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Climate Risk Stress Testing Model: Impacts on the Peruvian Financial System and Integration with the Solvency Stress Testing Model

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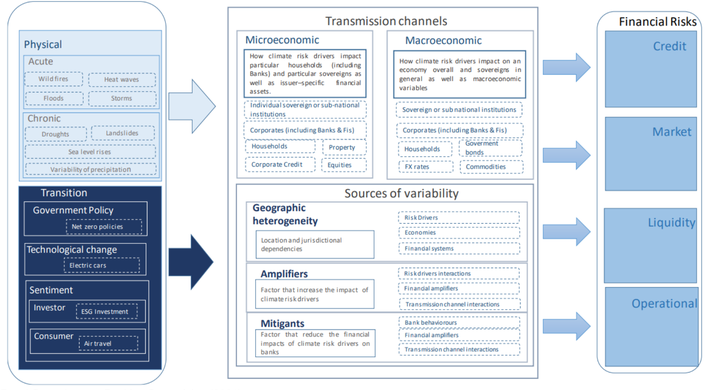
Agenda

1. SBS climate risk stress-testing framework
2. Source of historical information related to climate and macroeconomic variables
3. Sources of information related to climate and macroeconomic projection scenarios
4. Methodology of the SBS climate risk stress test model
5. SBS climate risk stress-testing: main results
6. SBS solvency stress test: climate module improvement

1. SBS climate risk stress-testing framework

Transmission channels of climate risk drivers to financial risks



Source: Basel Committee on Banking Supervision (2021).

Evolution of the Climate Risk Assessment in the SBS

2015 -2016 — **Development of the first version of the climate module** in the Solvency Stress Test tool: Exposure analysis

2022 — **First version of the Climate Risk Stress Test** for the financial system – *IESF 2022-II, WP-2022*

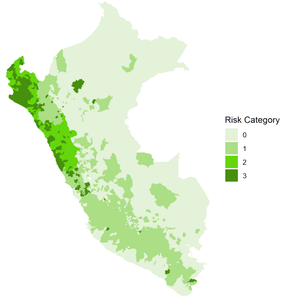
2023 — **Subscription of the SBS to the NFGS**

2023 — **Improvement of the climate module** of the Solvency Stress Test tool. *Calibration of potential coastal FEN impact published on IESF 2023-I and IESF 2023-II*

2024 — **Complete credit risk mapping** (PD & LGD) on the Climate Risk Stress Test (*WP-2024)*

2025 — Ongoing improvement of modeling and precipitation datasets

Vulnerability map of Peru - Districts affected by heavy rainfalls



Source: SBS, SENAMHI. Mapping used in the calibration of the impact of Coastal FEN on PD in the IESF 2023-II.

SBS climate risk stress-testing framework

Climate risk drivers

Physical risk
- Acute

Floods/droughts
- Chronic

Higher rain severity
Higher sea surface temperature (SST).

Transmission channels

Microeconomic
- Households and enterprises
- Collateral value

Macroeconomic
- GDP

Financial risk

Credit risk
- Probability of default: Income effect (payment capacity)
- LGD: wealth effect (collateral value impacts)

Short-term effects → Incorporation into SBS Solvency Stress Testing Model

2. Source of historical information related to climate and macroeconomic variables

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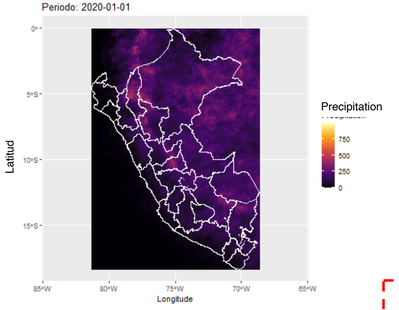
Short-term effects → Incorporation into SBS Solvency Stress Testing Model

The historical precipitation information was obtained through a webscraping process of georeferenced information from the PERSIANN-CCS-CDR of NOAA

Average monthly peruvian precipitation – 2020 (mm)



Source: PERSIANN-CCS-CDR. Own elaboration.

