

SILVIA: An operational system to monitoring landslides forced by heavy precipitations at national See en marken de mo

Carlos Millán (), Waldo Lavado (), Fiorella Vega (), Oscar Felipe (), Julia

National Service of Meteorology and Hydrology (SENAMHI), Lima, Peru

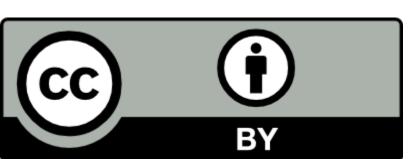
Panoramic view of the high-risk basins of the Rímac River, Santiago de Tuna, 2019 CMA

Acuña (1), and Ken Takahashi (1)



What is SILVIA?

SILIVIA is a system developed at SENAHI with the aim of marking the bases for monitoring and forecasting landslides triggered bV rainfalls

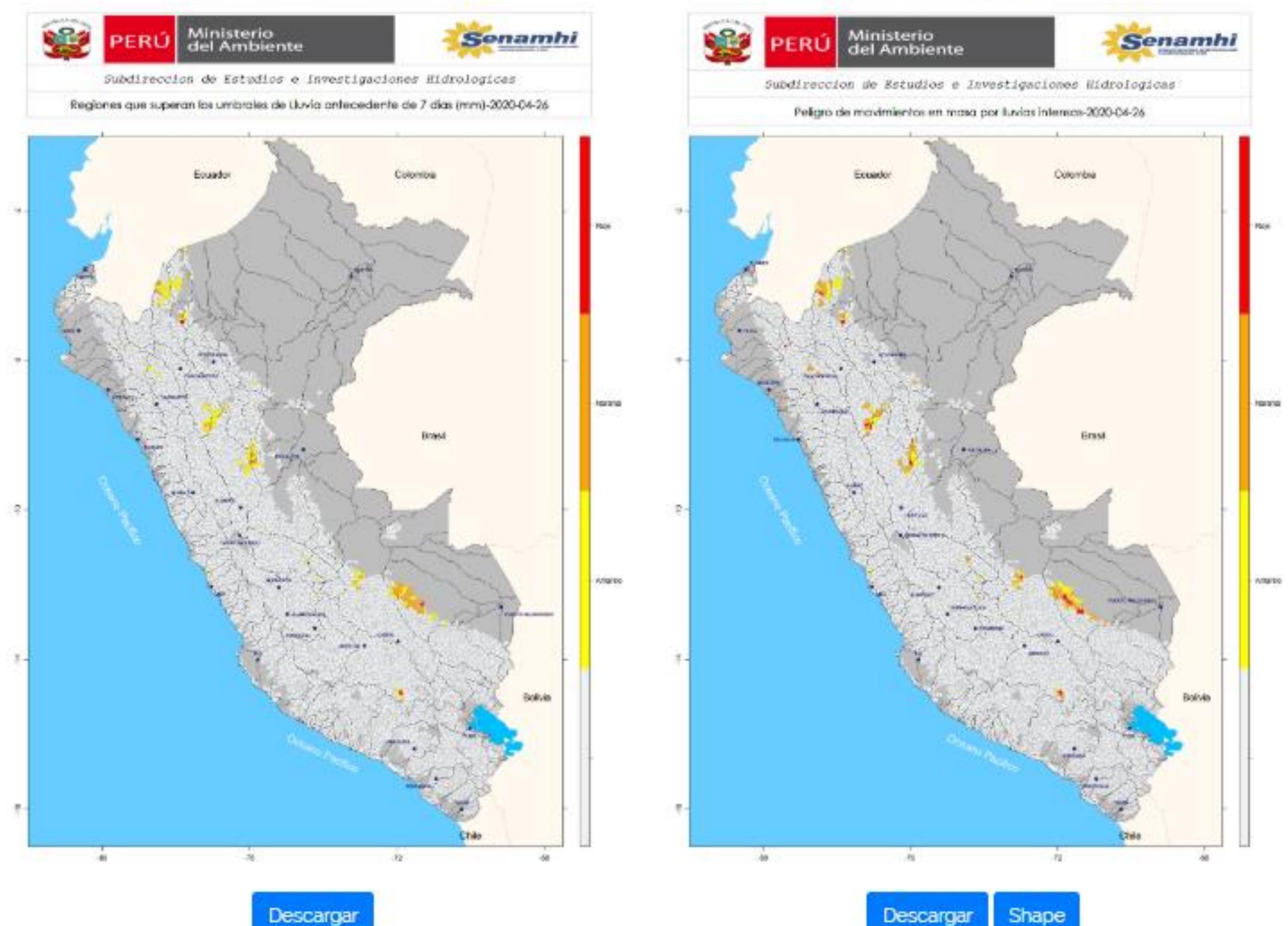






Sistema de Monitoreo y Pronóstico de Movimientos en Masa Potenciales generados por Lluvias Intensas (SILVIA)

