Executive Summary

The [paper](#) [1] analyses the **impact of climate-related physical risks** on the **one-year probability of default (PD)** of **Italian non-financial firms**, with a specific focus on **hydrogeological (HG) risks**, namely **floods** and **landslides**. These risks are particularly relevant in Italy due to the country's geomorphological characteristics and **increasing frequency** of extreme weather events.

Hydrogeological events pose **direct and indirect risks** to firms' financial stability. **Direct effects** include the **destruction of tangible assets** such as property, plant and equipment and inventories. **Indirect effects** arise from **production disruptions**, supply chain interruptions, demand shocks, work absenteeism, and increased restoration costs. These channels may weaken cash flows and, in extreme cases, lead to **insolvency**.

[1] Bankit - "Hydrogeological and credit risk: the Italian firms' physical risk-adjusted probability of default", February 2026

At a Glance

Keywords: Credit risk, Climate risk, Physical risk

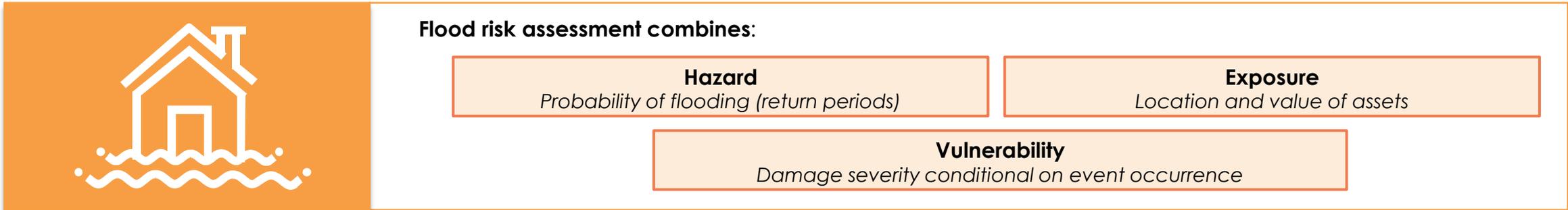# 01

Modelling Hydrogeological Risk

Flood Risk

Landslide Risk

Modelling Hydrogeological Risk 1/2
Flood Risk

Flood risk assessment for **Italian firms** is particularly **relevant** given the country's geomorphological configuration, which makes large areas highly exposed to **hydrogeological hazards**. Within the **physical risks**, **flood risk** represents one of the **most material threats**, for this reason, accurately **assessing its impact is essential** for evaluating potential losses.

Flood risk assessment combines:

Hazard	**Exposure**
Probability of flooding (return periods)	*Location and value of assets*

Vulnerability
Damage severity conditional on event occurrence

🔍 **How to classify Flood Risk?**

ISPRA* mosaic maps serve as the official national reference under the **EU Floods Directive (2007/60/EC)**. These maps classify flood risk into 3 classes based on the frequence of the events:

- **High Probability Hazard (HPH)**: 20 - 50 years

- **Medium Probability Hazard (MPH)**: 100 - 200 years

- **Low Probability Hazard (LPH)**: > 200 years

Pros
Unlike alternative raster-based maps (e.g., JRC), **ISPRA maps use vector data**, offering **higher spatial precision** for firm-level analysis

Cons
However, **ISPRA maps** do not **provide flood depth information**, which introduces modelling simplifications

Damage estimation remains **uncertain** due to:

- **Simplifying assumptions**
- **Cross-country transfer** of **damage functions**
- **Absence** of **depth-specific calibration**

The study adopts prudential assumptions consistent with regulatory practice.

* Istituto Superiore per la Protezione e la Ricerca Ambientale

Modelling Hydrogeological Risk 2/2
Landslide Risk

Landslide risk is a **critical concern in Italy**, where most of the territory is mountainous or hilly, necessitating a **detailed analysis** of the **physical vulnerability** of buildings and infrastructure. This **risk assessment** integrates the **probability of occurrence** with **potential damage magnitude**, providing a **qualitative measure** of how geological instability can lead to **significant losses.**

Landslide risk assessment is:

Primarily qualitative
Qualitative methodology for landslide risk assessment

Integrates probability and magnitude
Probability of occurrence and event magnitude

Based on the IFFI Inventory
Italy's most comprehensive and detailed landslide database

How to classify Landslide Risk?

