies of basic information about the potential risks they face and the effects of their activities (the 'double materiality'). In terms of improved transparency, the international financial community 'institutionalized' the topic of climate risks by establishing the Task Force on Climate-Related Financial Disclosures (TCFD) in December 2015. Since then, reporting requirements for non-financial and financial companies have become increasingly stringent. To complicate things further, the enforcement of these requirements varies according to the scope of the regulatory framework, including the transparency of financial investments (see Lavecchia et al. 2022 for a review).

In Europe, the regulation of non-financial reporting has been innovated with the publication of the Corporate Sustainability Reporting Directive (CSRD)[8] which extended the scope to almost 50,000 companies in the EU (from the previous 11,700) and to about 8,500 in Italy (from the previous 210[9]). However, as part of the process of simplifying and revising the CSRD promoted by the Omnibus package, the European Parliament recently endorsed reduced reporting duties, limiting the scope only to companies employing on average over 1,000 employees and with a net annual turnover of over €450 million. Moreover, the European standards for non-financial disclosure would also be simplified.

Concerning transparency in financial investments, the Sustainable Finance Disclosure Regulation (SFDR; 2019/2088), in force since 10 March 2021, aims to increase and standardize the reporting requirements of ESG investment processes for financial market participants both at entity and product level[10].

The European Taxonomy of Sustainable Investments To foster market confidence and reduce the risk of greenwashing, the Taxonomy Regulation (2020/852), which entered into force on 12 July 2020, introduces a classification system that defines an economic activity that meets specific requirements as environmentally sustainable; furthermore, Art. 8 of the regulation, as supplemented by Delegated Regulation (EU) 2021/2178, sets precise reporting requirements (which apply to undertakings within the scope of the CSRD) in the context of pre-contractual information and periodic reports. As for the CSRD, the Taxonomy framework is under review as part of the Omnibus package.

Pillar 3 Disclosure Requirements As part of the prudential regulation of the banking system, in January 2022 the European Banking Authority (EBA) set harmonized disclosure standards for large institutions with listed securities (Implementing Technical Standards [ITS] P3 ESG ITS). ESG risks should be communicated through tables for qualitative disclosure of environmental, social and governance risks and

[8] In addition to expanding the scope, the CSRD envisaged (i) the use of specific standards provided by the European Financial Reporting Advisory Group (EFRAG), (ii) the requirement of an external auditor, (iii) the inclusion of the non-financial report within the management report and (iv) the adoption of the single electronic reporting format, to improve the dissemination of information.

[9] OIBR, Innovazioni nella Direttiva UE su Reporting di Sostenibilita, 4 July 2022.

[10] The regulation classifies investments as sustainable investments ('Article 9'), investments that reward certain environmental or social characteristics ('Article 8') and the residual category of unsustainable investments ('Article 6'). For each category, there are different disclosure requirements regarding pre-contractual disclosures, periodic reports and communication on corporate websites.

templates for quantitative disclosure of the climate change-related transition risk, climate change-related physical risk and other mitigation actions.

CRR3 has recently extended the scope of ESG Pillar 3 disclosure to all institutions in a proportionate manner. In this scenario, the EBA launched a public consultation on proposed amendments to above-mentioned ITS to i) review the disclosure requirements for large institutions with listed securities, considering the developments in the Omnibus package; and ii) develop simplified and proportional disclosure requirements for large non-listed institutions, other institutions, small and non-complex institutions (SNCIs), and large subsidiaries.

4. Available data

Energy. We first report international (table 1) and national (table 2) sources for energy data. The first is Eurostat Physical energy flow accounts (PEFA) which, as part of the economic and environmental accounts, provides information on estimated energy flows compatibly with the concepts, principles and classifications of national accounts, enabling integrated analyses of economic, environmental and energy issues. The dataset contains data on the supply and use of energy (for intermediate and final consumption and uses relevant to emissions) classified by economic activity (NACE Rev.2), specifically for 21 sections. This information, published annually, complements traditional energy statistics, balances and derived indicators, which are the main source of information for EU energy policies. Information on energy consumption by households and by sector of economic activity is available in the statistics of the Energy Balances, also compiled by Eurostat.

The Global Energy Monitor, a non-profit research organization, provides open access to information to worldwide data on energy infrastructure, resources, and uses, concerning all power plants (coal, gas, wind, nuclear, etc.) built and planned. Data are available in form of interactive database (massive download is allowed). In particular, the Global Integrated Power Tracker lists power plants (coal, gas, oil, nuclear, renewables) with statistics aggregated by country and details on projects under approval, cancelled, and closed plants.

The Joint Research Centre (JRC) of the European Commission publishes a map of the power plants in Europe (Energy and Industry Geography Lab). Different layers (transport infrastructures for gas and power, ETS and E-PRTR plants, etc.) and disaggregation (sector, type of power plant, etc.) are available.

Starting in 1952, British Petroleum (BP) has published, once a year, a key compilation of statistics (Statistical Review of World Energy) of data on energy production, consumption and prices, broken down by source and country. In recent years, the Review has included data on emissions of CO2 and methane caused by and deriving from the use of fossil fuels. This harmonized and freely accessible collection of data is a key point of reference for the world energy community. Starting from 2023, the database is managed by the Energy Institute, a chartered professional membership body for the energy industry.

The Global Power Plant Database – as part of the Resource Watch platform developed by the World Resources Institute - is a free open source database of power plants around the world that covers approximately 30,000 power plants from 164 countries, including both thermal plants (e.g., coal, gas, oil, nuclear, biomass, waste, geothermal) and renewables (e.g., hydro, wind, solar).

As for the national sources, the Ministry of Environment and Energy Security (MASE, in Italian) publishes datasets on mean prices of fuel; oil consumption; consumption and imports of coal and natural gas (Security Energy and Mining Analysis and Statistics). Generally, data are provided with a monthly frequency, data on fuel prices are available also with a weekly frequency.

Additionally, the Ministry of Enterprises and Made in Italy provides a tool ("Osservaprezzi Carburanti" - Fuel Price Observatory) that grants access to real-time information on the selling prices of fuels charged at the distribution plants.

TERNA, the Italian Transmission System Operator (TSO), provides dashboards reporting electricity production and consumption in Italy, with regional and provincial breakdowns. Data are available by sector (consumption) and source (production).

The Italian Regulatory Authority for Energy, Networks and Environment (ARERA) carries on an Annual Survey on Regulated Sectors and publishes a dataset that provides individual information about operators in the electricity and gas sectors, for energy prices and consumption of households and corporations. Data are aggregated by region and user type.

The Italian National Institute of Statistics (ISTAT), periodically conducts a Survey on household energy consumption which provides insights about the energy characteristics of the residential sector in Italy. Tables are available for 2013, 2021 e 2024; the next edition of the survey is scheduled for 2027.

The Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) collects the Energy performance certificates (EPCs) and publishes aggregated statistics (SIAPE) concerning buildings and real estate units on the number of EPCs, energy class, average GHG emissions, and EP nren/EP ren indices grouped by issuance period, climate zone, property ownership, and size.

GHG emissions and other pollutants. Table 3 collects data on GHG emissions and other pollutants. In this section we have global, European and national resources.

As part of the initiatives promoted by research centres and universities, Carbon Monitor provides regularly updated estimates of CO2 emissions of the main world economies by macro-sector, as well as data on electricity production by energy source. Carbon Monitor has also created the GRACED platform to provide users with near-real-time estimates of daily CO2 emissions from fossil fuel and cement production with high spatial resolution.

The Organisation for Economic Co-operation and Development (OECD) presents trends in man-made emissions of major greenhouse gases and emissions by gas in its OECD Data explorer. Data refer to total emissions of CO_2 (emissions from energy use and industrial processes, e.g. cement production), CH_4 (methane emissions from solid waste, livestock, mining of hard coal and lignite, rice paddies, agriculture and leaks from natural gas pipelines), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). Data exclude indirect CO_2. For UNCCCC Annex I countries, data follow the IPCC 2006 guidelines. Territories' coverage is as those defined in the Kyoto Protocol.