Georeferenced information from **satellite data** and **artificial neural networks (PERSIANN-CCS-CDR)** from **NOAA**

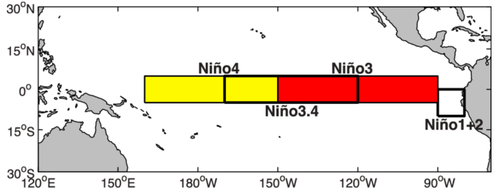
Granular information: intervals of 3 hours, from **January 1983 to December 2022**, in areas of 4 km², at **national level**

Data complemented with debtor-level information from the RCD, for each of the 1874 districts in Peru by **economic activity**.

The information granularity requires high computational capacity

The historical sea surface temperature information was obtained to reconstruct the activation indicators for FEN 1+2 and FEN 3.4

El Niño Regions



Source: Kozar et al. (2012)

Georeferenced information from the **Extended Reconstructed Sea Surface Temperature (ERSST v5)** of NOAA

Granular information: monthly, from **January 1854 to December 2022**, in areas of 222 km², in the **reference zone**

FEN 3.4
Responsible: NOAA.
Indicator: Oceanic Niño Index (ONI).

FEN 1+2
Responsible: Geophysical Institute of Peru (IGP).
Indicator: Costal El Niño Index (ICEN).

ERSST v5 is the official source of information for the construction of both indicators

3. Sources of information related to climate and macroeconomic projection scenarios

SBS climate risk stress-testing framework

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Short-term effects

Incorporation into SBS Solvency Stress Testing Model

The impact on PD and LGD is projected based on severe climate scenarios for 30 years, configured from a global-scale effort

Climate variable projection
- More than **100 climate models**
- Collaboration of **22 countries with 49 modeling centers**

Coupled Model Intercomparison Project (CMIP6)

Configuration of climate scenarios
- **Assumptions about socieconomic variables and levels of greenhouse gas concentration in the next century**.
- **Most pessimistic scenario:** No policies (Physical Risk).

Intergovernmental Panel on Climate Change (IPCC)

Product: IPCC AR6

Network for Greening the Financial System (NGFS)

Product: Climate Scenarios for Financial Supervisors

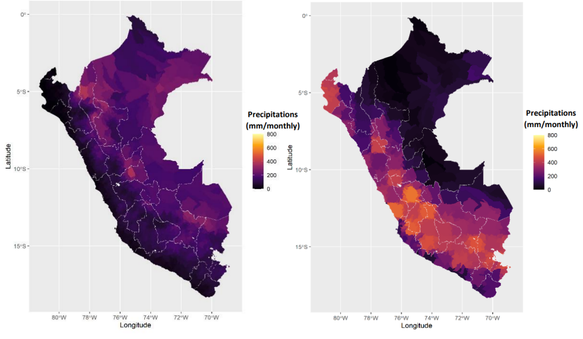
Climate Risk Stress Models for Financial Regulators

BoE, ECB

The stress test exercise uses the CMIP6 projection scenario associated with pure physical risk

Peru: National level proyected precipitation (mm/monthly)

January 2020 **January 2050**



Source: PERSIANN-CCS-CDR, CMIP6: CAMS-CSM1-0 model under SSP5-8.5 scenario. Own elaboration.