Risk categories combine **frequency*** and **damage magnitude**. Landslide modelling in Italy faces **spatial bias** due to **heterogeneity in regional inventories**. Nevertheless, **ISPRA maps** remain the **official harmonised reference**.

P4 – high and medium frequency
high magnitude

P3 - high and medium frequency
medium magnitude
OR
low frequency, high magnitude

P2 – high frequency, low magnitude
OR
low frequency, medium magnitude

P1 – medium and low frequency
medium and low magnitude

The modelling framework converts return periods into annualised probabilities using hydraulic engineering formulas.

See Methodology section

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Data

Perimeter of the Analysis

Data
Perimeter of the Analysis

The analysis combines **three data sources**: i) **ISPRA georeferenced maps** to identify floodable areas and areas exposed to landslide, ii) the **Infocamere database** with information about the location of primary and secondary units, iii) **S-ICAS* firms' financial variables.**

Integrating data from the **ISPRA hazard maps** (flood and landslide), the **Infocamere business registry**, and the **S-ICAS** financial database, **the dataset includes**:
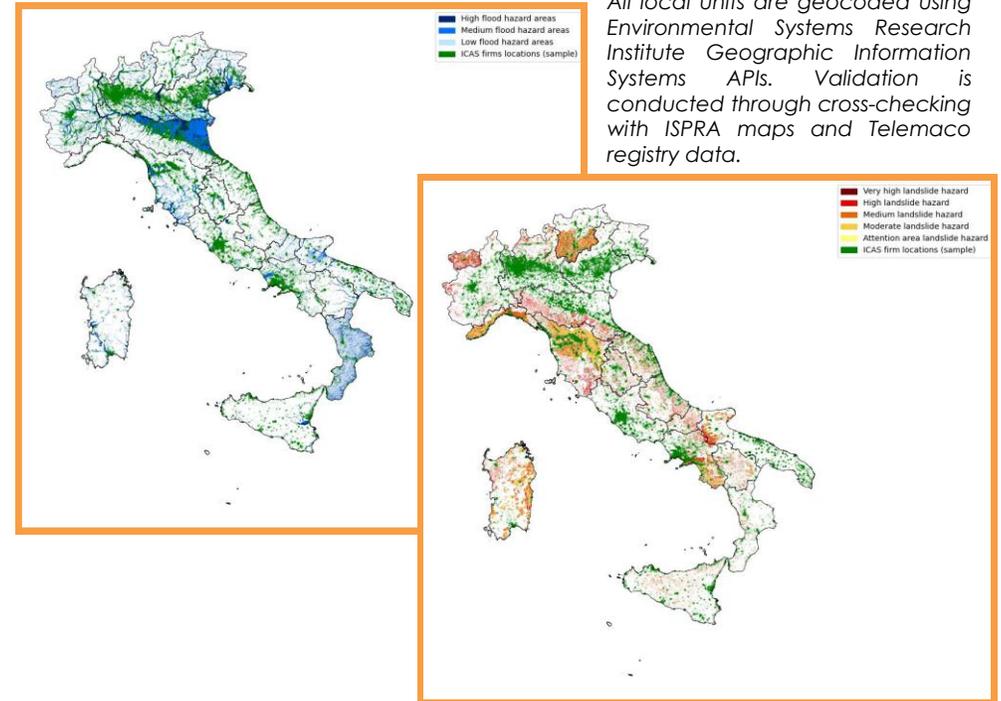
All local units are geocoded using Environmental Systems Research Institute Geographic Information Systems APIs. Validation is conducted through cross-checking with ISPRA maps and Telemaco registry data.

366,799 active firms   **745,370 local units**   **7.2 million employees**

Local units are **categorised** into:

Warehouses	Plants	Shops	Offices

Exposure weighting is applied by assigning **75% weight** to the **employment distribution** and **25% weight** to the **number of premises**, thereby prioritizing workforce concentration while still accounting for the geographic spread of local units.

The S-ICAS statistical model provides monthly one-year PD estimates and is part of the Eurosystem Credit Assessment Framework (ECAF). Hence, PD deterioration has implications for collateral eligibility in monetary policy operations.