Founded in 2016, Kayrros is a global climate technology company and a world leader in environmental intelligence. Kayrros uses satellite imagery, AI, and geo-analytics to help governments, investors and businesses understand the risks posed by the changing climate and energy landscapes and make more informed decisions. On its website, a map of methane emissions, the Kayrros Methane Watch, detected via satellite is available, upon registration.

The International Energy Agency (IEA) provides the Greenhouse Gas Emissions from Energy Highlights, a free extract from Greenhouse Gas Emissions from Energy (an annual time series, updated twice a year, of GHG emissions from energy, a major source of anthropogenic emissions), containing greenhouse gas emissions from the energy sector, broken down by fuel type and country, from 1971 to 2023, with an extended historical series on CO2 emissions from combustion from 1751 to 2022.

The ClimateDeck platform provided by Rodium Group, an independent research provider founded in 2008, provides global and US 50-state greenhouse gas (GHG) emissions inventory data and projections, energy market outlooks, clean investment tracking, and analysis of energy and climate policy

developments. The ClimateDeck equips users with comprehensive datasets, unique and responsive insights, and a robust set of tools for tracking pathways to climate targets and understanding the emissions and economic implications of major developments at the international, national, and state levels.

The Global Monitoring Laboratory (GML) of the National Oceanic and Atmospheric Administration (NOAA), an official website of the United States government, conducts research that addresses three major challenges: greenhouse gas and carbon cycle feedbacks, changes in clouds, aerosols, and surface radiation, and recovery of stratospheric ozone. The website provides measurements of atmospheric concentrations of CO_2, CH_4, N_2O, and SF_6 with charts and historical series (note: the series for N_2O and SF_6 start from the 1990s/2000s, while those for CO_2 and CH_4 start from the 1980s).

Carbon Mapper, a nonprofit organization, leads a coalition of partners — powered by philanthropy — to develop and deploy two satellites with capabilities to detect and quantify methane and CO_2 super-emitters at a level of granularity needed to support direct mitigation action. The data portal includes observations of methane and CO_2 super-emitters across the globe. Data is sourced from multiple sensors onboard aircraft, satellites, and other space-based systems. It's added to the portal on a frequent and ongoing basis.

As for European providers, Eurostat yearly publishes the Air emissions accounts, a collection of greenhouse gas emissions and other pollutants such as particulate matter, NMVOC, ammonia, etc. The archive provides statistics on direct emissions (Scope 1) deriving from production and consumption ("Environmental accounts," "Inventories," and "Environmental footprints"). The European Environment Agency (EEA), instead, publishes every year data on the 'allowances' issued under the EU's main carbon pricing tool, the EU ETS, whose microdata are collected through the European Union Transaction Log (EUTL). For the year 2017 only, the EEA has developed a map with health impacts of road traffic noise and air pollution in selected urban areas, with a 1x1 km grid resolution. No data are available for Italy at the moment.

Another European register with granular data on industrial emissions is the Industrial Emissions Portal Regulation (IEPR), which replaced the European Pollutant Release and Transfer Register Regulation (E-PRTR). It provides public access to key environmental data from about 60,000 large industrial facilities in EU Member States, Iceland, Liechtenstein, Norway, Switzerland, Serbia and the UK through the Industrial Emissions Portal.

The Centre for Research on Energy and Clean Air (CREA) is an independent and nonprofit research organization focused on revealing the trends, causes, and health impacts, as well as the solutions to air pollution. They use scientific data, research and evidence to support the efforts of governments, companies and campaigning organizations worldwide in their efforts to move towards clean energy and clean air. Data on CO_2 emissions, methane flaring in Russia, sanctions against Russia, electricity production by source in various parts of the world are available on CREA website.

The Copernicus Atmosphere Monitoring Service (CAMS) provides free and ready-to-use charts based on its global and European forecasts, allowing everyone to monitor the atmosphere in near-real time and foresee its evolution. CAMS is one of six services that form Copernicus, the European Union's Earth observation programme which looks at our planet and its environment for the ultimate benefit of all European citizens.

CAMS provides forecasts and daily analyses of chemical atmospheric compounds concentrations at the global scale, and of ambient air quality for Europe. The data, available for all on the atmosphere data store (ADS), is used by numerous national and local institutions, international organizations dealing with the environment, and many scientists across the world. Moreover, IT service companies rely on CAMS data to create air quality and atmosphere data applications. In addition to providing the full data for free, CAMS provides visual, intuitive charts of its forecasts and several analysis tools (e.g. the evolution of

Saharan dust transport in Europe or across the Atlantic Ocean or how an ozone or particulate matter pollution episode develops in a city, region or cross-borders).

Finally, as a national source, we signal the average greenhouse gas conversion factors published by the Italian Institute for Environmental Protection and Research (ISPRA) in its report "The environmental challenge for sustainable finance. Methodologies, information and environmental indicators" (2024) mentions conversion factors for energy uses into greenhouse gases (GHG).

Transition risk. The *OECD Climate Actions and Policies Measurement Framework* (CAPMF) is a key initiative developed by the Organization for Economic Co-operation and Development (OECD) to systematically collect and organize information on climate-related policies implemented by member and partner countries (table 5). The CAPMF provides a structured and comparable overview of mitigation and adaptation measures, enabling both cross-country and longitudinal analyses of climate governance strategies. The dataset includes variables covering emission reduction targets, economic instruments, sectoral regulations, fiscal incentives, and public investments in green technologies.

The *Map of the Attribution Studies* dataset provides a comprehensive overview of scientific research assessing the extent to which specific climate-related events can be attributed to anthropogenic climate change. Compiled, maintained, and published by Carbon Brief - a UK-based organization specializing in climate science and policy - the dataset catalogs attribution studies across a wide range of phenomena, including extreme temperatures, precipitation anomalies, droughts, floods, and tropical cyclones. Each entry typically contains metadata such as the event type, geographical location, time period, methodological approach, and key findings regarding the human influence on the event's likelihood or intensity.

Climate Data. Table 4 reports several major databases that collect climate-related information. The U.S. National Oceanic and Atmospheric Administration (NOAA) provides *Climate at a Glance*, a comprehensive global archive containing data on climate anomalies, average temperatures, and precipitation since 1850. The database covers the world as well as the United States specifically, with geographical disaggregation down to the county and city levels. NASA's *GIOVANNI* is a gridded archive offering a wide range of information on aerosols, the cryosphere, and the hydrosphere at the global level, including both historical and modelled data. The International Monetary Fund (IMF) provides a useful dashboard—*Climate Change Indicators*—which offers annual country-level data (since 1990) on climate and economic variables, including indicators of greenhouse gas emissions, financial and risk measures (covering financial, physical, and transition risks), economic indicators (such as those on countries' environmental policies), and other climate-related data. Quarterly emissions data for major global regions are also available.

Physical Risk. The measurement of the potential impacts and damages of climate-related hazards can be summarized in so-called physical risk metrics (table 6 and 7). The construction of these indicators needs thedetailed information on the type of hazard under consideration (e.g. flooding, windstorms, landslides, etc), the exposed asset (population, buildings, financial portfolios, etc) and, if available, its degree of vulnerability based on the intensity of the hazard and the presence of mitigation measures. It follows that detailed information on the localization of the units under analysis is necessary to derive accurate metrics. In this respect, a lot of international and national databases provide useful data inputs.

Measuring climate and environmental risks requires comparable data based on standard rules and classifications among countries. A world-wide overview about the climate-related data on historical and future events and impacts can be assessed by the Climate Change Knowledge Portal maintained by the World Bank Group. Similarly, at world level, the Centre for Research on the Epidemiology of Disasters (CRED) manages the Emergency Events Database (EM-DAT), which collects data on the main natural and technological (mainly industrial and transport accidents) risks of more than 27,000 mass disasters that occurred in the world from 1900 to the present day.