Lluvia antecedentes 7 días

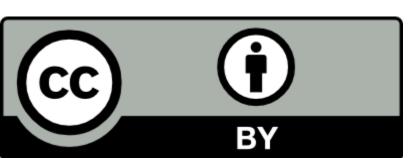


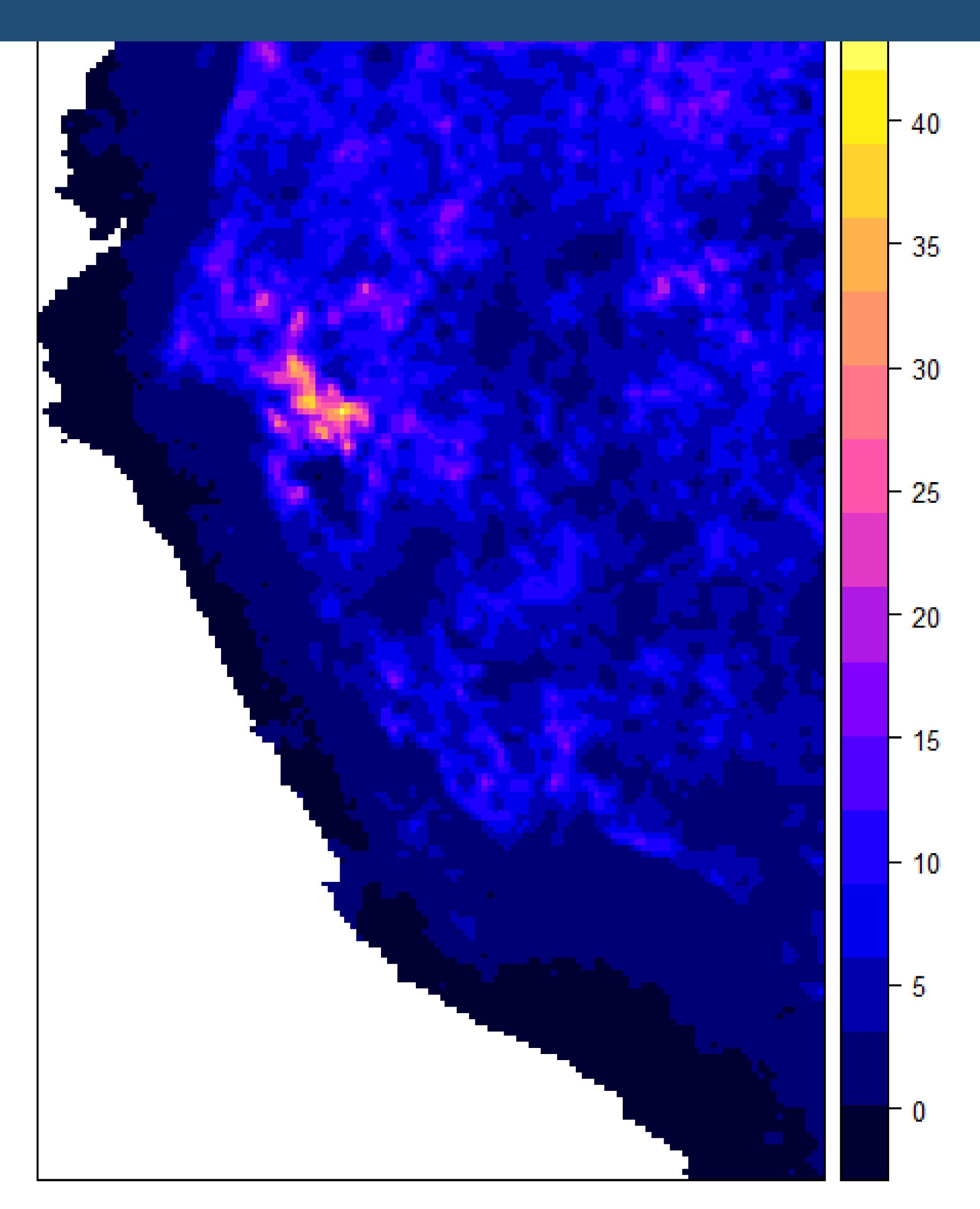
Peligro de movimientos en masa

Descargar Shape

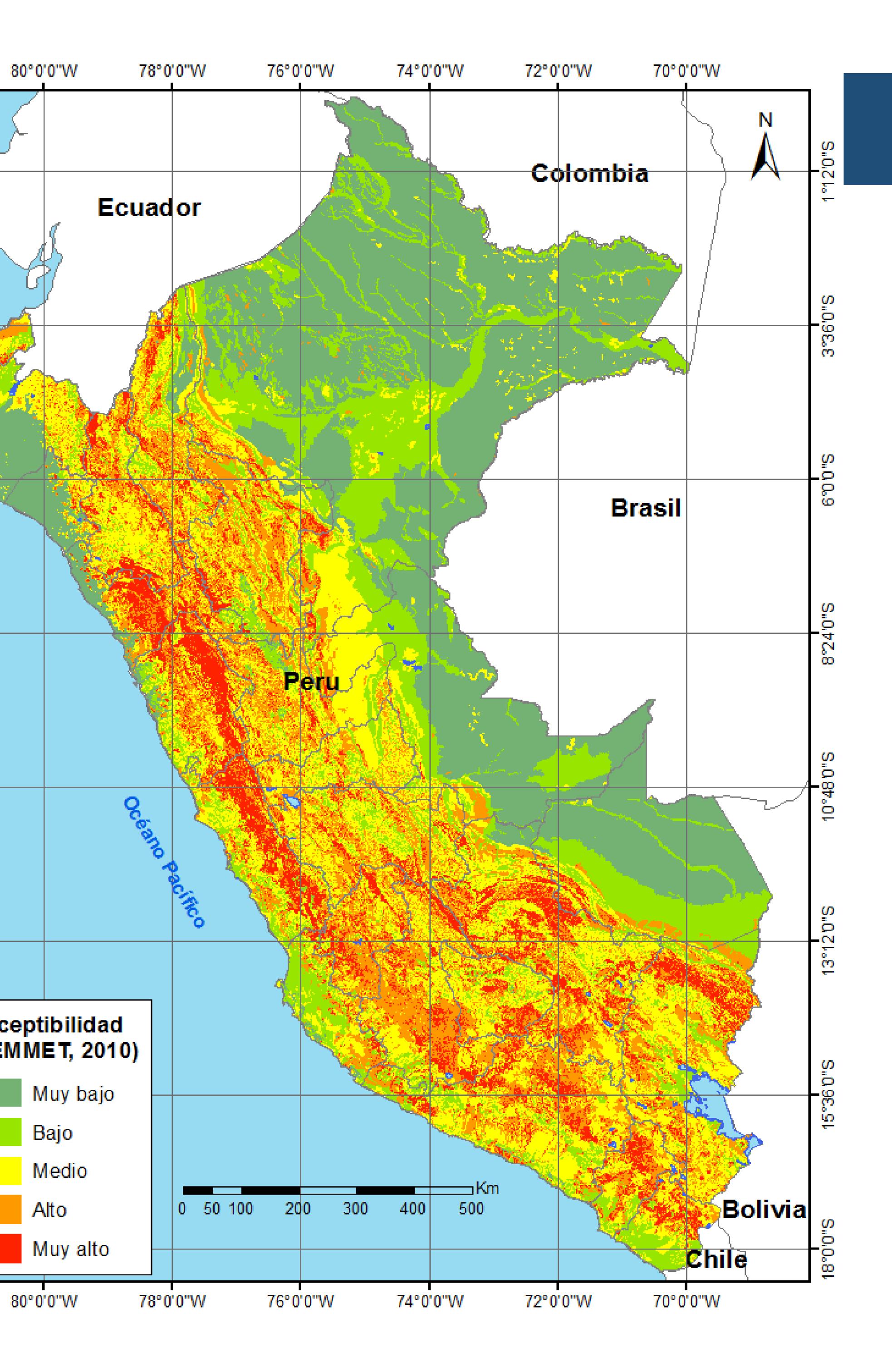
MATERIALS: Rainfall data

Peruvian Interpolated data of SENAMHI's Climatological and Hydrological Observations (PISCO) which has a daily operational product PISCO-prec_operativo (PISCOop_Pp) Format: Raster Spatial resolution: 10 km x 10 km Temporal resolution: Daily





