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Irene Alvarado Quesada
Jose Pablo Barquero Romero
Cristian Sancho Brenes

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Evaluación de la exposición del sector bancario a eventos hidrometeorológicos en Costa Rica

Irene Alvarado Quesada[†]

Jose Pablo Barquero Romero[†]

Cristian Sancho Brenes[‡]

Resumen

Este estudio examina por primera vez la exposición de la cartera crediticia del sistema bancario costarricense a eventos hidrometeorológicos, específicamente a eventos de exceso de lluvia, con un enfoque en el crédito de empresas a nivel cantonal. Proponemos un indicador de riesgo crediticio para identificar los cantones con las carteras de crédito más afectadas por eventos de lluvia. Además, incorporamos un enfoque novedoso que permite asignar una ubicación productiva única a aquellas empresas con dos o más establecimientos. Nuestros resultados muestran que los cantones con el mayor número de eventos de exceso de lluvia representan una proporción pequeña del saldo promedio de crédito del país. Además, observamos que los tres cantones con la puntuación de riesgo crediticio más alta están impulsados por actividades económicas que no se espera que sean particularmente vulnerables a eventos de lluvia excesiva.

Palabras clave: eventos hidrometeorológicos, riesgos físicos, sector bancario, riesgo crediticio

Clasificación JEL: Q54, G21, G28

[†] Departamento de Investigación Económica. División Económica, BCCR. alvaradoqi@bccr.fi.cr

[†] Departamento de Investigación Económica. División Económica, BCCR. barquerorj@bccr.fi.cr

[‡] Departamento de Gobierno y Gestión de Datos. División Análisis de Datos y Estadísticas, BCCR. sanchobc@bccr.fi.cr

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Irene Alvarado-Quesada[†]

Jose Pablo Barquero-Romero[†]

Cristian Sancho-Brenes[‡]

Abstract

This study examines, for the first time, the exposure of the credit portfolio of the banking system in Costa Rica to hydrometeorological events, specifically excess rainfall events, with a focus on firm credit at the canton level. We propose a credit risk indicator to identify cantons with credit portfolios that are more affected by rainfall events. Moreover, we introduce a novel approach with respect to firm level data to assign a single productive location to firms with two or more establishments. We find that cantons with the highest number of excess rainfall events represent a small share of the average credit balance of the country. Furthermore, we observe that the top three cantons with the highest credit risk score are driven by economic activities that are not expected to be notably vulnerable to extreme rainfall.

Key words: hydrometeorological events, physical risks, banking sector, credit risk

JEL codes: Q54, G21, G28

[†] Department of Economic Research, Economic Division, BCCR. Email address: alvaradoqi@bccr.fi.cr

[†] Department of Economic Research, Economic Division, BCCR. Email address: barquerorj@bccr.fi.cr

[‡] Department of Data Governance and Management, Division of Data Analysis and Statistics, BCCR. Email address: sanchobc@bccr.fi.cr

1. Introduction

Climate risks can impact financial stability and interfere with monetary policy transmission channels and price stability (NGFS 2019a, Bernardini et al. 2021, Romero & Naranjo-Saldarriaga 2024). The Network for Greening the Financial System (NGFS 2019) defines physical risks as the economic costs and financial losses resulting from the increasing severity and frequency of extreme climate change-related weather events (e.g., floods, storms) as well as longer term progressive shifts of the climate (e.g., changes in precipitation patterns, extreme weather variability). Physical risks can affect the economy via i) acute impacts caused by extreme weather events that can lead to business disruption, damages to properties, reduction of agricultural yield or of labor productivity, consequently leading to lower insurance coverage and impair asset values, and ii) chronic impacts, mainly resulting from increased temperatures, with an effect on labor, capital, land, and natural capital (NGFS 2023, NGFS 2023a).

Disruption in rainfall patterns and extreme floods are examples of physical risks associated with climate change. As global temperatures rise, the capacity of the atmosphere to hold water increases, leading to more frequent and intense precipitation (Rahat, S.H. et al. 2024). This could lead to a projected rise of 25 to 65 percent in economic damages for the period 1980 to 2080 (Winsemius et al. 2013), in addition to increased fatalities and the proliferation of waterborne pathogens that can cause severe diseases (European Commission 2023). These outcomes highlight the importance of estimating the economic effects of hydrometeorological events such as excess rainfall.

From a microeconomic perspective, climate-related physical risks can damage or destroy physical capital of households, firms, and governments, thereby reducing their asset values. Specifically, credit risk increases if climate risks reduce borrowers' ability to repay and service debt or banks' ability to fully recover the value of a loan in the event of default (NGFS 2019, BCBS 2021, ECB 2023). Pelka et al. (2015), de Roux (2021) and Aguilar-Gomez et al. (2024) provide examples of how extreme weather events affect credit exposure and performance. De Roux (2021) links coffee producers' credit scores and repayment rates in Colombia to rainfall data from nearby stations, finding that while producers' incomes and repayment capacity recover quickly from weather shocks, their credit access does not. Similarly, Pelka et al. (2015) analyze the effect of excessive rainfall on farmer loan repayment in Madagascar, indicating that excessive rainfall during the harvest period increases the credit risk for small-scale farmers.

From a macroeconomic perspective, physical risks can have negative impacts in labor productivity, GDP growth, government debt and socioeconomic equity (BCBS 2021a). Therefore, understanding the structural impact of physical risks on the economy and on the financial system is crucial for central banks to achieve their mandates.

In this paper, we examine the exposure of the credit portfolio of the banking system in Costa Rica to hydrometeorological events, specifically excess rainfall events, with a focus on firm credit at the canton level. We propose a credit risk indicator to identify cantons with credit portfolios that are more affected by rainfall events. We use monthly rainfall data by canton from January 2001 to December 2021, monthly credit data covering nearly 50% of Costa

Rica's banking system (and nearly 39% of its financial system) from December 2019 to December 2021, and firm characteristics data available since 2000.

To measure credit exposure to excess rainfall, we build on ECB (2023) and develop a credit risk indicator with three dimensions to assign a risk score to each canton. For the physical hazard dimension, we define an excess rainfall event as any instance where a canton experiences monthly rainfall levels at or above the canton's monthly average plus two standard deviations. We validate our methodology by comparing it with the approaches of Felbermayr et al. (2022) and de Roux (2021) and focus on six of the top ten cantons with the highest number of excess rainfall events. For the asset exposure dimension, we introduce a novel procedure that assigns a single productive location per province, canton, and district to all economic units and then links the average monthly credit data to firms based on their location. Finally, the geolocation dimension is addressed by incorporating the location-specific aspects of the previous dimensions.

We find that, in five out of the six selected cantons with the highest number of excess rainfall events, the economic activity with the largest share of average credit allocation coincides with one of their top three main economic activities. Some key economic activities of these cantons such as Agriculture, and Transportation and Storage, may face risks from excess rainfall, including declines in production and increased credit default. However, the six cantons under study account for only a small share of the average credit balance and other major financial indicators within our sample. Additionally, the top three cantons with the highest credit risk scores are located in the metropolitan area feature main economic activities such as Information and communication, and Real estate activities. Given these conditions, these cantons are not expected to be highly vulnerable to excess rainfall events.

Our research makes several contributions to the existing literature on the impact of rainfall-related shocks on credit exposure and performance. While prior studies such as de Roux (2021) and Pelka et al. (2015) have examined specific instances of how weather shocks affect credit access and scores for farmers, our study broadens this perspective by focusing on nearly half of Costa Rica's total banking credit portfolio. Additionally, by leveraging data from Costa Rica's cantonal GDP, we can compare credit allocation across cantons and assess how these allocations align with the main economic activities driving regional growth.

Finally, this paper offers new insight into the innovative approach of assigning a single productive location per province, canton, and district to all economic units or firms, which is is particularly relevant for economic units with multiple establishments (locations). To our knowledge, this is the first study to assess exposure of the financial system to hydrometeorological events in Costa Rica. At the same time, it supports the efforts of the Central Bank of Costa Rica (BCCR) to develop robust, granular information to assist the future development of climate-focused stress testing frameworks.