Focusing on the European Union, the Disaster Risk Management Knowledge Center (DRMKC) Risk Data Hub (RDH), developed by the European Commission's Joint Research Center (JRC), is a web platform with an EU-wide geolocation information system that collects information on the location and impact of past natural disasters[11] and presents an analysis of the potential risk of natural disasters. It takes into account the severity of the impact on different resolution grids and reference categories (buildings, population, etc.) and the occurrence probability of the events. Among the resources of the JRC, there is the Agri4Cast portal, a tool dedicated to the publication of climate change databases useful for the agricultural sector. In particular, the database Monthly Heating and Cooling Degree Days in the European Union reports monthly time series since 1979 on the daily maximum and minimum temperatures with a NUTS 3 level of spatial resolution for the geographical area. Among the products developed by the JRC, the EUSO Soil Degradation Dashboard provides data on land degradation processes such as erosion, pollution, and salinization, with global coverage and 16-day hourly forecasts at a 0.25-degree resolution. Based on information collected by meteorological stations, the Copernicus Climate Data Service provides daily meteorological data for Europe offering multiple access channels (API, Cloud infrastructures, open-source codes, etc). The European Storm Forecast Experiment (ESTOFEX) initiative serves as a platform that allows the exchange of information on forecasting of severe weather events (storms, tornadoes) in Europe and other areas. ESTOFEX also provides access to the European Severe Weather Database (ESWD) which collects and provides detailed information on these weather phenomena. The data are collected by national weather service institutes with the cooperation of a network of volunteer observers.

Among the international initiatives aimed at increasing the transparency and accessibility of data, OpenStreetMap collects detailed information on buildings and their characteristics that can be accessed and fed by individual citizens. This information could be useful to create physical risk indicators for the residential estate sector though the coverage and statistical significance of some information details vary between countries[12]. Furthermore, at European level, the EU Building Stock Observatory (BSO) reports accurate information and data on the EU's building stock such as size, energy and GHG efficiencies, etc.

In Italy, detailed information on hydrogeological risk (floods and landslides) and on the national landslide inventory is made available by the Italian Institute for Environmental Protection and Research (ISPRA) through the IdroGEO portal. ISPRA also disseminates a dataset on climate, weather and climate change that collects data, including historical ones, and indicators relating to climate status, variations and trends in Italy. The Institute of Atmospheric Sciences and Climate (ISAC), within Italy's National Research Council (CNR), publishes monthly maps of mean, minimum and maximum temperatures, as well as of the deviations from the 1991–2020 mean, with highly spatially disaggregated since as far back as 2002. Recently, another database has been developed, the MEteorological Reanalysis Italian DAtaset (MERIDA), to provide energy stakeholders with reliable meteorological data to increase the resilience of electricity distribution networks and allows them to implement measures aimed at restoring energy supply in the areas that are more prone to extreme weather events, and which have a major impact on the national electricity system. The project has been developed following the recommendations of the 'Working table for resilience' established by the Regulatory Authority for Energy Networks and the Environment (ARERA).

Climate scenarios. Climate scenarios (table 8) are helpful tools to foresee how economies and financial systems might evolve in response to different climate policies and changes. The Network for Greening the Financial System (NGFS) long-term climate scenarios are a set of forward-looking pathways developed to assess climate-related financial risks on financial stability and economic resilience. In November 2024 the NGFS published the fifth version of the climate scenarios (The NGFS Scenario data). Also, in May 2025 the NGFS published short term scenarios, dedicated to analysing the potential near-term impacts of climate policies and climate change. In Italy,

[11] The database reports events such as floods, earthquakes, wildfires, landslides, droughts, storms, eruptions and tsunamis.

[12] For Italy, where coverage is not very extensive, the data can be accessed with customized queries via the Real Estate Market Observatory (OMI) of the Italian Revenue Agency, which provides details at the municipal micro-area level.

climate scenarios and projections are elaborated by the Euro-Mediterranean Center on Climate Change (CMCC) and the Climate analysis over mediterranean region (CLIMED). The CMCC conducts high-resolution scenario analyses and climate simulations, which have proven useful also to draft the National Plan for Adaptation to Climate Change (NPACC). The CMCC provides access to interactive maps for different types of Italian, mediterranean and global indicators and emission scenarios through its Data delivery system (CMCC DDS). The CLIMED portal has been developed as a tool to support the planning of the National Energy System as well as to support national and local public administrations. It provides climate projections for Italy until 2100 under different global warming conditions.

Sustainable finance. Additional resources concern sustainable finance (table 9), which plays a key role in supporting the ecological transition. The NGFS provides the *Dashboard on Scaling Up Green Finance*, a global dataset offering country-level indicators on climate-related policies, GHG emissions, and green bond issuances, with historical coverage starting from 1970 for some metrics. The *FT Climate Dashboard*, developed by the Financial Times, aggregates information on 193 countries' historical emissions and climate targets, including progress on renewable energy and global rankings. At the national level, the *Osservatorio DNF*, managed by the University of Siena, collects and disseminates Non-Financial Disclosures from Italian companies for the years 2017–2023. For the financial industry, the *Online Tools for the Financial Sector* by UNEP FI provide instruments and datasets aimed at facilitating the implementation of sustainable finance policies and practices in the financial sector. Finally, Borsa Italiana and other exchanges publish the *ESG Bond List*.

Other relevant sources concern nature and broader environmental-economic information (table 10 and 11). The *Ecosystem Services Valuation Database (ESVD)* offers a global dataset with over 10,000 assessments of specific biomes and ecosystems. The *EUSO Soil Degradation Dashboard*, developed by JRC, provides data on land degradation processes such as erosion, pollution, and salinization, with global coverage and 16-day hourly forecasts at a 0.25-degree resolution. In addition, other statistics on European economic and environmental accounts, published by Eurostat, include material flow accounts, environmental tax data, and sectoral accounts for environmental goods and services, covering EU countries from 1990 to 2024. At the national level, the *Ecological Transition Plan and Monitoring Reports* by the Italian Ministry of Environment and Energy Security detail progress toward the 2030 targets, offering annual updates on measures, indicators, and financial resources allocated for the ecological transition.

5. Conclusions

The global energy transition is mobilizing substantial financial resources, estimated at approximately USD 2 trillion in 2024 (IEA, 2025). Depending on the level of climate ambition, these investments could more than double under a net-zero emissions scenario (IEA, 2025). Such significant financial flows, together with the increasing frequency and severity of climate-related extreme events, underscore the intensifying demand for reliable and granular data among financial institutions, insurers, investors, and corporations. Despite this growing demand, a considerable discrepancy persists between the data required for comprehensive climate-risk assessment and the information currently available, a divergence commonly referred to as the *sustainable data gap*.

While numerous legislative initiatives have been introduced in recent years to address this issue, the future trajectory of policy interventions remains uncertain, partly due to concerns regarding regulatory burdens and compliance costs. Concurrently, commercial data providers have increased investment in new datasets and analytical techniques aimed at mitigating informational deficiencies. Building on the framework proposed by Lavecchia et al. (2022), the present study updates and extends the review of data requirements and publicly accessible resources relevant to sustainability and climate-risk analysis.

Persistent weaknesses remain, particularly with respect to data coverage for small and medium-sized enterprises (SMEs) and for energy sources other than electricity and natural gas—the primary vectors typically captured by existing datasets. Although the availability and quality of data on physical climate risks have improved substantially because of recent investments, further progress requires greater integration across information sources. Establishing linkages at the asset or plant level and connecting data along entire value chains represent essential steps toward developing a coherent and comprehensive climate-data architecture.