PISCO_Op 14-09-2019 (mm)



The

MATERIALS: Susceptibility map

Susceptibility map (INGEMMET, 2010) correlated with factors their

- respective weights are:
- Vegetation cover (0.05)
- Hydrogeology (0.1)
- Geomorphology (0.25)
- Slope (0.2)
- Lithology (0.4)



METHODOLOGY: Rainfall thresholds

- The ARI of the rains of the last 7 days were determined as a **moving window**.
- ARI it was determinate for wet periods of each year between the months of November to April
- It was considering as a reference climatological period 1981 -2010
- From ARI, three thresholds were established based on the percentiles of 90% (P90), 95% (P95) and 99% (P99)
- Three levels of precipitation incidence were defined: Low Incidence (L1 - ILA between P90 and P95) Medium Incidence (L2 - ILA between P95 and P99) High Incidence (L3 - ILA greater than P99)



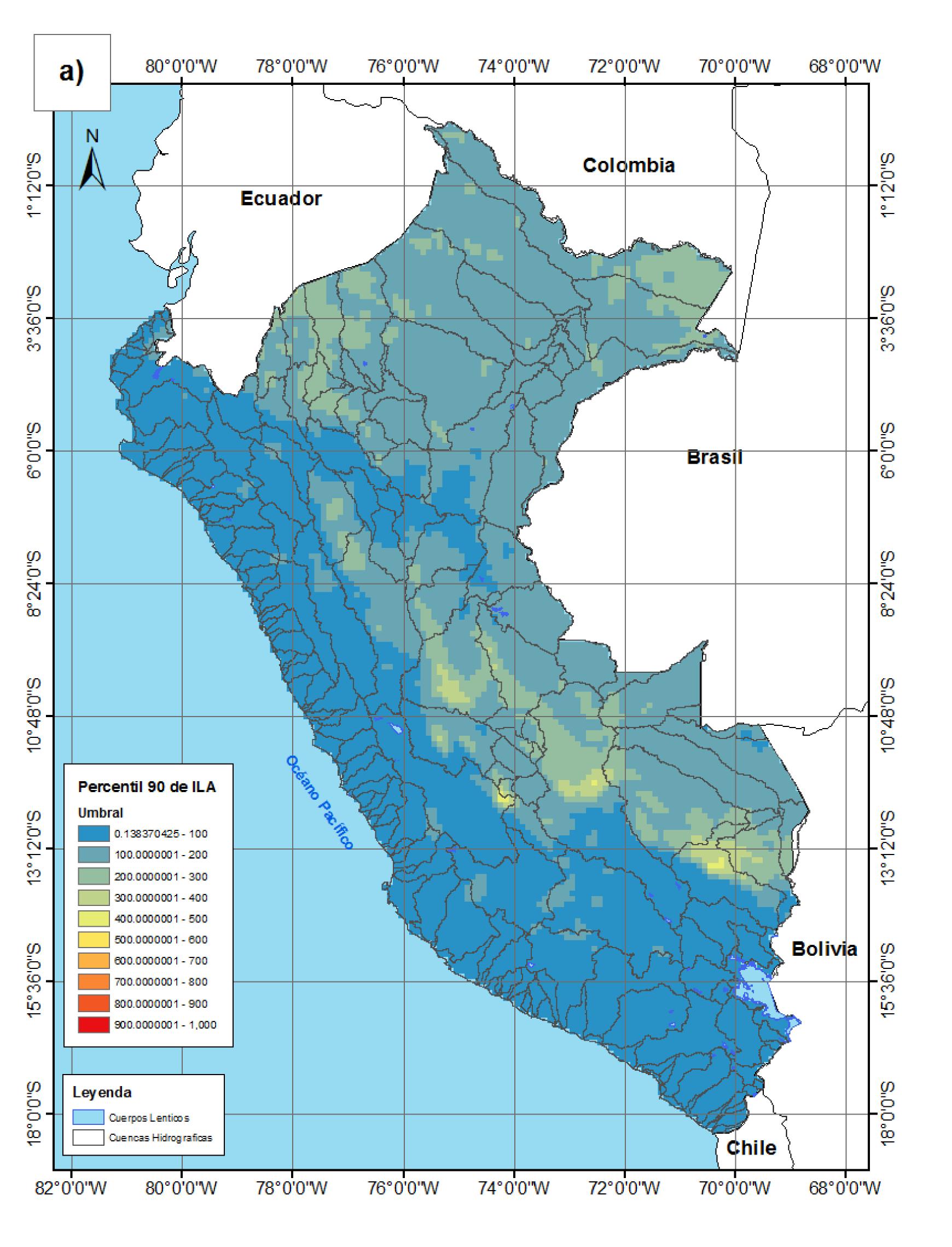
- Kirschbaum and Stanley (2018) determined an Antecedent Rainfall Index (ARI global), based on the weighted average of the last 7 days of rain. This methodology was adapted to establish the thresholds used in SILVIA.
- ARI calculates a weighted average of the last 7 rainy days. The function to determine ARI is presented in equation 1:

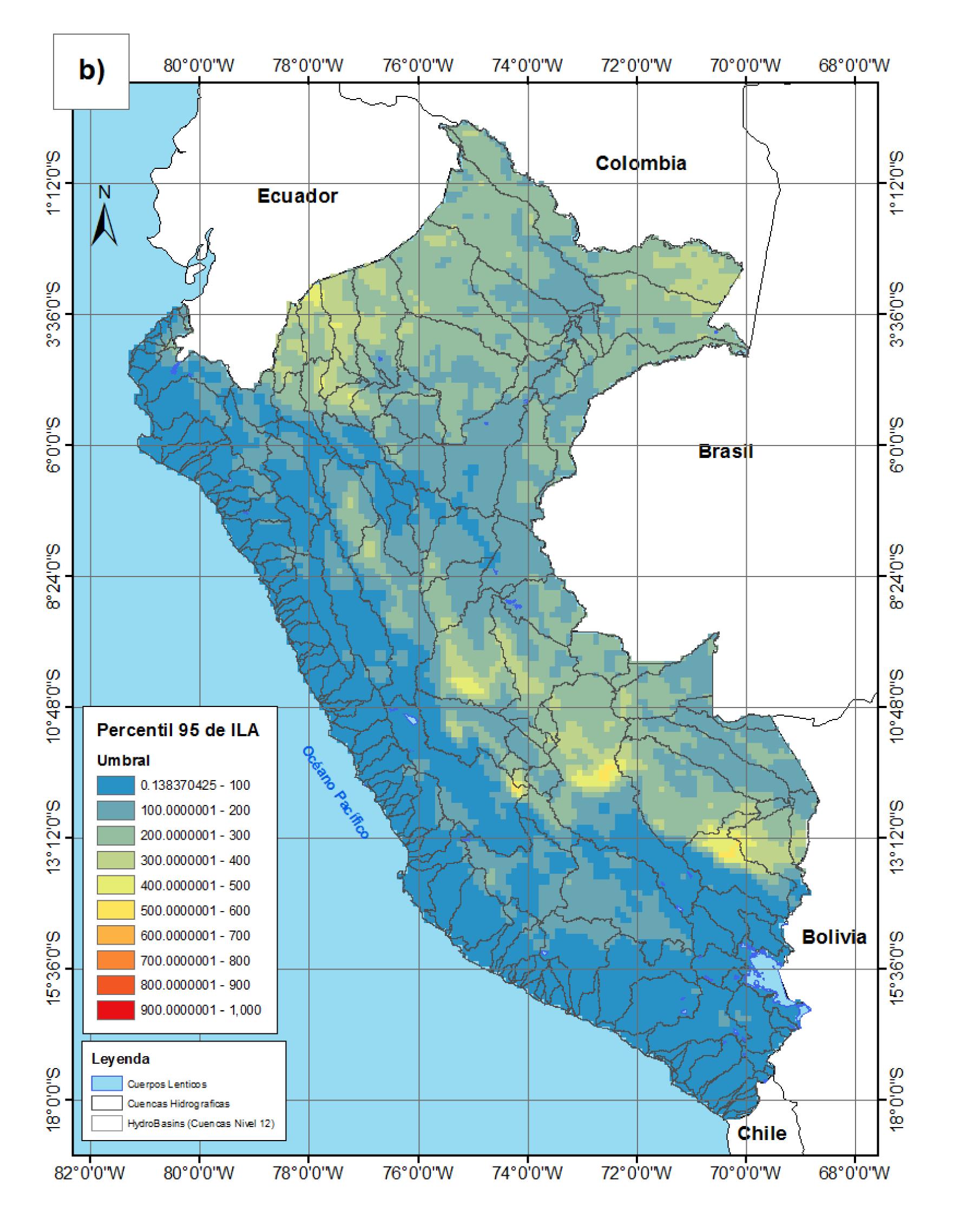
$$ARI = \frac{\sum_{t=1}^{6}}{\sum_{t=1}^{6}}$$