The paper is organized as follows: Section 2 discusses methodological and empirical approach of our study, the dataset that we use and the global importance allocation procedure for economic units. Section 3 presents the findings on overall credit information, production, and credit indicators for the selected sample of cantons with high number of excess rainfall events and the credit risk indicator, while Section 4 concludes by summarizing the main results.

2. Data and methodological approach

We assess risk exposure of the credit portfolio of close to 50% of the banking system of Costa Rica to excess rainfall events. We do so by calculating a credit risk indicator that associates rainfall data by canton to credit location at the economic unit level.

We follow ECB (2023)'s proposal of an analytical indicator of physical risks. We focus on three of the four dimensions that compose such indicators: physical hazards, exposure of assets, and geolocation. The dataset that we use includes: i) monthly credit data available from December 2019 to December 2021, covering 38.8% of the total credits of the financial system (and 49.6% of the banking system), ii) monthly rainfall data (in millimeters) at the canton[1] level from January 2001 to December 2021, and iii) firms characteristics information available since the year 2000. This dataset is part of the Environmental Economic Repository of the BCCR[2].

2.1. Physical hazard dimension

To address the physical hazard component of the credit risk indicator, we use rainfall data from the National Meteorological Institute (IMN) (see Figure A1 in Appendix A) to construct a proxy indicator for excess rainfall events. Firstly, we calculate the average precipitation and the standard deviation observed in each canton for a given month (e.g., the average precipitation and standard deviation in the canton of Turrialba for the months of January during the period 2001-2021). Secondly, we identify all observations (number of months) by canton in which rainfall values are equal or greater than the canton's monthly average plus two standard deviations:

$$Indicator_{i,m,y} = \frac{observed\_precipitation_{i,m,y} - average\_precipitation_{i,m}}{standard\_deviation\_precipitation_{i,m}}, \quad (1)$$

$$n_i = \sum Indicator_{i,m,y} \geq 2 \quad (2)$$

Where, i stands for canton, m stands for month, y stands for year, and n is the number of times canton i exceeds the rule of the indicator.

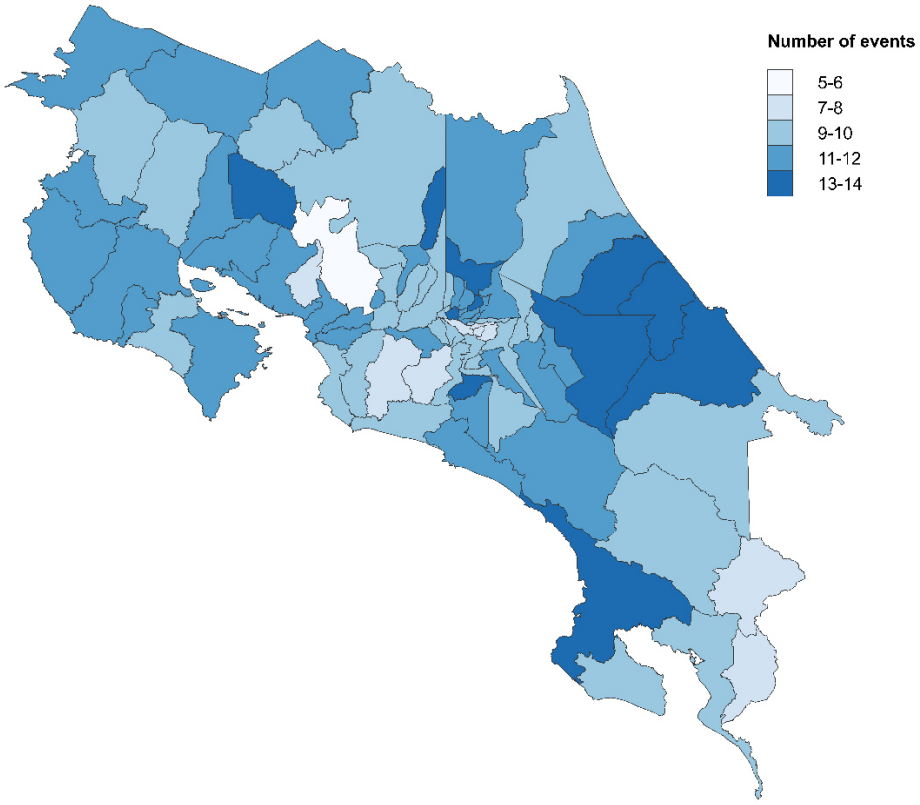
We define an *excess rainfall event* as any observation (i.e., month) in the dataset in which a canton shows monthly rainfall levels equal or above its own canton's monthly average plus two standard deviations. This methodology makes the intensity of rainfall comparable between cantons since all the metrics are in relative values based on mean and volatility.

[1] This study uses information of 82 out of the 84 cantons of Costa Rica. Until 2021, there were only 82 cantons, and the additional two, namely: Monteverde and Puerto Jiménez, are of recent creation.

[2] This repository was created as a response to increasing demands to develop macroeconomic and financial analyses with climate considerations. Its aim is to include, in the long run, environmental, climate and economic indicators at different sectoral and geographical levels.

For this study we focus positive or excess rainfall events since these types of anomalies can cause extensive and rapid damage more frequently[3]. The maximum number of excess rainfall events registered per canton during the period 2001-2021 is 14, while the minimum is 5.

Figure 1. Number of excess rainfall events by canton, 2001-2021



Notes: The figure shows the number of excess rainfall events per canton during the period 2001-2021 in Costa Rica. The lowest category of excess rainfall events includes cantons that register 5 or 6 events (in white), while the highest category includes cantons that register 13 or 14 events (in dark blue).

Source: Central Bank of Costa Rica with data from the IMN.

In total, 10 out of 82 cantons belong to the highest category of extreme rainfall events illustrated in Figure 1 (dark blue), each registering 13 or 14 excess rainfall events for the study period.

[3] We also calculated the number of months in the dataset in which a canton showed monthly rainfall levels equal or lower than its own canton's monthly average minus two standard deviations (i.e., rainfall shortage events). However, the results were not robust enough to add significant information to the analysis proposed in this paper.

Table 1. Top ten cantons by excess rainfall events, 2001-2021

	Canton	Degree of urbanization	Number of events
1	León Cortés	Predominantly rural	14
2	Siquirres	Predominantly rural	14
3	Matina	Rural	14
4	Río Cuarto	Predominantly rural	13
5	Turrialba	Predominantly rural	13
6	Heredia	Predominantly urban	13
7	San Isidro	Predominantly urban	13
8	Tilarán	Predominantly rural	13
9	Osa	Predominantly rural	13
10	Limón	Predominantly rural	13

Notes: The table displays the ten cantons of Costa Rica with the highest number of excess rainfall events registered during 2001-2021. The degree of urbanization of a canton is an average of the degree of urbanization of the different districts that comprise it, which are categorized in urban, predominantly urban, predominantly rural, and rural, according to the National Institute of Statistics and Census (INEC).

Source: Central Bank of Costa Rica with data from IMN and INEC.

We compared our methodology with that of Felbermayr et al. (2022) to assess robustness, and we found that nine out of the ten cantons that register the highest number of excess rainfall events coincide with those presented in Table 1 (See Table A2 of Appendix A). Additionally, we attempt a comparison with de Roux (2021). However, the methodology proposed by de Roux to account for the impact of rainfall events on loan performance poses challenges for our dataset. Specifically, the definition of 'rainfall shocks' in their study is restrictive for ours, as we currently cannot isolate and track only new loans in our sample. To address this, we applied a similar definition of extreme weather events to the entire loan sample. Yet, the results remain inconclusive.

In terms of total number of excess rainfall events per month for Costa Rica, we observe a distinct clustering of events primarily within the first decade of the sample period, with notably heightened rainfall excess observed between 2008 and 2011 (see Figure A2 in Appendix A). Moreover, when we consider intensity (proportion of total rainfall by canton that occurred during excess rainfall events) and persistence (occurrence of three or more consecutive excess events within a period of three-four months), we observe that six cantons located within the province of Heredia feature in the top ten ranking for both metrics (see Appendix B).