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Appendix

Energy data (international providers)			Table 1
Name	Provider	Main attributes	Description
Physical energy flow accounts, PEFA	Eurostat/Istat	Geographic area: European Union + Albania, Iceland, Switzerland, North Macedonia, Turkiye and Norway	The database allows access to statistics on energy flows from the environment to the economy (inputs), within the economy (products), and from the economy back to the environment (residuals). The data are annual starting from 2011 and cover all EU countries and some extra-EU countries.
Energy and Industry Geography Lab	JRC	Geographic area: European Union Spatial Unit: Country Period: 2010 – 2022 Further disaggregations: Sector	The JRC has published a map of the power plants in Europe and numerous layers (transport infrastructures for gas and power, ETS and E-PRTR plants, etc.). User guides are available.
Global Energy Monitor	Global energy monitor	Geographic area: world Spatial Unit: singol plant Period: n.a. Further disaggregations: Power plant, industrial plant, transport infrastructures	Interactive database (and with possible massive download) of all power plants (coal, gas, wind, nuclear, etc.) built and planned. In particular, the Global Integrated Power Tracker lists power plants (coal, gas, oil, nuclear, renewables) with statistics aggregated by country and details on projects under approval, cancelled, and closed plants. Presentation article available.
Statistical Review of World Energy	British Petroleum (dal 1952 al 2022)/the Energy Institute (since 2023)	Geographic area: world Spatial Unit: country (EU-27) Period: 1952 – present Further disaggregations: Type of energy source and CO_2 emissions	Collection of information on production, consumption and prices of energy sources, broken down by source and country. Annual publication (since 1952) and free of charge; it is a reference point for analyses of the global energy community. Since 2023, management has passed to The Energy Institute, which also keeps the historical archive (where it is possible to build time series by source and country).
EMBER - Electricity Data Explorer	EMBER	Geographic area: world Spatial Unit: country Period: 2000 – present Further disaggregations:	Data on electricity generation, installed capacity, electricity demand, power sector CO2 emissions, and carbon intensity, by country, from 2000 to today.
Global Power Plant Database	Resource Watch	Geographic area: Worldwide Spatial unit: Countries / specific data points Period: Further disaggregations:	Dashboard with more than 30,000 power plants (installed capacity over 1 MW) from 164 countries worldwide.

Energy data (national providers)			Table 2
Name	Provider	Main attributes	Description
Energy and Mining Analysis and Statistics (Analisi e statistiche energetiche e minerarie)	Italian ministry of environment and energy security (MASE)	Geographic area: Italy Spatial unit: Country Period: Variable; weekly, monthly, or annual frequency Further disaggregations: Type of fuel/combustible	The archive provides datasets on average fuel prices, oil consumption, and coal and natural gas consumption and imports. Data are generally reported with monthly frequency; weekly data are available for fuel prices.
Fuel Price Observatory (Osservaprezzi Carburanti)	Italian ministry of enterprises and made in Italy (MIMIT)	Geographic area: Italy Spatial unit: Country Period: 2015 – present Further disaggregations: Type of fuel/combustible	The tool allows real-time consultation of fuel prices applied at fuel stations. A historical archive of prices (starting from 2015) is also available.
Data on Electricity Production and Consumption	TERNA	Geographic area: Italy Spatial unit: Provinces Period: 2000 – 2022 Further disaggregations: Sector (for consumption), source (for production)	TERNA dashboards reporting electricity production and consumption in Italy, with regional and provincial breakdowns. Data are available by sector (consumption) and source (production).
Annual Survey on Regulated Sectors	ARERA	Geographic area: Italy Spatial unit: Country Period: 1997 – 2023 Further disaggregations: Type of energy source	The dataset provides individual information for operators in the electricity and gas sectors, for energy prices and consumption of households and corporations. Data are aggregated by region and user type.
Survey on household energy consumption (Indagine sui consumi energetici delle famiglie)	ISTAT	Geographic area: Italy Spatial unit: Region Period: 2013, 2021, and 2024 Further disaggregations: Various disaggregations	The survey provides insights about the energy characteristics of the residential sector. Tables are available for 2013, 2021 e 2024, and microdata are available for 2013 and 2021 as MFR; PUF is available only for 2013). Next edition (expected): 2027
Sistema informativo integrato (SII)	Acquirente Unico	Geographic area: Italy Spatial unit: Region/province Period: 2021–2023 Further disaggregations:	The archive contains granular data on electricity and gas consumption by households and businesses. Update frequency and reading details depend on the type of meter installed. ARERA has recently published statistics on monthly consumption and hourly electricity withdrawals (households e businesses) e gas (households only), with provincial level detail, only for the 2021–2023 period so far.

Energy performance certificates' archive (Sistema informativo sugli attestati di prestazione energetica (SIAPE)	ENEA	Geographic area: Italy Spatial unit: Region Period: 2015–present Further disaggregations:	The archive contains aggregated statistics on number of EPCs (energy performance certificate), energy class, average GHG emissions, and EP nren/EP ren indices grouped by issuance period, climate zone, property ownership, and size. Data available for 20 out of 21 regions (Sardinia is missing). Microdata are not available. The database is populated with data from regional registries starting from a specific date, without retroactive data recovery (e.g., Campania region has begun contributing from January 1st, 2025).
Portale PNIEC	GSE	Geographic area: Italy Spatial unit: Country Period: 2022–present Further disaggregations:	Portal for monitoring the 2030 targets of the 2023 PNIEC (Italian National Integrated Plan for Energy and Climate). 9 dimensions are considered.

GHG emissions and other pollutants			Table 3
Name	Provider	Main attributes	Description
Air Emissions Accounts - Database of greenhouse gas emissions and other pollutants such as particulate matter, NMVOC, ammonia, etc.	Eurostat	Geographic area: European Union + EFTA + Serbia and Turkey Spatial unit: Country Period: 1995–2023 Further disaggregations: Economic sector; for energy footprints: CPA08	The archive provides statistics on direct emissions (Scope 1) deriving from production and consumption ("Environmental accounts," "Inventories," and "Environmental footprints"). Annual data from 1995 onward, covering all EU countries plus EFTA members (Iceland, Norway, Switzerland), Serbia, and Turkey.
European Union Transaction Log (EUTL)	European Environment Agency (EEA)	Geographic area: EU Spatial unit: Country and individual operator Period: 2008 – 2025 Further disaggregations: Economic activity sector	The dataset provides information on direct emissions and emission allowances. Data are annual from 2008 and cover all EU countries plus Iceland, Liechtenstein, and Norway. EMBER offers a graphical representation of emissions from European thermal power plants (subject to EU-ETS) and allows downloads. It also provides the historical series of carbon prices. The JRC has created an integrated archive of facilities/companies with ORBIS codes (to obtain financial information). Another system for viewing and bulk downloading data (using JRC's ORBIS classification) is provided by the EUETS.INFO project.
European Emission Industrial Portal	European Environment Agency (EEA)	Geographic area: EU + EFTA + UK Spatial unit: Country Period: 2007 – 2023 Further disaggregations: Economic activity sector	The portal contains data from the European Pollutant Release and Transfer Register (E-PRTR), related to emissions and transfers of pollutants reported by about 60,000 industrial facilities located in the EU, Iceland, Liechtenstein, Norway, United Kingdom, Serbia, and Switzerland.
Stime Carbon Monitor e GRACED	Carbon Monitor	Geographic area: Global Spatial unit: Country Period: 2019 – present Further disaggregations: Economic activity sector	The Carbon Monitor website provides daily estimates of CO_2 emissions by macro-sector for major global economies, as well as data on electricity production by energy source. The GRACED platform offers daily CO_2 emission estimates at fine spatial resolution (1° x 1°) from fossil fuels and cement production.
OECD: Greenhouse gas emissions by country and sector	OECD	Geographic area: Global Spatial unit: Country Period: 1988 – 2023 Further disaggregations:	Greenhouse gas emissions (source: UNFCCC)