SBS climate risk stress-testing framework

Climate risk drivers

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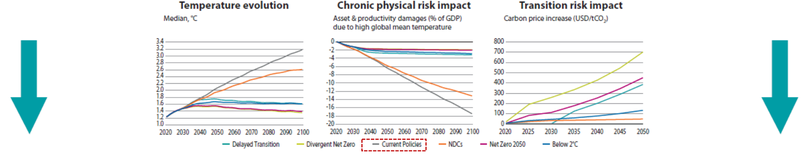
Short-term effects

Incorporation into SBS Solvency Stress Testing Model

Projections of GDP for 30 years are used, based on the scenarios developed by the Network for Greening the Financial System

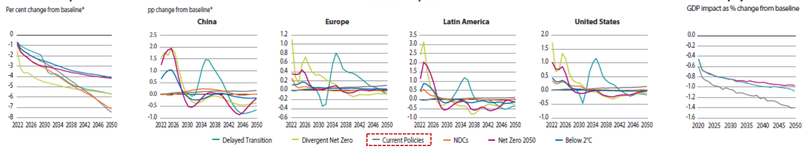
Integrated Assessment Models (IAMs) and damage function



Other transition risk variables: energy investment, emissions and energy mix, etc.

Source: IIASA NGFS Climate Scenarios Database, REMIND model.

NiGEM



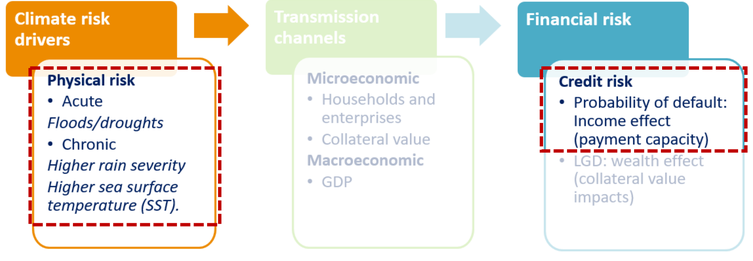
Other macro-financial variables: unemployment, equity prices, trade, interest rates, etc.

Current Policies scenario from the NGFS is used, which reflects pure physical risk

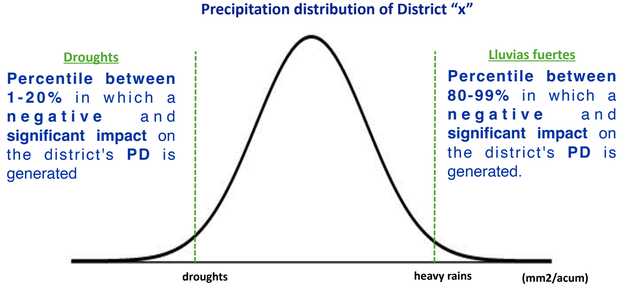
Positioning of scenarios is approximate, based on an assessment of physical and transition risks out to 2100.

4. Methodology of the SBS climate risk stress test model

SBS climate risk stress-testing framework



The micro and macroeconomic channel of the climate risk drivers is modeled in the PD across different credit segments (1)



The micro and macroeconomic channel of the climate risk drivers is modeled in the PD across different credit segments (2)

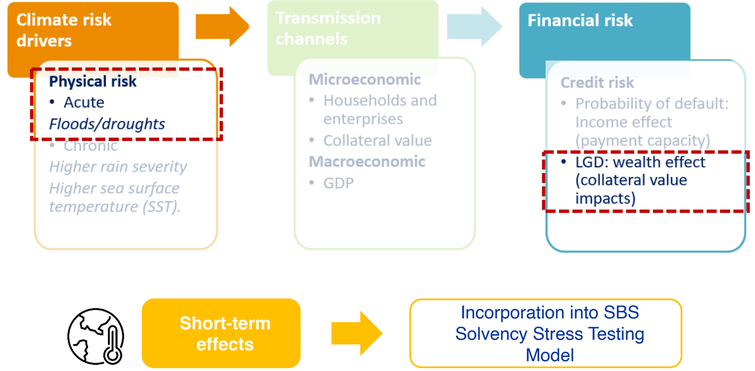
- ✓ **Panel estimation** at district level, from **January 2001 to June 2023**, with **monthly frequency**
- ✓ **Models were segmented by economic sectors**, consumption, and mortgage. **20 models:**

$$y_{i,t} = \alpha_i + \beta_{NINO}\left(ICEN_t \times \sum_{h=1}^{12} FEN_{t-h}\right) + \beta_{NINA}\left(ICEN_t \times \sum_{h=1}^{12} F\_NINA_{t-h}\right) + \beta_{rains}\left(\sum_{h=1}^{12} D_{i,t-h}^{n,\,rains}\right) + \beta_{droughts}\left(\sum_{h=1}^{12} D_{i,t-h}^{n,\,droughts}\right) + \varnothing GDP_{t-12} + \varepsilon_{i,t}$$