For the analysis of this paper, we focus on six cantons with the highest number of excess rainfall events, as identified by both our proposed methodology and the approach of Felbermayr et al. (2022). These cantons are León Cortés, Siquirres, Matina, Turrialba, Heredia, and Limón. We selected these six cantons following two criteria:

a. We chose the three cantons that, according to our methodology, display the maximum number of excess rainfall events for the period of study (14 events), namely: León Cortés, Siquirres, and Matina (see Table 1).
b. When we use our methodology to define excess rainfall events, but this time only for the period 2011-2021, five of the ten cantons of Table 1 are still ranked as those with the highest number of events: Siquirres, Matina, Turrialba, Heredia, and Limón[4].

2.2. Asset exposure dimension

To address the asset exposure component of the credit risk indicator, we use the monthly credit data of the Environmental Economic Repository, and we link it to economic units at any given location.

One of the main sources of information about firms is the Registry of Economic Variables (Revec) of the BCCR. This is a statistical registry whose purpose is to supply harmonized, updated data in a continuous and accurate way, of establishments, firms and business groups located in the country, at least in terms of characteristics such as identification, location, main economic activity, number of workers and income[5].

By using information from Revec, specifically data on firms' employment and sales, it is possible to approximate the total firm production conducted at each location and therefore the exposure of banks' credit portfolios to vulnerable industries and regions. This is called the global importance of economic units by location, and it is used to assign a productive location to all economic units per province, canton, and district. This approximation is particularly relevant for economic units with several establishments (locations) (see Appendix C for more detail). While it is possible to assign productive locations at the district level, this study is restricted to the cantonal scale due to the availability of rainfall data only at the canton level.

Finally, given that the two previous dimensions are location specific, we combine them and construct a credit risk indicator that allows us to rank all cantons according to their credit risk score.

3. Results

In this section we show credit results by location and economic activity, as well as detailed information concerning production and credits in a sample of cantons that have experienced excess rainfall events. Then, for these cantons we show the relevance of the allocated loans

[4] When using our methodology to count excess rainfall events for the period January 2011-December 2021, the maximum number of excess rainfall events that occurred in a canton were 10. Turrialba recorded 10 events, —*Heredia, Limón*, Pococí, and Zarcero—each recorded 9 events, and ten cantons, including *Siquirres and Matina*, each recorded 8 events.

[5] Revec's starting point is the data and information on natural or legal persons (legal units) from administrative records and databases of public and private institutions, or from interviews and consultations directly carried out by the BCCR to samples of legal units during the implementation of various periodic surveys.

in the main accounts of the financial institutions included in the analysis. Finally, we propose a credit risk indicator to assess the impact of excess rainfall events on the financial system.

3.1. Credit information

To start, we analyze the amount of credit allocated to each canton. We first explore the ten cantons with the largest average share of loans of the sample for the period December 2019-December 2021. The canton with the largest credit allocation is San José, which is also the capital city of Costa Rica and the most populous one.

Table 2. Top ten cantons by average credit balance and share of banks' assets, December 2019 – December 2021

	Canton	Degree of urbanization	Average credit balance	Share of banks' assets
			million CRC	*%*
1	San José	Urban	2 204 461.8	28.80
2	Alajuela	Predominantly urban	532 931.1	6.96
3	Heredia	Predominantly urban	433 169.3	5.66
4	Escazú	Predominantly urban	387 599.5	5.06
5	Santa Ana	Predominantly urban	317 035.5	4.14
6	San Carlos	Predominantly rural	269 726.1	3.52
7	Goicoechea	Predominantly urban	206 447.5	2.70
8	Cartago	Predominantly urban	191 312.0	2.50
9	Montes de Oca	Urban	176 695.5	2.31
10	Desamparados	Predominantly urban	174 741.6	2.28
	Total		**4 894 120.0**	**63.94**

Notes: The table displays the ten cantons of Costa Rica with the largest average credit balance from December 2019 to December 2021, as well the cantons' credit share with respect to the total average assets of the sample (last column). The degree of urbanization of a canton is an average of the degree of urbanization of the different districts that comprise it, which are categorized in urban, predominantly urban, predominantly rural, and rural, according to the National Institute of Statistics and Census (INEC).

Source: Central Bank of Costa Rica with data from INEC.

In the top ten, San José is followed by eight other cantons located in (predominantly) urban regions while there is only one canton that is predominantly rural (San Carlos). These cantons capture around 64% of the average loans of our sample of banks. In contrast, the ten cantons with the smallest share of average loans are in predominantly rural regions and capture just 0.55% of the average loans of the sample (see Table A3 in Appendix A).

In terms of credit by economic activity it is important to highlight that the second largest share of loans is given to households not performing economic activities but using them for

consumption and mortgages. These account on average for 17.8% of all credits in the sample (Table 3). The rest of the loans are given to economic units (average of 82.2%)[6]. In that group, the most important activities are financial and insurance activities, trade, real estate activities, professional and healthcare activities as well as agriculture, transportation, and construction. Also, an average 15.7% of all loans are given to economic units that perform multiple economic activities[7].

Table 3. Average credit balance and share of banks' assets by economic activity and households, December 2019 – December 2021

Economic activity	Average credit balance	Share of banks' assets
	million CRC	*%*
N.A.	1 850 593.2	24.16
Credit assigned to households	1 366 313.8	17.84
Multiple economic activities	1 199 098.6	15.66
Financial and insurance activities	757 894.8	9.90
Wholesale and retail trade; repair of motor vehicles and motorcycles	468 670.4	6.12
Real estate activities	326 720.8	4.27
Professional, scientific, and technical activities	316 289.7	4.13
Human health care and social assistance activities	185 182.9	2.42
Agriculture, forestry and fishing	162 982.1	2.13
Transportation and storage	128 678.9	1.68
Construction	127 940.3	1.67
Accommodation and meal service activities	121 554.0	1.59
Manufacturing industries	116 927.7	1.53
Rest of activities	529 420.7	6.91
Total	**7 658 267.9**	**100**

Notes: The table shows the average credit balance by economic activity and households from December 2019 to December 2021, as well as the credit share by economic activity with respect to the total average assets of the sample (last column). An average 82.2% of all credits is assigned to economic units (i.e., firms), while the remaining percentage (avg. 17.8%) is assigned to households. Credits assigned to economic units for which an economic activity is not available are found under the description 'N.A.'. Credits assigned to economic units with more than one economic activity are found under the description 'Multiple economic activities'.

Source: Central Bank of Costa Rica.

[6] With the information available to the BCCR at the time of this publication, it was not possible to assign an economic activity to an average 24.2% of the loans.

[7] Table A4 of Appendix A presents a table with the average credit balance and share of banks' assets for a disaggregated list of economic activities.

3.2. Credit and production indicators for selected cantons

We focus our analysis on a sample of six cantons that have experienced the highest number of excess rainfall events, as described in Section 2.1: León Cortés, Siquirres, Matina, Turrialba, Heredia, and Limón. We find that the share of average credit allocated to households in these cantons with respect to their average credit balance varies between 14.2% and 30%. The only exception is Matina, where the average credit associated to households represents only 6.9% of the canton's average credit balance. In terms of average credit balance corresponding to economic units conducting one or more economic activity, Matina holds the largest share (63.7%), followed by Siquirres (53.3%) and Heredia (48.5%).