* Banca d'Italia In-House Credit Assessment System statistical model

03

Methodology

Risk-adjusted Financial Statements – Income Statement

Risk-adjusted Financial Statements – Balance Sheet

Methodology 1/2
Risk-adjusted Financial Statements – Income Statement

To estimate the **hydrogeological risk-adjusted probabilities of default (PDs)** of Italian non-financial firms, **risk-adjusted financial statements** are constructed by **incorporating expected production disruptions** and **asset losses** into the firm's **balance sheet** and **income statement**.

Income Statement Adjustments

Revenues

Revenue losses depend on:
- **Local unit exposure.**
- **Hazard probability.** 🔍
- **Duration of disruption** (2–8 months depending on risk).

Costs

Cost adjustments:
- **Variable** and **labour costs** respond to revenue changes via **NACE-level elasticities**.
- **Fixed costs remain constant.**
- **Interest expenses** assumed **unchanged**.

Impairment losses

Impairment losses are **added** for:
- **Property, Plant and Equipment (PPE).**
- **Warehouse Inventories (WI).**

🔍 *Hazard probability*

The modelling framework converts return periods into annualised probabilities using hydraulic engineering formulas:

$$p = 1 - \left(1 - \frac{1}{T}\right)^N$$

probability of occurrence of the event

N=1, because the probability refers to the likelihood of the event occurring within the current year

average return time*

Flood	Landslide
HPH: $T = [20; 50] \rightarrow \bar{T} = 35 \rightarrow$ p = 0.028	**P4**: $T = [1; 30] \rightarrow \bar{T} = 15 \rightarrow$ p = 0.067
	P3: $T = [30; 100] \rightarrow \bar{T} = 65 \rightarrow$ p = 0.015
MPH: $T = [100; 200] \rightarrow \bar{T} = 150 \rightarrow$ p = 0.007	**P2**: $T = [100; 300] \rightarrow \bar{T} = 200 \rightarrow$ p = 0.005
LPH: $T > 200 \rightarrow \bar{T} = 200 \rightarrow$ p = 0.007	**P1**: $T > 300 \rightarrow \bar{T} = 300 \rightarrow$ p = 0.003

* For interval-based return periods, the arithmetic mean is used to calculate annual probability.

Risk-adjusted Financial Statements – Balance Sheet

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Balance Sheet Adjustments

Assets

Asset losses depend on:
- **Local unit exposure.**
- **Value of the asset.**
- **Vulnerability.**
- **Hazard probability.**

Results

In conclusion, based on the **changes** in **revenues and costs**, together with the estimated **reductions in balance sheet asset values**, the **HG risk-adjusted income statement** and the **HG risk-adjusted balance sheet** are constructed.

The **risk-adjusted financial statements** are then input into the **S-ICAS model** to derive **physical-risk-adjusted PDs**.

Asset losses

The **expected loss** for corporate **assets** is calculated by aggregating the **physical risk exposure** of **each local unit** *k*, weighted by its operational significance. This probabilistic framework **integrates site-specific hazard frequencies with vulnerability factors** to quantify the **potential write-downs** of property, plants, and inventories **caused by hydrogeological events**.

$$EL\ Asset_{i,l} = \Sigma_k[exposure_{i,k} \times asset_l \times \Sigma_j(\boxed{vulnerability_{k,j}} \times hazard_{k,j})]$$

Value of the vulnerability parameter:

1 | **Flood damage**: 60% asset loss assumption (prudential, **aligned with IRB LGD benchmark**).

Landslide damage vulnerability varies by category:
- **P4**: 80%
- **P2**: 40%
- **P3**: 60%
- **P1**: 20%

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Results

Discrete Indicators

Physical Risk-Adjusted PD

Results 1/2
Discrete Indicators

Three discrete indicators have been developed to assess Italian non-financial firms' exposure to flood risk, landslide risk, and overall hydrogeological (HG) risk. These scores range from 0 (no risk) to 3 (highest risk). The analysis is done on i) all local units and ii) at the headquarters level, where risk could be overestimated or underestimated depending on the headquarters location compared to other local units.