- where t is the number of days before the present, pt is the precipitation at time t, and wt = $(t + 1)^{-2}$.
- $p_t w_t$ $f_{=0} w_t$

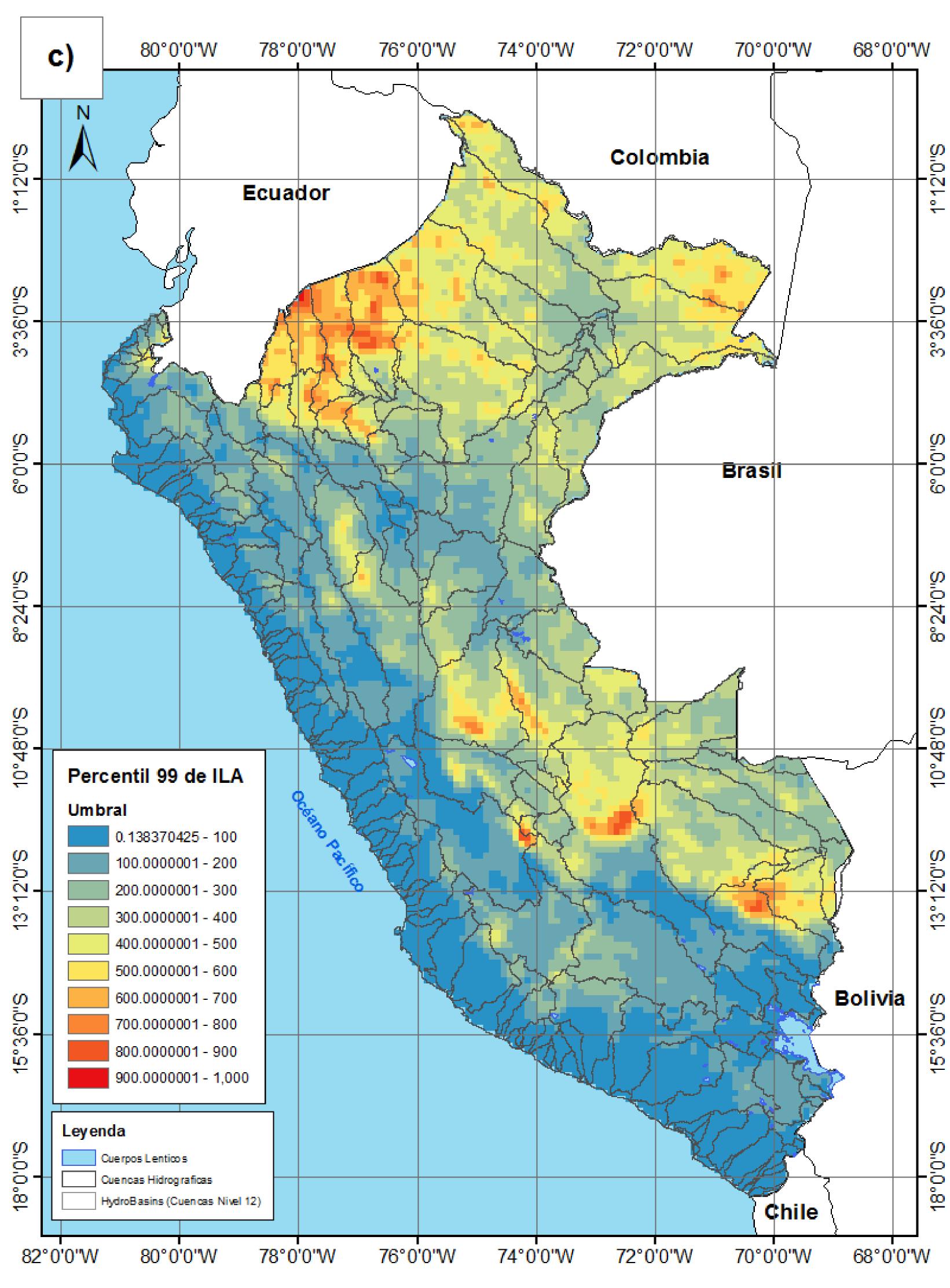
METHODOLOGY: Rainfall thresholds

Rainfall Index Thresholds Weighted at the 90th (a), 95 (b) and 99 (c) percentiles