Table 4. Credit indicators for selected cantons, December 2019 – December 2021

Credit indicator by canton	Unit	León Cortés	Siquirres	Matina	Turrialba	Heredia	Limón
Average credit balance	*million CRC*	4 156.1	16 081.7	14 690.2	37 069.3	433 169.3	56 829.6
Share of average household credit relative to average credit balance	*%*	29.7	18.0	6.9	14.2	29.5	23.8
Share of average credit of economic units with one economic activity relative to average credit balance	*%*	31.0	51.8	52.3	39.9	20.6	39.1
Share of average credit of economic units with multiple economic activities relative to average credit balance	*%*	1.7	1.6	11.4	2.5	28.0	3.3
Share of average credit of economic units with unavailable economic activity relative to average credit balance	*%*	37.6	28.7	29.4	43.4	21.9	33.8

Notes: The table displays a selection of credit indicators for six of the ten cantons of Costa Rica with the highest number of excess rainfall events, covering the period from December 2019 to December 2021. We note some economic units (i.e., firms) lack an assigned economic activity. Credits allocated to these economic units are listed under the category 'Share of average credit of economic units with unavailable economic activity relative to average credit balance'.

Source: Central Bank of Costa Rica.

As for production indicators, we analyze each canton separately[8]. Of all six cantons, ***León Cortés*** has the lowest average gross value added (GVA) for the study period (67 810.4 million CRC). The canton's main economic activity section is "D- Electricity, gas, steam and air conditioning supply", accounting for an average 41.3% of its GVA. It is followed, but not closely, by "A- Agriculture, forestry and fishing" (avg. 16.2% of GVA) and by "P- Education" (avg. 15.1% of GVA).

Alternatively, ***Siquirres***' main economic activity section is "A- Agriculture, forestry and fishing", accounting for an average 27.9% of its GVA and mainly driven by banana cultivation. The economic activity section that holds the largest share of Siquirres' average credit balance corresponds to "C- Manufacturing" with 14.2%. This section coincides with Siquirres' third most important economic activity section.

Matina is the only selected canton that, according to its degree of urbanization, is cataloged as rural. More than half of its average GVA comes from the economic activity section "A- Agriculture, forestry and fishing" (57.5%), which is also mainly derived from banana cultivation. Its following top economic activities, "P- Education" and "B- Mining and quarrying", represent less than an average 10% of GVA each (8.9% and 5.7%, respectively).

Matina's main economic activity section coincides with the economic activity that holds the largest share of average credit balance. Moreover, its share ("A- Agriculture, forestry and fishing", 45.9%) represents the largest share of average credit balance of an economic activity section from all five selected cantons.

The main economic activity section of ***Turrialba*** is "G- Wholesale and retail trade" with an average 14.9% of its GVA, followed closely by "P-Education" with an average 14.1%. Like Matina, the main economic activity in Turrialba also aligns with the economic activity receiving the largest share of its average credit balance, representing 7.2% of the total. Notably, Turrialba has the highest share of its average credit balance allocated to firms for which no specific economic activity can be assigned, averaging 43.4%.

Heredia, a predominantly urban canton, holds the highest average gross value added of the five selected cantons (1 982 669.6 million CRC). Its three main economic activity sections are similar when considering their participation in the average GVA of the canton: "C- Manufacturing" with an avg. 13.6%, "J- Information and communication" with an avg.13.1%, and "M- Professional, scientific and technical activities" with an avg. 13.0%.

Unlike the other selected cantons, Heredia has the largest share of average credit attributed to economic units with multiple economic activities, accounting for 28% of its average credit balance, whereas for the rest of the selected cantons this indicator stands between 1.6% and 11.4%. The economic activity section of Heredia with the largest share of credits represents only 3.5% of its average credit balance (i.e., "G- Wholesale and retail trade").

Finally, the top three economic activity sections of ***Limón*** also have comparable average participations with respect to the canton's average GVA: "G- Wholesale and retail trade"

[8] See Tables A5-A10 (Appendix A) for detailed production indicators of the selected six cantons of Costa Rica with the highest number of excess rainfall events.

accounts for 14.8%, “H- Transportation and storage” accounts for 13.2%, and “P-Education” accounts for 12.5%.

Our initial hypothesis when analyzing credit and production of the selected cantons with extreme rainfall events is that i) credits located in areas prone to excess rainfall and ii) with a direct association to economic activities such as infrastructure and agriculture, may have a higher risk of default.

Infrastructure is a key input for all economic activities. Damages in infrastructure due to excess rainfall could affect most if not all economic activities. Yet, it is difficult to differentiate the impacts of excess rainfall among cantons, let alone assess the potential damage to infrastructure *a priori*, without knowing the magnitude and duration of the anomaly. Limón could be most affected by damages in land and water infrastructure caused by excess rainfall: the economic activity that has the largest share of average credit balance, namely “H- Transportation and storage” with 13.9%, is also the second most important economic activity of the canton, accounting for 13.2% of its average GVA.

As for agriculture, we observe two cantons that are predominantly agricultural: Matina (avg. 57.5% of GVA) and Siquirres (avg. 27.9 % of GVA). In terms of credit distribution, they show important differences: Matina’s largest share of its average credit balance is attributed to agricultural activities (avg. 45.9%), whereas Siquirres’ largest share goes to manufacturing industries (avg. 14.2%). Given these characteristics, excess rainfall events affecting both cantons could have a larger impact on Matina than on Siquirres. This outcome can be expected not only because of the weight of agriculture over Matina’s average GVA, but also due to its large share of credits associated to agriculture as compared with Siquirres (45.9% vs 3.7%, respectively).

In addition to these cantons, the largest share of average credit balance of León Cortés is associated to “A- Agriculture, forestry and fishing” activities, accounting for 15.0%. This is the second largest sector in economic relevance of León Cortés, representing an average 16.2% of its GVA. Even though this sector is less than half of the main economic sector of the canton, it can still reflect a potential material exposure to excess rainfall events.

3.3. Exposure of the financial system

We also study the relative importance of credits allocated to the selected cantons with high number of excess rainfall events with respect to the main accounts of our banks’ sample. If we compare the number of credits for the cantons with excess rainfall, they represent on average around 0.2% of total assets and less than 0.4% of the non-delinquent loan portfolio. When it comes to equity, they do represent a higher percentage (1.8%) but is still relatively low.

Table 5. Credit balance for selected cantons as a percentage of main financial indicators, December 2019 – December 2021

Main accounts	Credit in selected cantons as percentage of accounts		
	Average (%)	*Max (%)*	*Min (%)*
Total assets	0.22	0.35	0.10
Loan portfolio (up to date and overdue up to 90 days)	0.38	0.68	0.15
Adjusted equity	1.79	3.46	0.93

Notes: The table illustrates the relevance of the credit allocated to the six selected cantons with the highest number of excess rainfall events —León Cortés, Siquirres, Matina, Turrialba, Heredia, and Limón— in relation to (a) total assets, (b) loan portfolio, and (c) adjusted equity within the banks' sample studied.

Source: Central Bank of Costa Rica.

We conclude that the banks analyzed in this paper do not have a significant risk exposure in their balances derived from excess rainfall events. This is due to two main reasons. Firstly, credits granted in the cantons with the highest exposure are not allocated to activities that historically show the greatest damages from these types of events. Secondly, the total credits in the selected cantons do not represent a substantial amount of the banks' assets, loans, or equity. However, we need to highlight that these results are a picture in time: they do not show a trend for these indicators.

3.4. Credit risk indicator

To identify the exposure of the financial system to excess rainfall events at canton level, we develop a preliminary credit risk indicator composed of three dimensions: physical hazards (i.e., excess rainfall events), asset exposure (i.e., average credit balance) and geolocation (both rainfall and credit balance data are georeferenced).

Following up on equation (1) and (2), we define a physical hazard indicator, PHI_i, as the share of excess rainfall events of canton i with respect to the total excess rainfall events of the country for the period 2001 – 2021:

$$PHI_i = \frac{n_i}{N}; \tag{3}$$

$$N = \sum_i n \tag{4}$$

Where n_i is the number excess rainfall events of canton i, and N is the sum of all excess rainfall events of all cantons.