Kayrros Methane Watch	Kayrros	Geographic area: Global Spatial unit: Individual emission point / country Period: 2019 - present Further disaggregations:	Map of methane emissions detected via satellite, with download available upon registration.
Greenhouse Gas Emissions from Energy Highlights	IEA	Geographic area: World Spatial unit: Country Time period: 1971 – 2023 Other disaggregations: fuel type	Greenhouse gas emissions from the energy sector, broken down by fuel type and country, from 1971 to 2023 (estimation for 2023), with an extended historical series on CO2 emissions from combustion from 1751 to 2022. Free Excel file available upon registration on the IEA website
ClimateDeck Rodium Group	Rhodium Group	Geographic area: World Spatial unit: Country Time period: 1974 – 2023 Other disaggregations: economic sector	Preliminary estimate of GHG emissions at the global level and for 50 US states through 2030. Historical data on greenhouse gas emissions for over 190 countries, disaggregated by economic sector. Access available upon contact via email with the provider
Global monitoring laboratory	US government	Geographic area: World Spatial unit: Time period: late twentieth century - first half of 2025, monthly data Other disaggregations:	The website provides measurements of atmospheric concentrations of CO_2, CH_4, N_2O, and SF_6 with charts and historical series (note: the series for N_2O and SF_6 start from the 1990s/2000s, while those for CO_2 and CH_4 start from the 1980s). The website states that there will be no further updates to the data
Viewer on combined health impacts from road traffic noise and air pollution in urban areas	European Environmental Agency (EEA)	Geographic area: EU Spatial unit: city, cell of 1x1 km (when available) Time period: 2017 Other disaggregations:	Health impacts of road traffic noise and air pollution in selected urban areas, with a 1x1 km grid resolution. No data available for Italy at the moment
Carbon Mapper	Carbon Mapper	Geographic area: World Spatial unit: grid Time period: variable, generally 2025 data Other disaggregations:	Satellite data on CO_2 and methane emission rates for super-emitters
Center for Research on Energy and Clean Air	CREA	Geographic coverage: Europe / World Spatial unit: Countries / Specific points Period: Further disaggregations:	Data on CO_2 emissions, methane flaring in Russia, sanctions against Russia, electricity production by source in various parts of the world.
Copernicus Atmosphere Monitoring Service (CAMS)	European Commission	Geographic coverage: World (more detailed for Europe) Spatial unit: Grid Period: Further disaggregations: country, region	Detailed maps with daily forecasts for atmospheric compound concentrations and air quality (Europe only). Data are available for download in the Atmosphere Data Store (link).

Average Greenhouse Gas Conversion Factors	ISPRA	Geographic coverage: Italy Spatial unit: country Period: Further disaggregations: n.a.	ISPRA document containing the conversion factors for energy uses into greenhouse gases (GHG).

Climate data			Table 4
Name	Provider	Main attributes	Description
Climate at a Glance	NOAA	Geographic coverage: World Spatial unit: Continents Period: 1850 – present Further disaggregations:	Data on climate anomalies, average temperatures, and precipitation at the global level and for the United States, with disaggregation down to county/city level.
GIOVANNI – NASA	NASA	Geographic coverage: World Spatial unit: Grid Period: n.a. Further disaggregations: n.a.	NASA archive with information on aerosols, cryosphere, and hydrosphere at the global level, including historical and modeled data. Full access requires registration.
Climate Change Indicators Dashboard	IMF	Geographic coverage: World Spatial unit: country Period: 1990 - present Further disaggregations: n.a.	The archive provides a very broad set of information on climate and economic variables, including indicators on greenhouse gas emissions, financial and risk indicators (including financial, physical, and transition risks), economic indicators (e.g., on countries' environmental policies), and climate change data. The data are annual and available by country. Quarterly emissions data for major global regions are also available.

Transition risk			Table 5
Name	Provider	Main attributes	Description
OECD Climate Actions and Policies Measurement Framework (CAPMF)	OECD	Geographic coverage: World Spatial unit: country (53) Period: 2018 - 2023 Further disaggregations: n.a.	The OECD Climate Actions and Policies Measurement Framework (CAPMF) is the most extensive internationally harmonised climate mitigation policy database to date. It tracks 130 policy variables, aggregated into 56 key climate actions and policies
Map of the attribution studies	Carbon brief	Geographic coverage: World Spatial unit: event site Period: n.a. Further disaggregations: n.a.	List of attribution studies referring to 735 extreme weather events. Last updated: November 2024

Physical risk (international providers)			Table 6
Name	Provider	Main attributes	Description
World Bank Climate Change Knowledge Portal	World Bank	Geographic coverage: World Spatial unit: country Period: 1991 – 2021 for some statistics Further disaggregations: NUTS 2	Historical and forward-looking (scenario-based) information on various climate indicators, disaggregated by country and NUTS, available for download.
OSM - OpenStreetMap	OSM Foundation	Geographic coverage: World Spatial unit: country and single building Period: live Further disaggregations: property classification variables	Property data and classification variables. For European comparisons, see also the EUBUCCO v0.1 project.
EU Building Stock Observatory	European Commission	Geographic coverage: EU-27 Spatial unit: country Period: n.a. Further disaggregations: Sector of economic activity for some statistics	Statistics on the building stock of European countries (energy consumption, building elements and technical building systems installed, energy performance certificates, nearly zero-energy buildings and renovation rates, energy poverty and financing aspects)
European Storm Forecast Experiment (ESTOFEX) and European Severe Weather Database, (ESWD)	European Severe Storms Laboratory (ESSL)	Geographic coverage: Europe Spatial unit: city Period: 2007-current Further disaggregations: type of event	The European Storm Forecast Experiment (ESTOFEX) platform publishes daily bulletins with forecasts of hail, strong wind gusts, tornadoes and excessive precipitation in Europe and other areas. The European Severe Weather Database (ESWD) is a repository that collects data on these phenomena in Europe.
EUMETVIEW	European Organisation for the Exploitation of Meteorological Satellites	Geographic coverage: Europe, Africa and South America Spatial unit: grid Period: n.a Further disaggregations: n.a.	Portal with satellite data collection on weather, climate, and environment.
CLIMDEX	University of Sidney (UNSW)	Geographic coverage: World Spatial unit: grid Period: 1953-present Further disaggregations: n.a.	Database of indices on temperature and precipitation extremes recommended by the WMO Expert Team on Climate Change Detection and Indices. These indices were also used in the National Climate Change Adaptation Plan (PNACC – see table XX).
E-OBS (Copernicus Climate change service)	Copernicus Climate Change Service (C3S)	Geographic coverage: Europe Spatial unit: grid Period: 1953-present (daily data) Further disaggregations: n.a.	Daily meteorological data (maximum, minimum, and average temperature; precipitation; humidity; wind speed, etc.), at grid level, for Europe, from meteorological stations.
Climate Reanalyzer	Climate Change Institute at the University of Maine	Geographic coverage: World Spatial unit: Period: Further disaggregations: n.a.	The site offers daily and historical weather maps, satellite photos, daily data on ice thickness, temperatures, and reprocessing of public datasets (list available here).