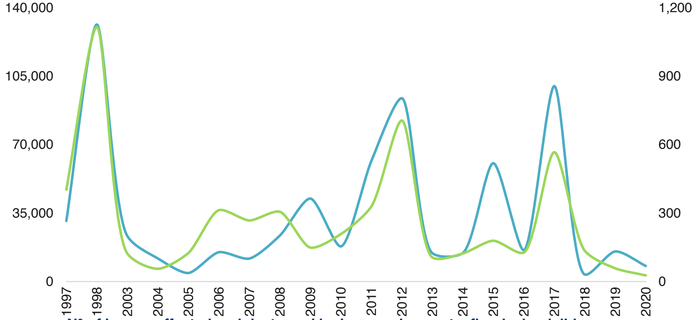
$$y_{i,t} = \ln\left(\frac{PD_{i,t}}{1 - PD_{i,t}}\right) \qquad D_{i,t}^{n,rains} = \begin{cases} 1 & if\ X_{i,t} > Percentile_n(X_i) \\ 0 & if\ X_{i,t} \le Percentile_n(X_i) \end{cases} \qquad D_{i,t}^{n,droughts} = \begin{cases} 1 & if\ X_{i,t} < Percentile_n(X_i) \\ 0 & if\ X_{i,t} \ge Percentile_n(X_i) \end{cases}$$

- ✓ $y_{i,t}$ is the transform observed PD.
- ✓ $D_{i,t-h}^{n}$ are dummy varibales that capture the occurerrence of atypical rains (heavy rains, droughts) in the district and period t. **Main impact in sectors (i) agriculture, (ii) transportation y communications and (iii) commerce.**
- ✓ X_t is a vector of **dummy variables** activated in period **t** if conditions for **El Niño** or **La Niña** in the **Niño 1+2 zone** are met. **Main impact in fishing sector.**

SBS climate risk stress-testing framework

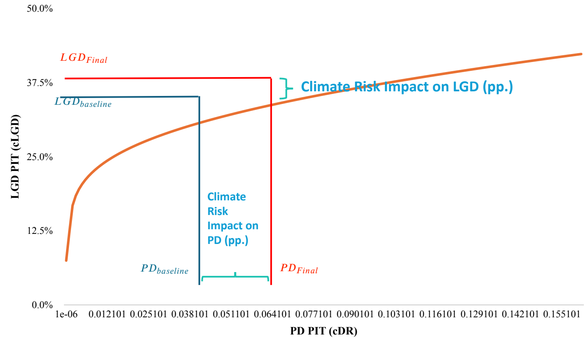


Residential real estate LGD: evidence of the negative impact of heavy rains on the state of housing in Peru



Source: INDECI, PERSIANN-CCS-CDR. Own elaboration.

Uncovered LGD: Relationship between cLGD and cDR (Frye-Jacobs methodology)

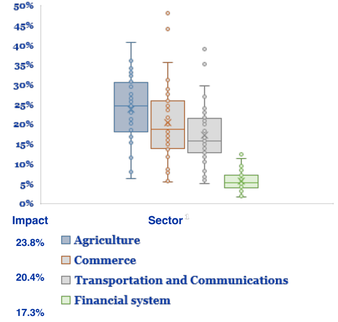


The calibration of the uncovered LGD impact was carried out separately by credit type, given the different correlation coefficients established by Basel III and proprietary calibrations, as well as by the cDR series (monthly IR)