We then define an asset exposure indicator, AEI_i, as the share of average credit balance of canton i with respect to the total average credit balance of the sample for the period 2019 – 2021:

(5) $$AEI_i = \frac{c_i}{C};$$

(6) $$C = \sum_i c$$

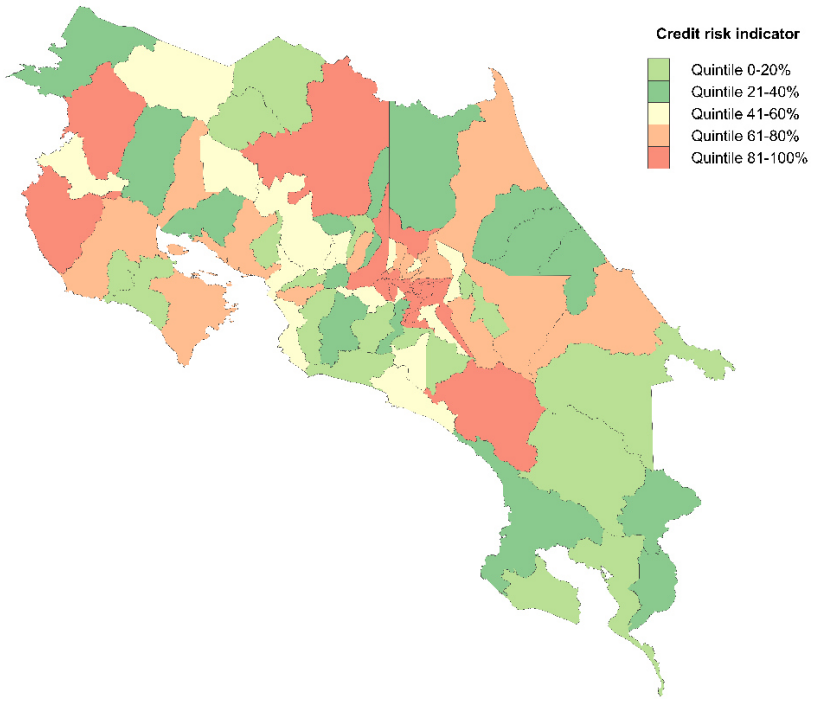
Where c_i is the average credit balance of canton i, and C is the total average credit balance of the sample.

To create an indicator that summarizes our results, we multiply the physical hazard indicator by the asset exposure indicator, resulting in a credit risk indicator of canton i:

(7) $$CRI_i = PHI_i \cdot AEI_i$$

Where $1 \geq CRI_i \geq 0$.

Figure 2. Credit risk indicator by canton



Notes: The figure shows the 82 cantons of Costa Rica by quintile according to the value of their credit risk indicator (CRI). The first quintile (0-20%) represents the lowest 1/5 of the range of values of the CRI and includes 17 cantons (in light green), while the fifth quintile (81-100%) represents the highest 1/5 of the range of values of the CRI, also including 17 cantons (in red). We observe that the cantons with the highest CRI value are predominantly located in the Great Metropolitan Area, with exceptions such as Liberia, Santa Cruz, San Carlos, and Pérez Zeledón.

Source: Central Bank of Costa Rica.

We arrange the cantons by quintiles according to the results of the credit risk indicator (see Table A11 in Appendix A). We find that the fifth quintile with the highest 1/5 values of the CRI includes 17 cantons. The top three cantons according to their CRI value are: San José ($CRI = 0.0027$), Heredia ($CRI = 0.0009$), and Alajuela ($CRI = 0.0008$).

San José's average credit balance accounts for 28.8% of the average credit balance of the sample (2 204.5 billion CRC). Its main economic activity section is "Q- Human health and social work activities" (avg. 14.6% of GVA), and its largest share of average credit balance is associated with "K- Financial and insurance activities" (29.6%).

Heredia and Alajuela follow San José, with an average credit balance of 5.7% and 7.0%, of the total credit balance of the sample, respectively. The main economic activity section for both cantons is "C-Manufacturing". Manufacturing activities account for an average 13.6% of Heredia's GVA and for almost half of Alajuela's GVA (avg. 49.3%). Furthermore, for both cantons, "G- Wholesale and retail trade" is the economic activity section with the highest share of average credit balance (3.5% and 5.7% for Heredia and Alajuela, respectively). Furthermore, Alajuela also has a large share of average credit attributed to economic units with multiple economic activities (28.2% of avg. credit balance).

These three cantons are in the metropolitan area of the country. Therefore, when we consider the asset exposure component to assess credit risk in addition to the number of excess rainfall events, we observe that higher credit risk is in the central valley of Costa Rica and in predominantly urban cantons. Furthermore, the production of these cantons is not highly associated with agricultural activities, but instead with manufacturing, human health care and social assistance, financial and insurance activities, and trade.

4. Concluding remarks and policy implications

We find that five out of the six selected cantons that experienced the highest number of excess rainfall events display a coincidence between the economic activity with the largest share of average credit allocation and one of their top three main economic activities. We identify that some key economic activities of these cantons, such as Agriculture and Transportation and Storage, could be severely impacted by excess rainfall events. Therefore, if an event would take place in cantons highly driven by these activities, both their production as well as the potential credit payment capacity could be negatively affected. However, when we analyze overall credit, we observe that the sum of credits of the selected cantons only represents 7.4% of the average credit balance of the sample. Moreover, when Heredia is excluded from the sum, this share is reduced to 1.7%.

The results of the proposed credit risk indicator show that the top three cantons of Costa Rica with the highest credit risk score are in the metropolitan area of the country: namely San José, Heredia, and Alajuela. This result is mostly driven by the share of credits allocated to these regions, except for Heredia that also displays a high number of excess rainfall events throughout the period of study. Yet, the main economic activities of these cantons, (e.g., Information and communication, Real estate activities, and Financial and insurance activities, among others) are not severely exposed to excess rainfall events as others economic activities related to agriculture and infrastructure.

Future research should explore the indirect economic impacts of extreme rainfall by examining connections between economic activities and using network analysis to understand credit exposure among neighboring regions. Incorporating a vulnerability component into credit risk indicators and analyzing extreme weather events, such as hurricanes and ENSO, would improve risk assessments. Additionally, expanding the study's sample size to cover a larger portion of the financial system and regularly updating it to reflect evolving climate patterns is recommended for a more comprehensive analysis.

5. Acknowledgements

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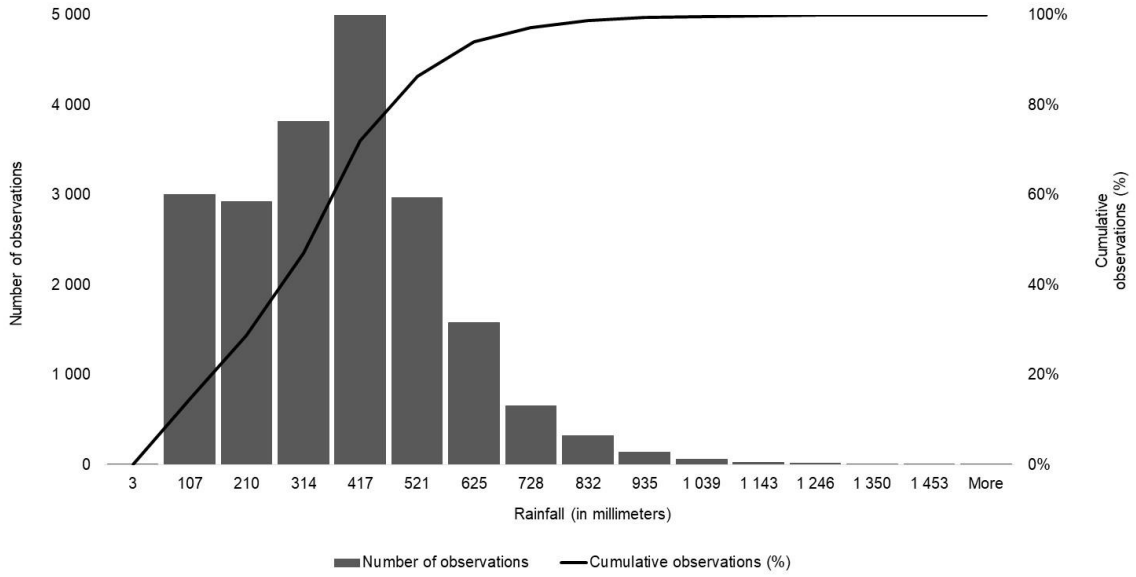
Appendix