Risk Data Hub (RDH) of the Disaster Risk Management Knowledge Centre (DRMKC)	JRC	Geographic coverage: Europe Spatial unit: different breakdowns based on the indicator Period: 1980 - present Further disaggregations: type of risk and potential loss	The archive contains information on losses associated with historical events and potential impact analyses for different physical risks. Two main modules: historical events and risk analysis. A list of catastrophic events is also available (here).
Agri4Cast	European Commission	Geographic coverage: European Union Spatial unit: country, region and other based on the indicator Period: 1979 -2022 Further disaggregations: different breakdowns based on the indicator	Agro-meteorological grids, irrigation grids, indices of low and high temperature days, crop statistics. Registration required.
EM-DAT	Centre for Research on the Epidemiology of Disasters (CRED)	Geographic coverage: World Spatial unit: country Period: 1900 - 2022 Further disaggregations: different breakdowns based on the indicator	The archive considers the main natural risks (geophysical, meteorological, hydrological, climatic, biological and extraterrestrial) and technological risks (mainly industrial and transport accidents).
SIGMA Explorer	Swiss RE	Geographic coverage: World Spatial unit: country Period: 1970 - 2021 Further disaggregations: n.a.	SwissRe's database of natural disasters, man-made disasters, and earthquakes and insurance premiums.
Dashboard EIOPA on the insurance protection gap	EIOPA	Geographical area: European Economic Area Spatial unit: country Period: 2022-2024 Further disaggregations:	Dashboard on European insurance protection gap. It focuses on natural catastrophe risks (Windstorm, Flood, Coastal flood, Wildfire, Earthquake). Results are represented by a score varying from 1 (no protection gap) to 4 (very high protection gap).
FIRMS - Fire information for resource management system	NASA	Geographical area: world Spatial unit: specific locations Period: 2000 - present Further disaggregations:	Data on wildfires locations worldwide collected via satellites (coordinates, radiative power and other variables for each event).
Global Wildfire Information System (GWIS)	GEO/Copernicus Climate Change Service (C3S)	Geographical area: world Spatial unit: Period: 2002 - present Further disaggregations: country, region	Data on wildfires and lightning occurrence (both historical and forecast up to 10 days in advance) with statistics provided at national level and for regions of interest.
City-scale climate hazards	World resource institute	Geographical area: world Spatial unit: city (0.25-degree resolution) Period: Further disaggregations:	This dataset contains estimated average magnitudes and probabilities of extreme-magnitude exceedance for 14 climate hazards, calculated for the 996 cities larger than 500,000 in population, at recent historical level and 1.5°C, 2.0°C, and 3.0°C of global warming above pre-industrial baseline. Concerning Italy it covers six cities (Rome, Milan, Turin, Naples, Genoa and Palermo).

EIOPA Catastrophe data hub	EIOPA	Geographical area: European Economic Area Spatial unit: country Period: Further disaggregations:	The sample includes 35 large European groups active in non-life business and 9 non-life and composite solo undertakings with relevant exposure to fire and other damages to property business. Data: overall value or replacement value of the commercial or residential buildings insured. Incurred claims for buildings and other claims reported by the insurance undertakings or groups in the sample.

Physical risk (national providers)			Table 7
Name	Provider	Main attributes	Description
Sistema informativo nazionale ambientale	ISPRA	Geographical area: Italy Spatial unit: Municipality (for some indicators) Period: different time ranges based on the indicator Further breakdowns: different breakdowns based on the indicator	Inland waters, physical agents, environment and health, environmental sustainability, air, climate, weather, climate change, environmental controls and inspections, circular economy, geology, soil, contaminated sites, environmental indicators, sea and coast, nature and biodiversity, waste, chemicals.
Piattaforma nazionale adattamento cambiamenti climatici	ISPRA	Geographical area: Italy Spatial unit: Period: 1960-present Further breakdowns:	Data and information on climate change in Italy, including national impact indicators (and regional case studies), management and adaptation.
Sistema nazionale di raccolta, elaborazione e diffusione dei dati climatici (SCIA)	ISPRA	Geographical area: Italy Spatial unit: Italy/station/grid Period: 1860 – present (daily, weekly, monthly, yearly frequency) Further breakdowns:	Database containing climate variations and trends in Italy (average minimum and maximum temperatures, humidity, wind, precipitation, etc.) compiled by ISPRA.
Mappe su temperature (e deviazioni) medie, minime e massime del CNR-ISAC	CNR	Geographical area: Italy Spatial unit: Period: 2002 – present Further breakdowns:	Maps of average, minimum and maximum temperatures, with deviations from historical averages (1991-2020) produced by ISAC-CNR for civil protection - full database here.
MEteorological Reanalysis Italian DAtaset (MERIDA)	Ricerca sul Sistema Energetico (RSE)	Geographical area: Italy Spatial unit: grid 21-7 e 4 km (HRES version) Period: 1990-2023 (2022 for HRES) Further breakdowns:	Historical series of meteorological variables (list here) with fine spatial granularity.

Climate scenarios			Table 8
Name	Provider	Main attributes	Description
Scenario portal NGFS	NGFS	Geographical area: Worldwide Spatial unit: Country (where downscaling is possible) Period: Different periods depending on the type of scenario Further breakdowns: Scenarios are distinguished by physical risks and transition risks	The archive contains the fifth edition of the NGFS long-term scenarios (previous versions are also available). The NGFS IIASA Scenario Explorer allows for the analysis of transition scenarios, while the NGFS CA Climate Impact Explorer allows for the analysis of physical risk scenarios. It is possible to both explore the scenarios and download them.
Centro Euro-Mediterraneo sui Cambiamenti Climatici - Data Delivery System (CMCC-DDS)	CMCC Foundation	Geographical area: Italy, Mediterranean, with possible extensions to larger scales for some global data Spatial unit: various Period: different periods depending on the dataset Further breakdowns: various, depending on the type of dataset	Multiple datasets: High-resolution climate scenarios for Italy for various emission scenarios (RCP 4.5 or RCP 8.5) and periods (2021-2050, 2041-2070, and 2071-2100). Lower resolution global data. Climate variables (average daily temperature, days of intense precipitation, days of intense cold, etc.).
Climate analysis over MEDiterranean Region (CLIMED)	RSE	Geographical area: Italy Spatial unit: Country Period: 2021-2050, 2041-2070, and 2071-2100 Further breakdowns: emission scenario (RCP 2.6, 4.5 or 8.5) and climate models (Euro-CORDEX, Med-CORDEX, ENSEMBLES)	Historical data (1971-2000) and prospective data (2021-2050; 2041-2070; 2071-2100) for different scenarios, at grid level for different climate variables. (average/maximum/minimum temperature, total rainfall, wind intensity, hot days, tropical nights, etc.).

Sustainable finance			Table 9
Name	Provider	Main attributes	Description
Dashboard on scaling up green finance	NGFS	Geographical area: World Spatial unit: Country Time period: 1970 – present (for some indicators) Further breakdowns: multiple, depending on the indicator	The dashboard provides links to websites where 21 annual indicators on ecological transition in countries are available, including, for example, greenhouse gas emissions, national policies, and green and social bond issuances.
FT climate dashboard	Financial Times	Geographical area: World Spatial unit: Country Period: 1990–2021 Further breakdowns:	Dashboard with information on total GHG emissions, per capita, global ranking, year-on-year change, summary of climate pledges, % of renewables in the electricity production mix
Osservatorio DNF	University of Siena	Geographic coverage: Italy Spatial unit: regions Period: 2017-2023 Further disaggregations: economic sectors	The archive contains annual data obtained from the Non-Financial Reporting of the main Italian companies, including those on their direct and indirect emissions.
Online Tools for the Financial Sector	UNEP FI	Geographic coverage: World Spatial unit: country Period: 2017-2023 Further disaggregations: asset class	Useful tools for financial sector agents
ESG Bond Lists	SSE e Borse Valori (Borsa Italiana, LSE, Euronext)	Geographic coverage: World Spatial unit: country Period: 2017-2023 Further disaggregations: asset class	Asset ESG: green and sustainable bonds

Nature and others			Table 10
Name	Provider	Main attributes	Description
ESVD - Ecosystem services valuation database	ESVD	Geographic coverage: World Spatial unit: specific area Period: Further disaggregations:	Database containing more than 10,000 assessments of specific biomes/ecosystems. For a description of the contents, see Brander et al. (2024).
EUSO Soil Degradation Dashboard	JRC	Geographic coverage: World Spatial unit: 0.25 degree Period: 16-day hourly forecast Further disaggregations:	Dashboard on land degradation (erosion, pollution, salinization, etc.) created by the European Commission's Joint Research Centre (JRC). Here for a list of resources.
Other statistics on European economic and environmental accounts	Eurostat	Geographic coverage: EU Spatial unit: country Period: 1990-2024 Further disaggregations:	Other statistics (full list here) include: Material Flow Accounts, Environmental Tax Data, Environmental Goods and Services Sector Accounts, and Environmental Protection Expenditure Accounts.
Ecological Transition Plan and Monitoring Reports	Italian ministry of environment and energy security (MASE)	Geographic coverage: Italy Spatial unit: country Period: 2019-2030 Further disaggregations:	The PTE is the strategic plan for the ecological transition, divided into eight themes. By law, a report will be published annually, detailing progress and comparing it with the 2030 target (here is the first report, May 2022).