All local units

Risk Indicator	Flood (% firms)	Landslide (% firms)	HG (% firms)
0	66.7	91.8	62.1
Low	15.5	4.3	16.8
Medium	12.7	2.7	14.9
High	5.1	1.2	6.2

33% exposed to flood risk

8% exposed to landslide risk

38% of firms exposed to HG risk

Only headquarters

Risk Indicator	Flood (% firms)	Landslide (% firms)	HG (% firms)
0	70.6	92.8	66.3
Low	12.3	3.2	13.3
Medium	11.4	2.7	13.5
High	5.6	1.4	6.8

Flood Risk

Landslide Risk

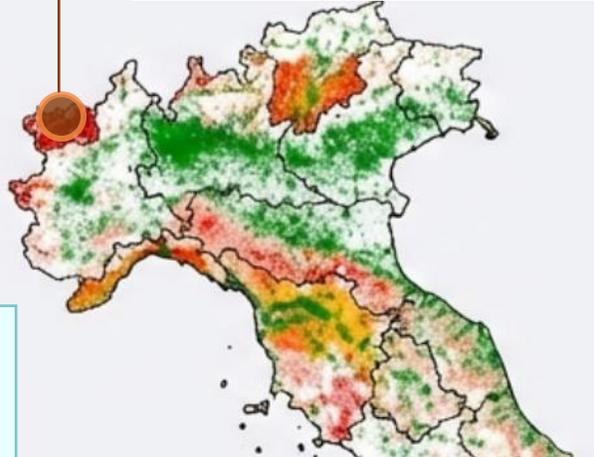**Aosta Valley** shows high relative landslide exposure **(32%)**

Liguria (and **Calabria**) have highest severe-risk shares **(7.7%)**

Emilia-Romagna (55%) and **Tuscany (54%)** show highest flood exposure

Headquarters-only assessment underestimates or misclassifies risk:
- *9% discrepancy overall.*
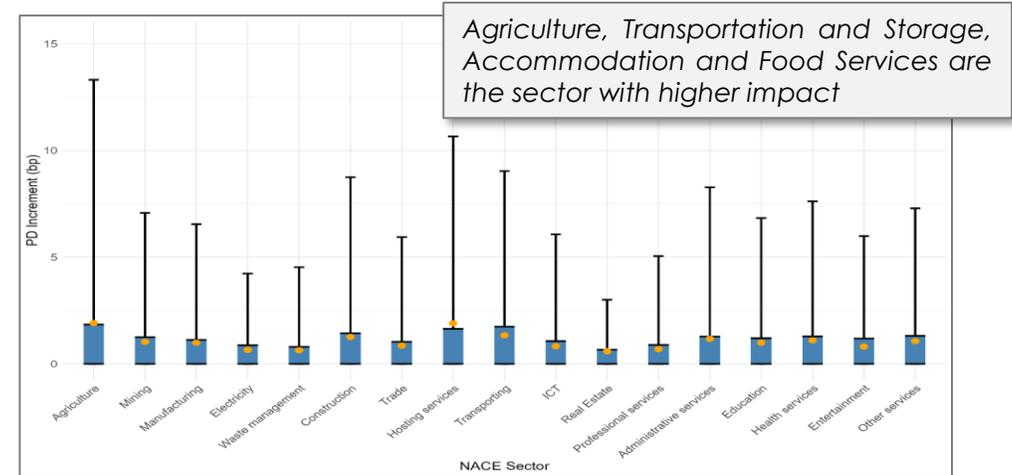- *23% when excluding single-unit firms.*

Physical Risk-Adjusted PD

Using the **S-ICAS model**, the **risk-adjusted financial statements** are **converted** into **physical-risk adjusted Probabilities of Default**. By quantifying the financial consequences of expected losses from floods and landslides, it evaluates the **impact on firms' creditworthiness** across **different sectors**, **sizes**, and **regions**.

	Firms (#)	Firms (%)	Average PD increments			
			Baseline	Lower Bound	Average	Upper Bound
0	227,591	62.1	0.0	0.0	0.0	0.0
Low	61,520	16.8	0.9	0.7	1.0	1.4
Medium	54,864	14.9	1.8	1.1	2.5	3.8
High	22,824	6.2	9.1	4.4	18.9	32.0
Total	366,799		1.0	0.6	1.7	2.8

The **main results** obtained are summarized below:

- ➤ **38% of firms** experience **PD deterioration.**

- ➤ **Average PD increase modest**.