5. SBS climate risk stress-testing: main results

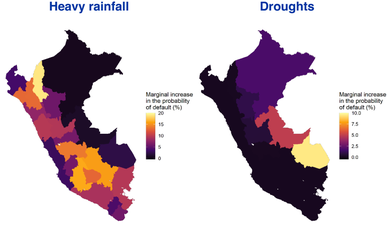
SBS climate risk stress-testing: PD outcomes (microeconomic channel - precipitations)

Marginal impact of extreme precipitations events on the PD of the Financial System by economic activity (% variation)



Source: Credit Bureau Data Report, SUNAT, Top 10mil, SPP, NOAA, CMIP6, NGFS.
Notes: Impact of the 30 CMIP6 models with information of 30-year horizon sea surface temperature predictions under the SSP5-8.5 scenario related to *fossil-fueled development* narrative. Own elaboration.

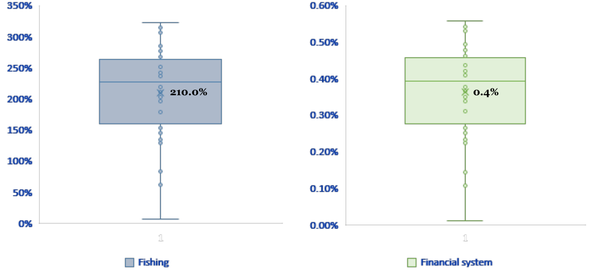
Marginal impact of extreme precipitations events on the PD of the Financial System by region (% variation)



Source: Credit Bureau Data Report, SUNAT, Top 10mil, SPP, NOAA, CMIP6, NGFS.

SBS climate risk stress-testing: PD outcomes (microeconomic channel – sea surface temperature)

Marginal impact of Sea Surface Temperature (SST) on the PD of the Financial System by CMIP6 model (%)



Source: Credit Bureau Data Report, SUNAT, Top 10mil, SPP, NOAA, CMIP6.
Notes: Impact of the 30 CMIP6 models with information of 30-year horizon sea surface temperature predictions under the SSP5-8.5 scenario related to *fossil-fueled development* narrative. Own elaboration.

SBS climate risk stress-testing: PD outcomes (macroeconomic channel - GDP)

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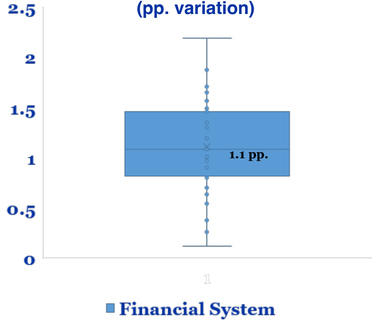
Impact of the GDP change on the PD under chronic physical risk

	Counter-factual	Medium chronic physical risk	High chronic physical risk	Impact -medium chronic physical risk	Impact - high chronic physical risk
Agriculture	-1.79%	-1.61%	-1.36%	0.19%	0.44%
Transportation and Communication	-5.81%	-5.20%	-4.40%	0.60%	1.41%
Commerce	-4.04%	-3.62%	-3.06%	0.42%	0.98%
Fishing	-2.54%	-2.28%	-1.92%	0.26%	0.62%
Others	-4.13%	-3.70%	-3.12%	0.43%	1.00%
Financial System	-4.10%	-3.67%	-3.10%	0.43%	1.00%

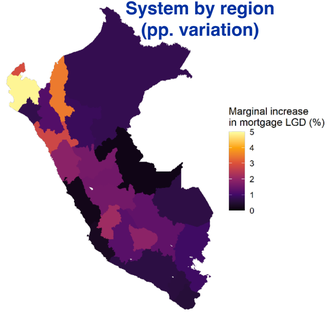
Source: Credit Bureau Data Report, SUNAT, Top 10mil, SPP, NOAA, CMIP6, NGFS.
Note: Average impacts on the GDP of Peru of the three IAM 30-year horizon projection and the damage function effect that incorporates chronic physical risk from the NGFS Phase IV *Current Policies* scenario. Own elaboration.