Climate and Environmental Risk Data in Italy

Katia Specchia

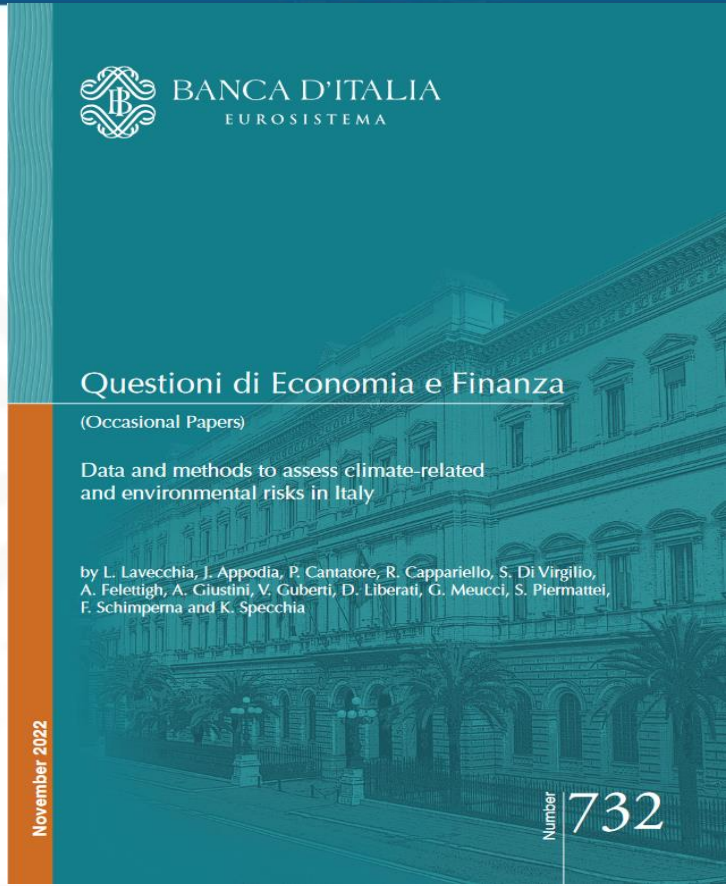
Supervisory Regulations and Policies Directorate
Insurance Supervisory Authority (IVASS)

IFC Satellite Seminar on "Sustainability data issues and central banks' experience“

Amsterdam, 4 October 2025

Agenda

1. **Foreword and Structure of the paper**
2. **The sustainable data gap in Italy**
   - Data required for economic and financial analysis of climate risks
   - Data required by financial intermediaries to respond to requests from supervisors
   - Available data
   - Data available but not accessible
3. **Conclusions**



Foreword and Structure of the paper

- **Research context and motivation: Rising Demand for Climate Data**

Mitigation and adaptation to climate change are top priorities. Lots of public-private resources needed. Global initiatives have increased demand for climate-related data in sustainable finance and risk management.

- **Regulatory Pressure in Europe: Data Requirements**

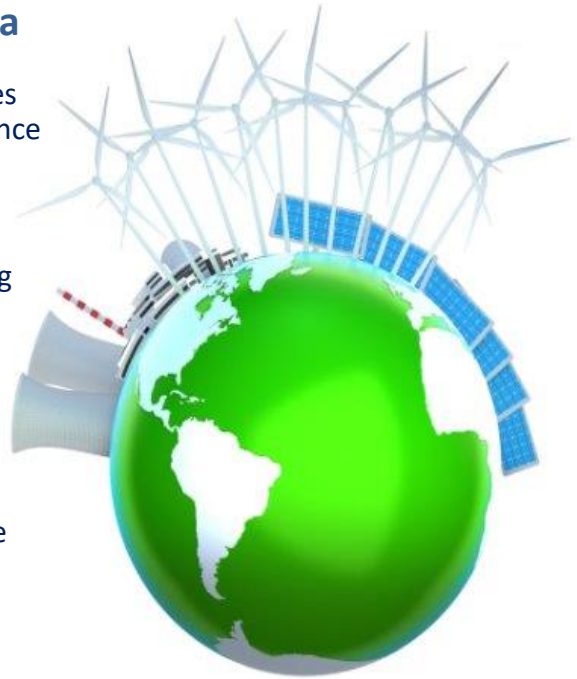
European regulations push firms for comprehensive climate disclosures, intensifying reporting expectations. Goal is to enhance risk management and ensure compliance with regulatory climate requirements set by supervisory authorities and regulatory frameworks.

- **Sustainable Data Gap Challenges**

Huge demand for high-quality microdata.
Missing/insufficient data concern: GHG emissions, energy use, physical/transition risk exposures; insurance protection gap and peril-specific economic losses; integration of climate scenarios into financial models; granular data for SMEs.
Private data providers offer partial solutions, but suffer from low transparency on the methodology involved and inconsistency (uncorrelation among scores/ratings).
The study maps available sources, assessing accessibility and quality for risk management.

- **Italy's Data Limitations and constraints**

Research focuses on identifying sustainable data gaps related to climate and environmental risks in Italy.



What about existing public data sources?

1. What data is required?
2. What data is already available?
3. Where is the *sustainable data gap* in Italy?

The data required for economic and financial analysis

- **Physical Climate Risks**: physical risks result from extreme weather damaging infrastructure and disrupting operations.
- **Transition Climate Risks:** transition risks arise from policy changes and market shifts affecting asset values
- **Risk Evaluation and Mitigation:** comprehensive data is crucial to assess impacts and develop mitigation strategies. Accurate risk assessment depends on detailed data like geolocated risk maps and firm-level energy use.

- Pressure from stakeholders to commit to Net zero; align firms' performances to climate benchmarks
- Define mitigation/adaptation plans
- Measure and manage physical and transition risks
- Decline climate scenarios
- Country view: current exposure, vulnerability and available insurance coverage for climate risks

	Ante 2022	2022	2023	2024	2025	2026	…
NFD		*Disclosure ESG as defined in the NFRD*		*Disclosure ESG as defined in the CSRD/EFRAG schemes*			
Scope		*Large listed undertakings, banks, insurances (relevant Public interest entities - PIEs)*		*Relevant PIEs*	*Relevant PIEs and large non-listed undertakings*	*(As 2025) + listed SMEs, small and non-complex credit institutions and captive insurance undertakings*	
Taxonomy Reg.							
NFCs within the NFRD/ CSRD's scope		• % of *Capex, Opex, turnover* from *taxonomy **eligible** activities.*		• *% Capex, Opex, turnover* from *taxonomy **aligned*** and *taxonomy **eligible** activities.*			
Banks within NFRD/ CSRD's scope		• % Total assets from *taxonomy-**eligible** activities.*		• *Green Asset Ratio* (GAR) for lending and debt assets from firms covered by the NFRD/CSRD, computed according to the Capex and turnover from *taxonomy **aligned** activities*. % of guarantees from *taxonomy **aligned** activities.*	• % revenues from services different from *lending* from *taxonomy **aligned** activities* and GAR from trading activity		
Insurances within NFRD/ CSRD's scope		• % Total assets from *taxonomy-**eligible** activities.* • % Total non-life insurance gross premiums written from *taxonomy-**eligible** underwriting insurance activities*		•% Total assets from *taxonomy-**aligned** activities.* •% Total non-life insurance gross premiums written from *taxonomy-**aligned** underwriting insurance activities*			
Pillar 3							
Large Institution		• Quantitative and qualitative disclosure of ESG risks		• Integration of quantitative disclosure with the *Green Asset Ratio* (GAR).			
All banks					• Integration of quantitative disclosure with the *Banking Book Taxonomy Alignment Ratio* (BTAR), *scope 3 GHG emissions* and alignment metrics.		
					• Extension of Pillar 3 to all banks		
Pillar 2/3							
Insurances		• identify any material exposure to climate change risks and, where relevant, assess the impact of climate change scenarios on their business (in the ORSA Report and public disclosure)					
Survey IVASS							
Insurances		• Investments broken by NACE code, data on taxonomy eligible activities, on carbon footprint and green bonds. *Data on nat cat risk impact underwriting and on taxonomy **eligible** insurance activities*		• Investments broken by NACE code, data on taxonomy eligible and taxonomy aligned activities, on carbon footprint and green bonds. *Data on nat cat risk impact underwriting and on taxonomy **eligible*** and taxonomy ***aligned** insurance activities*			