- ➤ Firms in **high-risk areas** show **significant PD increase**.

- ➤ **Average PD increase** for **highest risk category** reaches **32 basis points** under **upper-bound scenario**.

Agriculture, Transportation and Storage, Accommodation and Food Services are the sector with higher impact

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Further Results

Impact on Collateral & Insurance Effect

Further Results
Impact on Collateral & Insurance Effect

The study also explores **how hydrogeological risks affect the collateral** used in banking operations and highlights the **crucial role of insurance** in protecting firms. The results show that **the impact on collateral** value **is currently negligible**, while **insurance coverage** can **reduce** the expected **increase in a firm's default probability** by **nearly 50%.**

Impact on Collateral

Variation	Migrated (#)	Migrated (%)	Stable (#)	Stable (%)	Average PD increment (bp)
PD	139,841	38.1	226,958	61.9	1.02
CQS	1,571	0.4	365,228	99.6	1.02

➢ Only **0.43% migrate** to **worse Credit Quality Step (CQS)**.

➢ The **aggregate impact** on **Eurosystem collateral pool** remains **negligible** under baseline assumptions.

Given the role of **S-ICAS** in **Eurosystem Credit Assessment Framework (ECAF)**:

- **Limited CQS migration** implies **negligible effect** on **collateral eligibility**.

- **No material constraint** on Italian banks' refinancing capacity **under current hazard frequencies.**

Insurance Effect

Using 2024 Banca d'Italia survey data:

- **Insurance coverage reduces PD deterioration by ~50%.**

- **Insurance** acts as **financial stability stabiliser**.

- **Banks** typically **do not differentiate insured vs uninsured borrowers**.
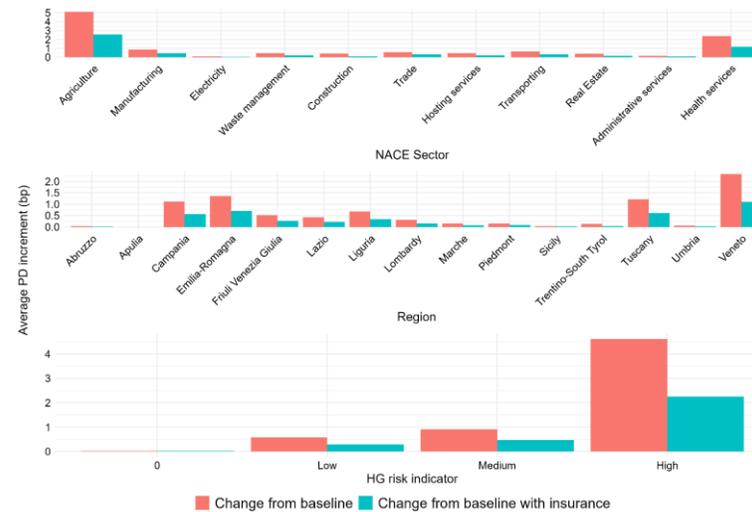
The mitigation role of insurance becomes critical in forward-looking climate scenarios.

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Conclusions and Key Takeaways

Conclusions and Key Takeaways

a. **38%** of Italian non-financial **firms** are **exposed to hydrogeological risk.**

b. **Average impact on PD** is **limited** under current hazard frequencies.

c. Only **0.43% of firms migrate** to a **worse CQS.**

d. **High-risk areas** and **specific sectors** experience **significant deterioration.**

e. **Insurance** coverage **halves PD deterioration.**

f. **Collateral implications** for monetary policy operations **are negligible** at present.

g. **Future increases** in **extreme event frequency** could substantially **amplify credit risk effects.**

Overall Key Takeaways

- **Granular geolocation** materially **improves risk assessment accuracy.**

- **Physical climate risk** can be **integrated** into **PD modelling** via **financial statement adjustments.**

- Current systemic **impact on credit risk is contained** but **heterogeneous.**

- **Insurance** is a **critical mitigant.**

- **Forward-looking risk** may be **materially higher** than baseline estimates.

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