SBS climate risk stress-testing: LGD outcomes (residential real estate)

Marginal impact of heavy rainfall on the residential real estate LGD by CMIP6 model (pp. variation)



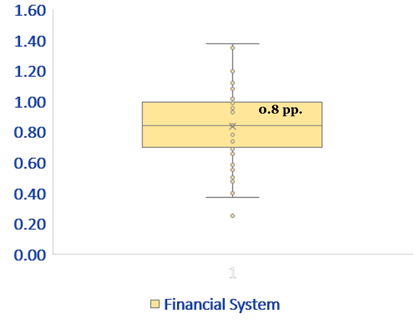
Marginal impact of heavy rainfall on the residential real estate LGD of the Financial System by region (pp. variation)



Source: Credit Bureau Data Report, SUNAT, Top 10mil, SPP, NOAA, CMIP6, INDECI.
Notes: Impact of the 37 CMIP6 models with information of 30-year horizon precipitation predictions under the SSP5-8.5 scenario related to fossil-fueled development narrative. Own elaboration.

SBS climate risk stress-testing: LGD outcomes (overall)

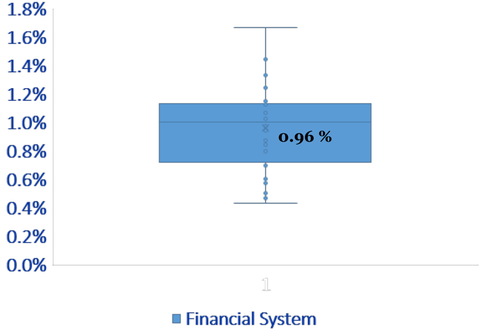
Marginal impact of heavy rainfall on the Aggregate LGD by CMIP6 model (pp. variation)



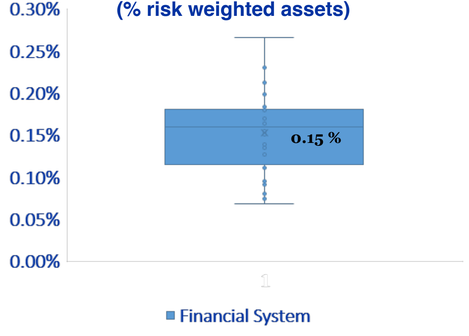
Source: Credit Bureau Data Report, SUNAT, Top 10mil, SPP, NOAA, CMIP6, INDECI.
Notes: Impact of the 37 CMIP6 models with information of 30-year horizon precipitation predictions under the SSP5-8.5 scenario related to fossil-fueled development narrative. Own elaboration.

SBS climate risk stress-testing: impact of loan loss provisions on regulatory capital and RWA

Increase in loan loss provisions due to climate risk on the Financial System by CMIP6 model (% regulatory capital)



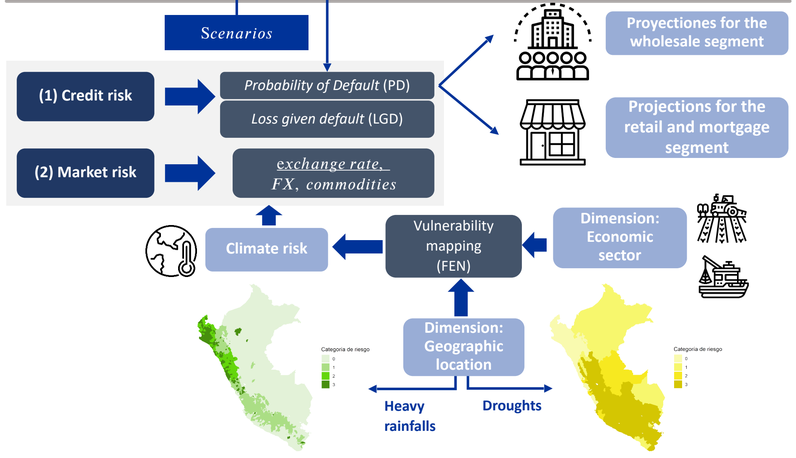
Increase in loan loss provisions due to climate risk on the Financial System by CMIP6 model (% risk weighted assets)