METHODOLOGY: Analysis scope

- Peru include a total of 10849 basins
- Average area: **118.57 km2**
- The following methodology was applied:
- map.
- extension area.
- 4.1° are not being considered

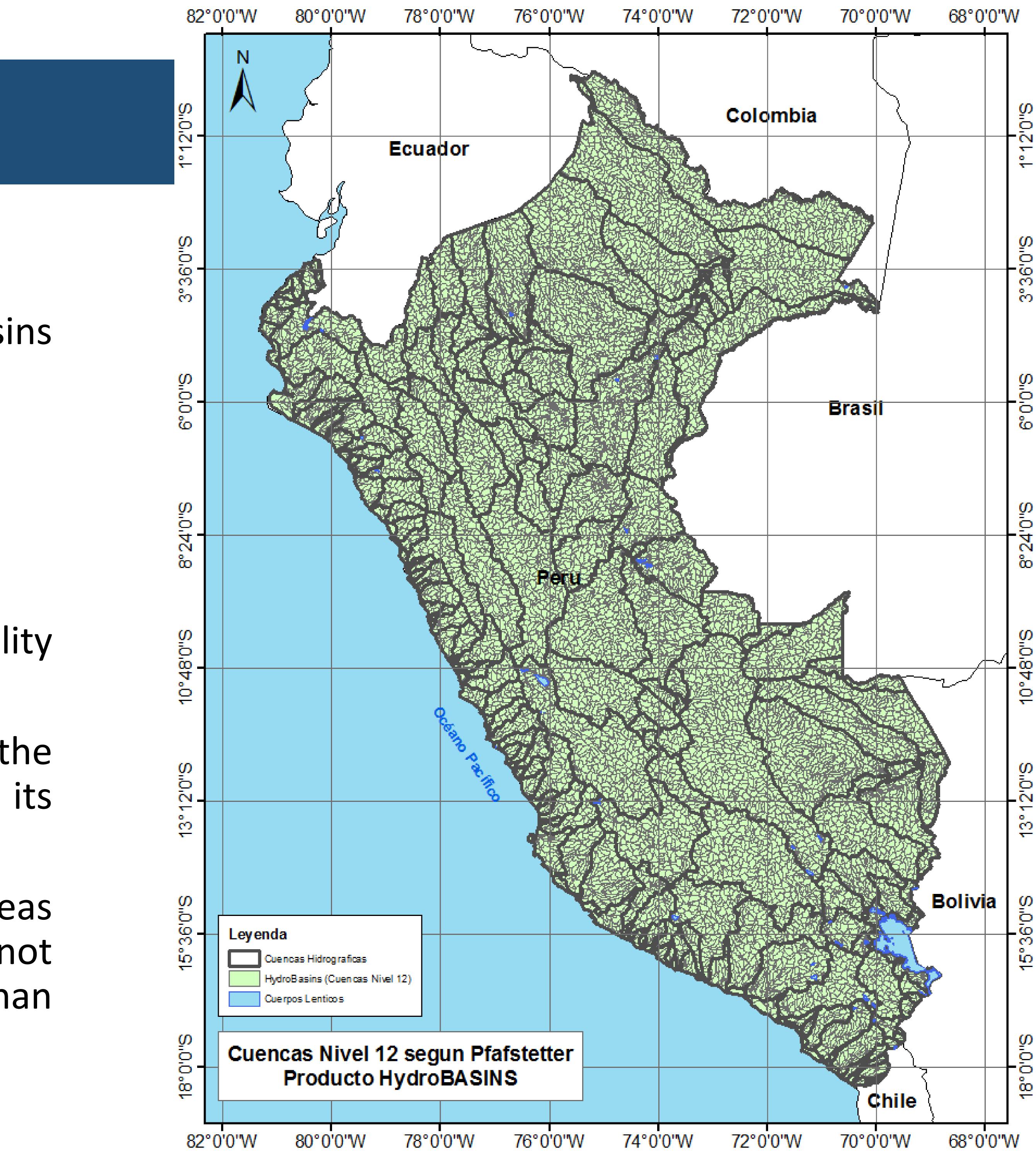
(cc)