A. Figures and tables

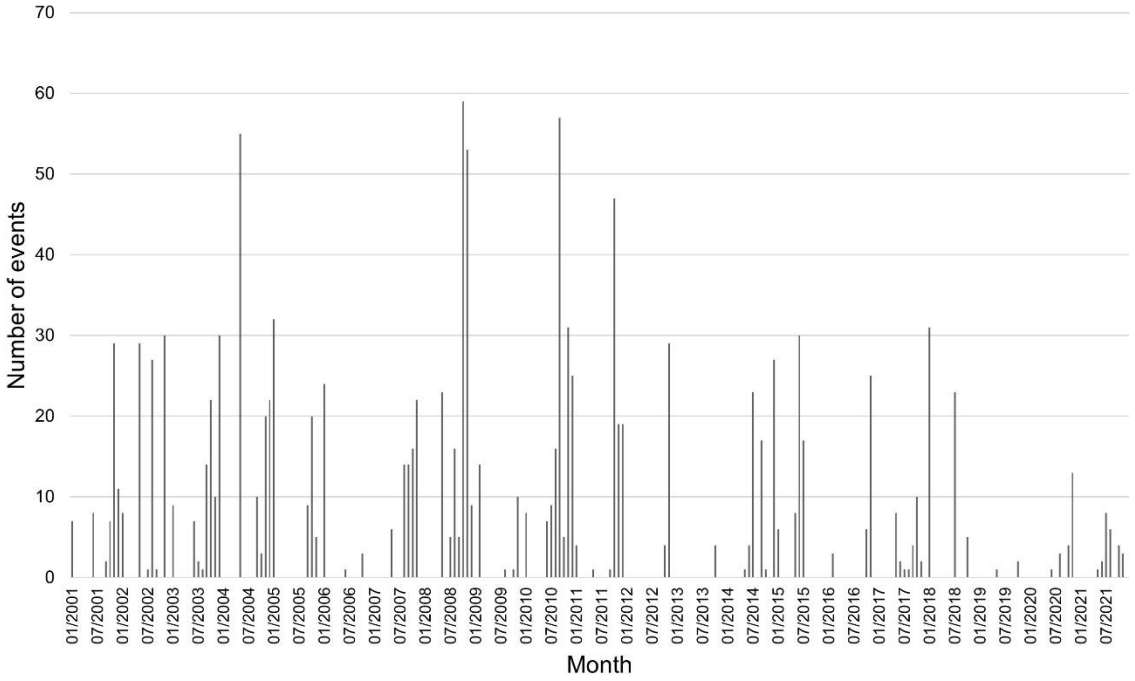
Figure A1. Histogram- Rainfall in Costa Rica, 2001- 2021



Notes: The figure displays a histogram and the cumulative percentage of monthly rainfall in Costa Rica for the period 2001-2021. The histogram categorizes rainfall into intervals of 104 mm (dark gray bars), illustrating the distribution of rainfall amounts. The cumulative curve (black line) represents the total accumulated rainfall over the study period.

Source: Central Bank of Costa Rica with data from the National Meteorological Institute (IMN).

Figure A2. Total number of excess rainfall events per month in Costa Rica, 2001-2021



Notes: The figure displays the number of excess rainfall events per month during the period of study. We observe that months with more excess rainfall events tend to cluster from 2001 to 2012, with the following years showing markedly less precipitation than the previous decade.

Source: Central Bank of Costa Rica with data from the National Meteorological Institute (IMN).

Table A1. Descriptive statistics

	Credit sample						
	Mean	St. Dev.	Min	Pct. 25	Median	Pct. 75	Max
Credit balance by canton (million CRC)	92 215	254 108	1 501	14 690	27 912	73 590	2 204 462
Credit balance by canton (% with respect to total)	1.20	3.32	0.02	0.19	0.36	0.96	28.80
Credit balance by economic activity (million CRC)	332 870	504 891	1 904	68 670	126 146	345 758	1 884 004
Credit balance by economic activity (% with respect to total)	4.17	6.32	0.02	0.86	1.58	4.33	23.58
	Rainfall database						
	Mean	St.Dev.	Min	Pct. 25	Median	Pct. 75	Max
Rainfall observed by canton per month (mm)	327	188	3	182	326	435	1 557
Excess rainfall events per canton (per month)	0.04	0.20	0.00	0.00	0.00	0.00	1.00
Excess rainfall events per canton (for the period 2001-2021)	11	2	5	10	11	12	14

Notes: The table displays summary statistics of the variables in the credit sample and in the rainfall database. The credit sample consists of the average credit balance by canton from our banks' sample from 2019 to 2021. The upper part of the table presents summary statistics of the size of the average monthly credit balance by canton as well as its relative importance as a percentage of the total average credit balance. Credit balance statistics are shown by canton and by economic activity. The lower part of the table consists of monthly observed rainfall by canton measured in millimeters. We also present the main statistics for the number of times observed rainfall was greater than the monthly average plus two or more standard deviations for the same month (excess rainfall events).

Source: Central Bank of Costa Rica

Table A2. Top ten cantons by excess rainfall events following Felbermayr et al. (2022), 2001-2021

	Canton	Number of events	Ranking with respect to proposed methodology
1	Matina	37	3
2	Siquirres	36	2
3	Limón	34	10
4	Turrialba	33	5
5	León Cortés	32	1
6	Guácimo	31	N.A.
7	Heredia	31	6
8	San Isidro	31	7
9	Tilarán	31	8
10	Río Cuarto	31	4

Notes: This table shows the ten cantons of Costa Rica with the highest number of excess rainfall events registered during 2001-2021 when using the methodology proposed by Felbermayr et al. (2022) to calculate extreme precipitation events with two standard errors. Nine out of the ten cantons in this table coincide with the top ten cantons obtained when using the methodology that we propose in this paper, with Guácimo being the exception. The last column displays the ranking of each canton with our proposed methodology.

Source: Central Bank of Costa Rica with data from the National Meteorological Institute (IMN).

Table A3. Bottom ten cantons by average credit balance and share of banks' assets, December 2019 – December 2021

	Canton	Degree of urbanization	Average credit balance	Share of banks' assets
			million CRC	*%*
73	Hojancha	Predominantly rural	6 204.0	0.08
74	Los Chiles	Predominantly rural	5 732.8	0.07
75	Alvarado	Predominantly rural	5 439.3	0.07
76	Acosta	Predominantly rural	4 957.3	0.06
77	León Cortés	Predominantly rural	4 156.1	0.05
78	Guatuso	Predominantly rural	4 054.9	0.05
79	Nandayure	Predominantly rural	3 886.2	0.05
80	Jiménez	Predominantly rural	3 405.6	0.04
81	San Mateo	Predominantly rural	2 822.0	0.04
82	Turrubares	Predominantly rural	1 500.7	0.02
	Total		**42 158.8**	**0.55**

Notes: The table displays the ten cantons of Costa Rica with the smallest average credit balance from December 2019 to December 2021, as well the cantons' credit share with respect to the total average assets of the sample (last column). The degree of urbanization of a canton is an average of the degree of urbanization of the different districts that comprise it, which are categorized in urban, predominantly urban, predominantly rural, and rural, according to the National Institute of Statistics and Census (INEC).

Source: Central Bank of Costa Rica with data from INEC.