Source: Credit Bureau Data Report, SUNAT, Top 10mil, SPP, NOAA, CMIP6, INDECI, NGFS.
Notes: Impact of the 30 CMIP6 models with information of 30-year horizon precipitation and sea surface temperature predictions under the SSP5-8.5 scenario related to fossil-fueled development narrative. Average impacts on the GDP of Peru of the three IAM 30-year horizon projection and the damage function effect that incorporates high chronic physical risk from the NGFS Phase IV Current Policies scenario. Own elaboration.

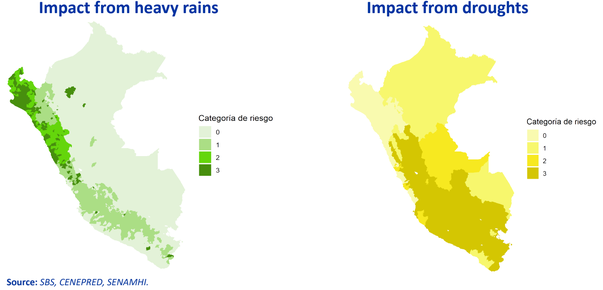
6. SBS solvency stress test: climate module improvement

SBS solvency stress test methodology



Regions highly susceptible to coastal FEN in the summer of 2024 were identified for the solvency stress test exercise as of September 2023

Vulnerability of Peru to the materialization of a coastal FEN in 2024, by geographic location

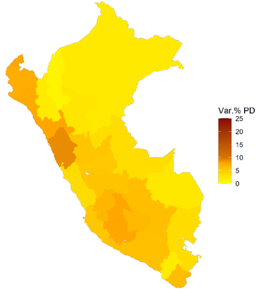


Source: *SBS, CENEPRED, SENAMHI.*

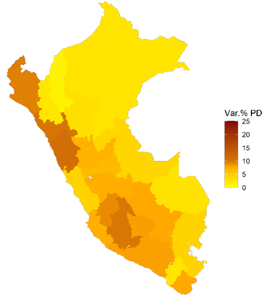
The possible **impact** of a **coastal FEN** on the **PD of the financial system** was calibrated based on (i) **geographic location** and (ii) the **economic sector**

Given the scenarios of coastal FEN occurrence in early 2024, differentiated impacts by geographic location were calibrated in September 2023 through the incorporation of the climate module into the SBS solvency stress test exercise

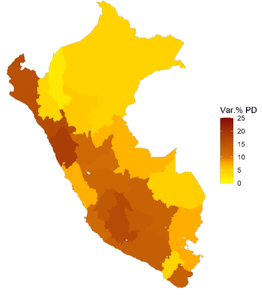
Strong Coastal FEN – additional impact to September 2024 (one year)[1/]



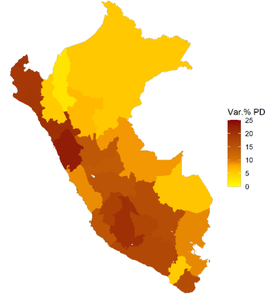
Strong Coastal FEN – additional impact to September 2024 (two year) [1/]



Longer duration strong coastal FEN – additional impact to September 2024 (one year) [1/]



Longer duration strong coastal FEN – additional impact to September 2024 (two year) [1/]



[1/] Impact of the strong coastal FEN recorded as the percentile variation compared to the occurrence of a moderate coastal FEN in the respective year.
Source: SBS, SENAMHI, CENEPRED