Available data - 1

From official statistical sources and other public resources	• Eurostat environmental accounts (Air Emissions Accounts; Physical Energy Flow Account; Eurostat/Material flow accounts, Environmental taxes revenues, National expenditure on environmental protection by institutional sector) • Climate Change Knowledge Portal, EIOPA Catastrophe data Hub • Emissions data for EU ETS installations (EU transaction log; EUTL) • European Pollutant Release and Transfer Register (E-PRTR) • Dashboards: IMF - Climate change indicators, NGFS Dashboard on scaling up green finance, EIOPA Dashboard on insurance protection gap, FT Climate • CO2 emissions data: Greenhouse Gas Emissions from Energy, Carbon Monitor and GRACED • Real estate data: OpenStreetMap and OMI • Data on severe weather events: European Storm Forecast Experiment (ESTOFEX) and European Severe Weather Database (ESWD)

Available data - 2

National sources	• ISPRA: national GHG inventory + data on water, air, sea and coasts, nature and biodiversity, climate, waste, environmental indicators, hydrogeological risk maps (IdroGEO portal); • MASE (formerly MITE): monthly data on fuel prices, oil, coal and natural gas consumption + fuel price monitoring (real-time prices) and Ecological Transition Plan; • ARERA: annual survey on regulated sectors; • DNF Observatory (University of Siena and Sustainability makers); • Istat: Household expenditure survey, household energy consumption surveys;
Risk indicators	• JRC: DRMKC - RiskData Hub and Agri4Cast; WWF risk filter suite, Sigma Explorer, EIOPA Dashboard on Insurance Protection gap, Emergency Events Database (EM-DAT)

Available data - 3

Green finance	• UNEP Finance Initiative UNEP-FI • Sustainable Stock Exchange Initiative (SSEI)
Scenario data	• NGFS: scenario data on the IIASA and Climate Analytics platform • RSE: Meteorological Reanalysis Italian Dataset (MERIDA) • CMCC: data and scenarios • OECD Climate Actions and Policies Measurement Framework (CAPMF)

The unavailable data

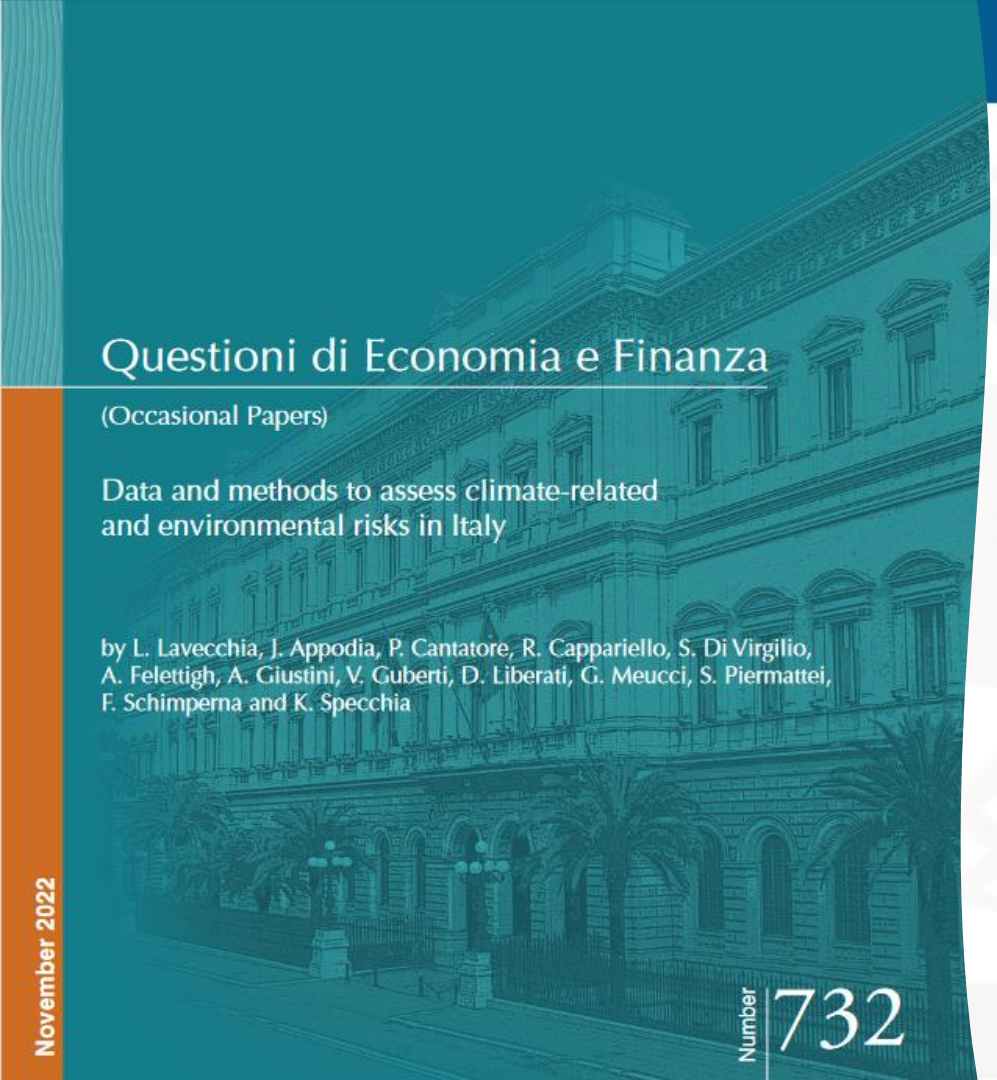
1. The Sistema informativo integrato (SII) by Acquirente Unico
2. Sistema Informativo sugli Attestati di Prestazione Energetica (SIAPE) by ENEA

The sustainable data gap in Italy

- The sustainable data gap is concentrated :
  - By theme: energy (use, prices, expenditure), for HHs and firms; GHG emissions; climate scenarios data; natural catastrophe risks coverages and economic losses
  - By regulations: Pillar 3, CSRD
  - By firm size: micro and SMEs

Conclusions

- **The financial system is increasingly committed to supporting the green transition**, yet data limitations remain a critical bottleneck, especially in assessing and managing natural catastrophe risks
- **Bridging the data gap is not just a technical challenge**—it's a strategic imperative for a resilient and sustainable financial system:
  - **High-quality, granular and forward-looking data** are essential for: internal risk analysis and transition plans, regulations, financial stability monitoring, insurance underwriting and pricing;
  - **Public data sources offer valuable insights**, but accessibility, interoperability and granularity are still insufficient
  - **The sustainable data gap persists**, notably in: Energy consumption and GHG emissions, SME-level disclosures, Insurance protection gap and peril-specific economic losses, Integration of EPCs and climate scenarios into financial risk models
- **Coordinated action is needed**: Among statistical agencies, regulators, financial institutions and data providers; To harmonize standards, improve data sharing, and support the development of robust climate risk analytics



Thank you

Katia.Specchia@ivass.it