Table A4. Average credit balance and share of banks' assets by economic activities and households, December 2019 – December 2021

Economic activity	Average credit balance	Share of banks' assets
	million CRC	*%*
N.A.	1 850 593.2	24.16
Credits assigned to households	1 366 313.8	17.84
Multiple economic activities	1 199 098.6	15.66
Financial and insurance activities	757 894.8	9.90
Wholesale and retail trade; repair of motor vehicles and motorcycles	468 670.4	6.12
Real estate activities	326 720.8	4.27
Professional, scientific, and technical activities	316 289.7	4.13
Human health care and social assistance activities	185 182.9	2.42
Agriculture, forestry and fishing	162 982.1	2.13
Transportation and storage	128 678.9	1.68
Construction	127 940.3	1.67
Accommodation and meal service activities	121 554.0	1.59
Manufacturing industries	116 927.7	1.53
Supply of electricity, gas, steam, and air conditioning	87 097.5	1.14
Household activities as employers; undifferentiated activities of households as producers of goods and services for own use	87 023.1	1.14
Other service activities	72 695.4	0.95
Teaching	65 196.5	0.85
Administrative and support service activities	64 774.5	0.85
No information about activity or identification	58 183.0	0.76
Information and communications	57 667.8	0.75
Artistic, entertainment and recreational activities	22 613.4	0.30
Public administration and defense; mandatory affiliation social security plans	8 802.5	0.11
Water supply; sewage disposal, waste management and decontamination	3 593.2	0.05
Mining and quarrying	1 773.7	0.02
Total	**7 658 267.9**	**100**

Notes: The table shows the average credit balance by economic activity and households from December 2019 to December 2021 (using a disaggregated list of economic activities), as well as the credit share by economic activity relative to the total average assets of the sample (last column). An average 82.2% of all credits is assigned to economic units (i.e., firms), while

the remaining percentage (avg. 17.8%) is assigned to households. Credits assigned to economic units that lack an assigned economic activity are found under the description 'N.A.'. Credits assigned to economic units with more than one economic activity are found under the description 'Multiple economic activities'.

Source: Central Bank of Costa Rica.

Table A5. Production indicators by canton: *León Cortés*

Indicators	**Unit**	
Average gross value added (GVA) (2019-2021)	*million CRC*	67 810.4
Main economic activity, avg. 2019 – 2021	*National accounts classification*	EA082- Electricity, gas, steam, and air conditioning supply
	Avg. % of GVA	41.3
Top 3 economic activities (sections), avg. 2019 – 2021		
1. D- Electricity, gas, steam, and air conditioning supply	*Avg. % of GVA*	41.3
2. A- Agriculture, forestry, and fishing	*Avg. % of GVA*	16.2
3. P- Education	*Avg. % of GVA*	15.1
Economic activity section with the largest share of avg. credit balance	*ISIC Rev.4*	A- Agriculture, forestry, and fishing
	%	15.0

Notes: The table shows a selection of average production indicators for León Cortés for the years 2019-2021.The 'main economic activity' category follows the national accounts classification used in the Supply and Use Table 2021 of the Central Bank of Costa Rica, and the 'sections' category of economic activities follows the International Standard Industrial Classification of All Economic Activities (ISIC), Rev.4.

Source: Central Bank of Costa Rica.

Table A6. Production indicators by canton: *Siquirres*

Indicators	**Unit**	
Average gross value added (GVA) (2019-2021)	*million CRC*	349 090.2
Main economic activity, avg. 2019 – 2021	*National accounts classification*	EA014- Banana cultivation
	Avg. % of GVA	21.7
Top 3 economic activities (sections), avg. 2019 – 2021		
1. A- Agriculture, forestry and fishing	*Avg. % of GVA*	27.9
2. D- Electricity, gas, steam, and air conditioning supply	*Avg. % of GVA*	17.3
3. C- Manufacturing	*Avg. % of GVA*	14.1
Economic activity section with the largest share of avg. credit balance	*ISIC Rev.4*	C- Manufacturing
	%	14.2

Notes: The table shows a selection of average production indicators for Siquirres for the years 2019-2021.The 'main economic activity' category follows the national accounts classification used in the Supply and Use Table 2021 of the Central Bank of Costa Rica, and the 'sections' category of economic activities follows the International Standard Industrial Classification of All Economic Activities (ISIC), Rev.4.

Source: Central Bank of Costa Rica.

Table A7. Production indicators by canton: *Matina*

Indicators	**Unit**	
Average gross value added (GVA) (2019-2021)	*million CRC*	197 418.2
Main economic activity, avg. 2019 – 2021	*National accounts classification*	EA014- Banana cultivation
	Avg. % of GVA	55.2
Top 3 economic activities (sections), avg. 2019 – 2021		
1. A- Agriculture, forestry, and fishing	*Avg. % of GVA*	57.5
2. P- Education	*Avg. % of GVA*	8.9
3. B- Mining and quarrying	*Avg. % of GVA*	5.7
Economic activity section with the largest share of avg. credit balance	*ISIC Rev.4*	A- Agriculture, forestry, and fishing
	%	45.9

Notes: The table shows a selection of average production indicators for Matina for the years 2019-2021.The 'main economic activity' category follows the national accounts classification used in the Supply and Use Table 2021 of the Central Bank of Costa Rica, and the 'sections' category of economic activities follows the International Standard Industrial Classification of All Economic Activities (ISIC), Rev.4.

Source: Central Bank of Costa Rica.

Table A8. Production indicators by canton: *Turrialba*

Indicators	**Unit**	
Average gross value added (GVA) (2019-2021)	*million CRC*	298 546.7
Main economic activity, avg. 2019 – 2021	*National accounts classification*	EA132- Teaching
	Avg. % of GVA	14.1
Top 3 economic activities (sections), avg. 2019 – 2021		
1. G- Wholesale and retail trade	*Avg. % of GVA*	14.9
2. P- Education	*Avg. % of GVA*	14.1
3. C- Manufacturing	*Avg. % of GVA*	12.7
Economic activity section with the largest share of avg. credit balance	*ISIC Rev.4*	G- Wholesale and retail trade
	%	7.2

Notes: The table shows a selection of average production indicators for Turrialba for the years 2019-2021.The 'main economic activity' category follows the national accounts classification used in the Supply and Use Table 2021 of the Central Bank of Costa Rica, and the 'sections' category of economic activities follows the International Standard Industrial Classification of All Economic Activities (ISIC), Rev.4.

Source: Central Bank of Costa Rica.

Table A9. Production indicators by canton: *Heredia*

Indicators	**Unit**	
Average gross value added (GVA) (2019-2021)	*million CRC*	1 982 669.6
Main economic activity, avg. 2019 – 2021	*National accounts classification*	EA105- Information, programing, and computing consulting activities, editing of computing and related programs
	Avg. % of GVA	12.1
Top 3 economic activities (sections), avg. 2019 – 2021		
1. C- Manufacturing	*Avg. % of GVA*	13.6
2. J- Information and communication	*Avg. % of GVA*	13.1
3. M- Professional, scientific, and technical activities	*Avg. % of GVA*	13.0
Economic activity section with the largest share of avg. credit balance	*ISIC Rev.4*	G- Wholesale and retail trade
	%	3.5

Notes: The table shows a selection of average production indicators for Heredia for the years 2019-2021.The 'main economic activity' category follows the national accounts classification used in the Supply and Use Table 2021 of the Central Bank of Costa Rica, and the 'sections' category of economic activities follows the International Standard Industrial Classification of All Economic Activities (ISIC), Rev.4.

Source: Central Bank of Costa Rica.

Table A10. Production indicators by canton: *Limón*

Indicators	**Unit**	
Average gross value added (GVA) (2019-2021)	*million CRC*	446 083.9
Main economic activity, avg. 2019 – 2021	*National accounts classification*	EA132- Teaching
	Avg. % of GVA	12.5
Top 3 economic activities (sections), avg. 2019 – 2021		
1. G- Wholesale and retail trade	*Avg. % of GVA*	14.8
2. H- Transportation and storage	*Avg. % of GVA*	13.2
3. P – Education	*Avg. % of GVA*	12.5
Economic activity section with the largest share of avg. credit balance	*ISIC Rev.4*	H- Transportation and storage
	%	13.9

Notes: The table shows a selection of average production indicators for Limón for the years 2019-2021.The 'main economic activity' category follows the national accounts classification used in the Supply and Use Table 2021 of the Central Bank of Costa Rica, and the 'sections' category of economic activities follows the International Standard Industrial Classification of All Economic Activities (ISIC), Rev.4.

Source: Central Bank of Costa Rica.

Table A11. Credit risk indicator by canton

	Canton	Physical hazard indicator	Asset exposure indicator	Credit risk indicator	Quintile
1	San José	0,009	0,290	0,0027	
2	Heredia	0,015	0,057	0,0009	
3	Alajuela	0,012	0,070	0,0008	
4	Escazú	0,012	0,051	0,0006	
5	Santa Ana	0,012	0,042	0,0005	
6	San Carlos	0,010	0,035	0,0004	
7	Goicoechea	0,012	0,027	0,0003	
8	Desamparados	0,012	0,023	0,0003	
9	Cartago	0,010	0,025	0,0003	5
10	Tibás	0,013	0,020	0,0003	
11	Belén	0,012	0,020	0,0002	
12	Montes de Oca	0,009	0,023	0,0002	
13	Curridabat	0,009	0,022	0,0002	
14	Pérez Zeledón	0,014	0,013	0,0002	
15	Santa Cruz	0,014	0,012	0,0002	
16	La Unión	0,009	0,017	0,0002	
17	Liberia	0,010	0,014	0,0001	
18	Santo Domingo	0,013	0,011	0,0001	
19	Moravia	0,013	0,011	0,0001	
20	Pococí	0,010	0,012	0,0001	
21	Vázquez de Coronado	0,014	0,008	0,0001	
22	Limón	0,015	0,007	0,0001	
23	Grecia	0,012	0,010	0,0001	
24	Flores	0,012	0,009	0,0001	
25	Puntarenas	0,013	0,008	0,0001	4
26	San Pablo	0,013	0,006	0,0001	
27	San Rafael	0,013	0,006	0,0001	
28	Nicoya	0,014	0,006	0,0001	
29	Barva	0,014	0,005	0,0001	
30	Cañas	0,013	0,006	0,0001	
31	Turrialba	0,015	0,005	0,0001	
32	Orotina	0,014	0,005	0,0001	
33	Paraíso	0,014	0,005	0,0001	
34	El Guarco	0,013	0,005	0,0001	
35	Palmares	0,013	0,005	0,0001	
36	Carrillo	0,013	0,005	0,0001	
37	Esparza	0,013	0,004	0,0001	
38	Naranjo	0,012	0,005	0,0001	3
39	San Ramón	0,006	0,009	0,0001	
40	Tarrazú	0,013	0,004	0,0000	
41	Aguirre	0,014	0,004	0,0000	
42	San Isidro	0,015	0,003	0,0000	

43	Mora	0,013	0,004	0,0000	
44	Alajuelita	0,012	0,004	0,0000	
45	Garabito	0,012	0,004	0,0000	
46	Oreamuno	0,012	0,004	0,0000	
47	Upala	0,013	0,003	0,0000	
48	Tilarán	0,015	0,003	0,0000	
49	Santa Bárbara	0,012	0,003	0,0000	
50	Siquirres	0,016	0,002	0,0000	
51	Atenas	0,010	0,003	0,0000	
52	Poás	0,012	0,003	0,0000	
53	Aserrí	0,010	0,003	0,0000	
54	Matina	0,016	0,002	0,0000	
55	Río Cuarto	0,015	0,002	0,0000	
56	Coto Brus	0,009	0,003	0,0000	
57	Abangares	0,014	0,002	0,0000	2
58	Guácimo	0,014	0,002	0,0000	
59	Osa	0,015	0,002	0,0000	
60	Puriscal	0,009	0,003	0,0000	
61	Alfaro Ruiz	0,010	0,002	0,0000	
62	Bagaces	0,012	0,002	0,0000	
63	Sarapiquí	0,013	0,002	0,0000	
64	La Cruz	0,014	0,002	0,0000	
65	Corredores	0,009	0,002	0,0000	
66	Buenos Aires	0,012	0,001	0,0000	
67	Valverde Vega	0,013	0,001	0,0000	
68	Golfito	0,012	0,001	0,0000	
69	Hojancha	0,014	0,001	0,0000	
70	Dota	0,012	0,001	0,0000	
71	Parrita	0,012	0,001	0,0000	
72	Los Chiles	0,013	0,001	0,0000	
73	Talamanca	0,010	0,001	0,0000	
74	León Cortés	0,016	0,001	0,0000	1
75	Montes de Oca	0,008	0,001	0,0000	
76	Alvarado	0,012	0,001	0,0000	
77	Guatuso	0,012	0,001	0,0000	
78	Acosta	0,009	0,001	0,0000	
79	Nandayure	0,012	0,001	0,0000	
80	Jiménez	0,013	0,000	0,0000	
81	San Mateo	0,014	0,000	0,0000	
82	Turrubares	0,010	0,000	0,0000	

Notes: The table shows the values of: 1) the physical hazard indicator (PHI), defined as the share of excess rainfall events by canton with respect to the total excess rainfall events of the period 2001 – 2021; 2) the asset exposure indicator (AEI), defined as the share of average credit balance by canton with respect to the total average credit balance of the sample for the period 2019 – 2021, and 3) the credit risk indicator (CRI), defined as the product of the two former indicators. The last column groups the cantons in quintiles according to the range of values of the credit risk indicator (CRI).

Source: Central Bank of Costa Rica.

B. Intensity and persistence of excess rainfall events

To analyze the intensity of extreme rainfall events, we devised a variable measuring the proportion of total rainfall by canton attributable to excess rainfall events. Our findings highlight a significant concentration of events with intense rainfall in the cantons of Heredia province, where six of the top ten cantons exhibiting this phenomenon are in this province. In these areas, more than 27% of the total rainfall occurring in these cantons is attributed to excess rainfall episodes.

Additionally, we developed another metric to gauge persistence, focusing on the occurrence of three or more consecutive excess rainfall events within a period of three or four months. Once again, Heredia province emerges as the focal point, with most cantons demonstrating this pattern. Notably, seven of the top ten cantons obtained with this metric belong to Heredia province.

Remarkably, six cantons within Heredia –namely Heredia, Barva, Sarapiquí, San Isidro, San Rafael, and San Pablo– feature prominently in the top ten rankings for both metrics. This dual concentration of excess rainfall events not only exhibit temporal clustering but also underscores a geographical focal point. While the former was unexpected, the latter aligns with the geographical characteristics of Costa Rica.

C. Global importance allocation for economic units

The Data and Statistics Analysis Division of the BCCR conducts a procedure to allocate the global importance to economic units by location (province, canton, and district). The purpose of this procedure is to associate the location of natural persons o legal units with the Environmental Economic Repository data to estimate the risk incurred by the financial sector with credits located in areas that have a higher proneness to climatic events.

The administrative records used for this procedure are:

i. Registry of Economic Variables (Revec) of the BCCR (already described in in Section 2. “Data and Methodological Approach”).

ii. Electronic receipts: electronic documents authorized by the Tax Administration Office that support the sale or acquisition of goods and the provision of services, containing the information of issuers and receivers.

iii. Single Tax Registry: identification record of natural persons or legal units that carry out a lucrative activity subject to taxes managed by the Tax Administration.

iv. Social Security Administration: information of employers and employees registered in the Caja Costarricense del Seguro Social (Costa Rica’s public healthcare system).

The assignment of a productive location to all economic units consisted of a subframe of natural persons and legal units that carry out a productive activity in the national territory. For each unit, all available establishments (or locations) are compiled. If they coincide between the different administrative records, the economic unit will have a single productive location per province, canton, and district.

However, for cases where the location of the economic unit differs between the different sources, a weight or global importance is assigned to each location of the economic unit. To determine the global importance, the following criteria are implemented: for cases where issuers register more than one location for each economic unit, 55% is redistributed accounting for the reported sales of the electronic receipts issued in each location. Likewise, for employers that register more than one location, 25% is redistributed proportionally according to the number of employees that are reported in each location. Finally, when there is more than one location registered in the Single Tax Registry, 20% is redistributed with equal weights among the available locations.