Analysis area for issuing alerts: Level 12 basins (Pfastetter method, HydroBASINS v1.0)

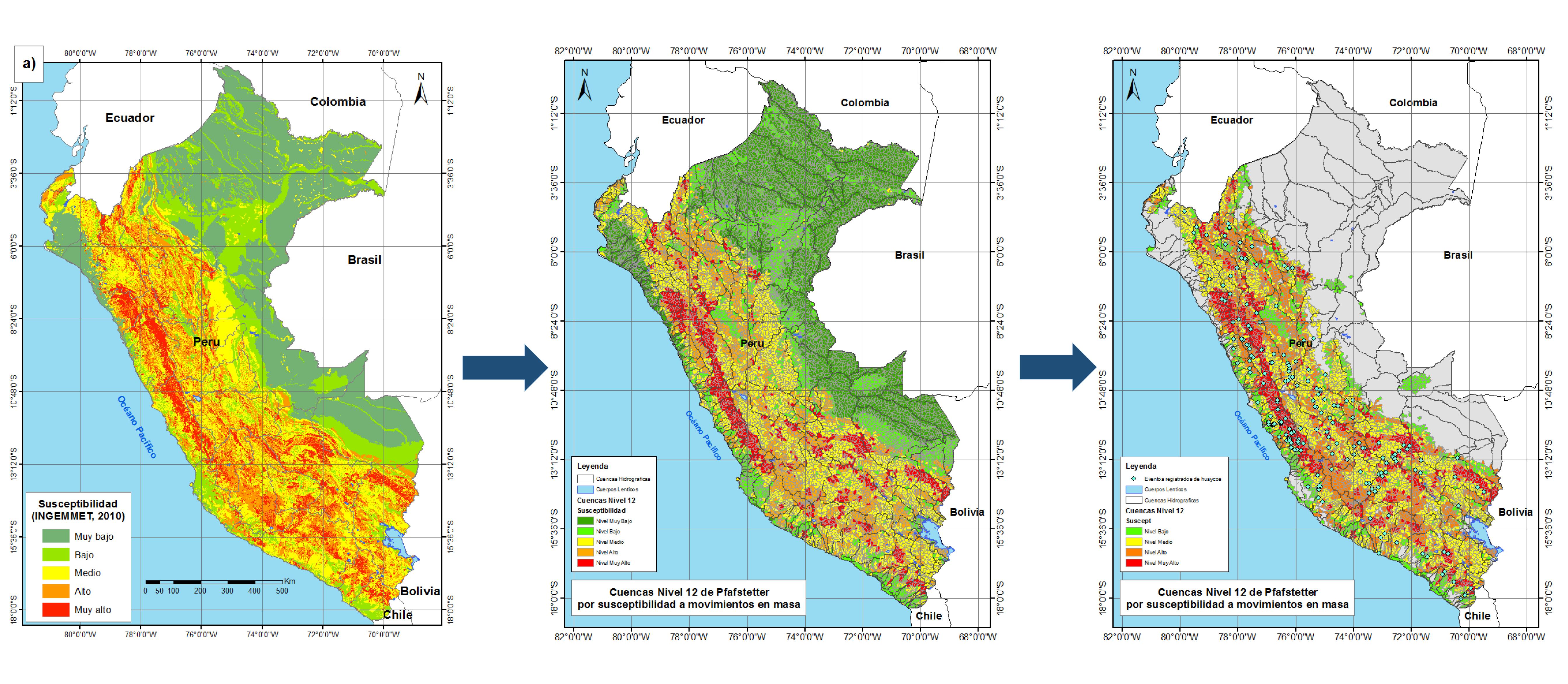
Overlapping basins with the adapted susceptibility

• Determination of susceptibility level, considering the mode of the susceptibility categories within its

• Included two restrictions: i) the first is that the areas categorized with Very Low susceptibility were not considered. ii) level 12 basins with a slope less than



METHODOLOGY: Analysis scope





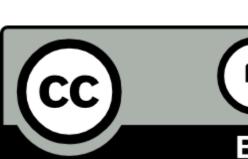
METHODOLOGY: Hazard classification

Hazard matrix based on:

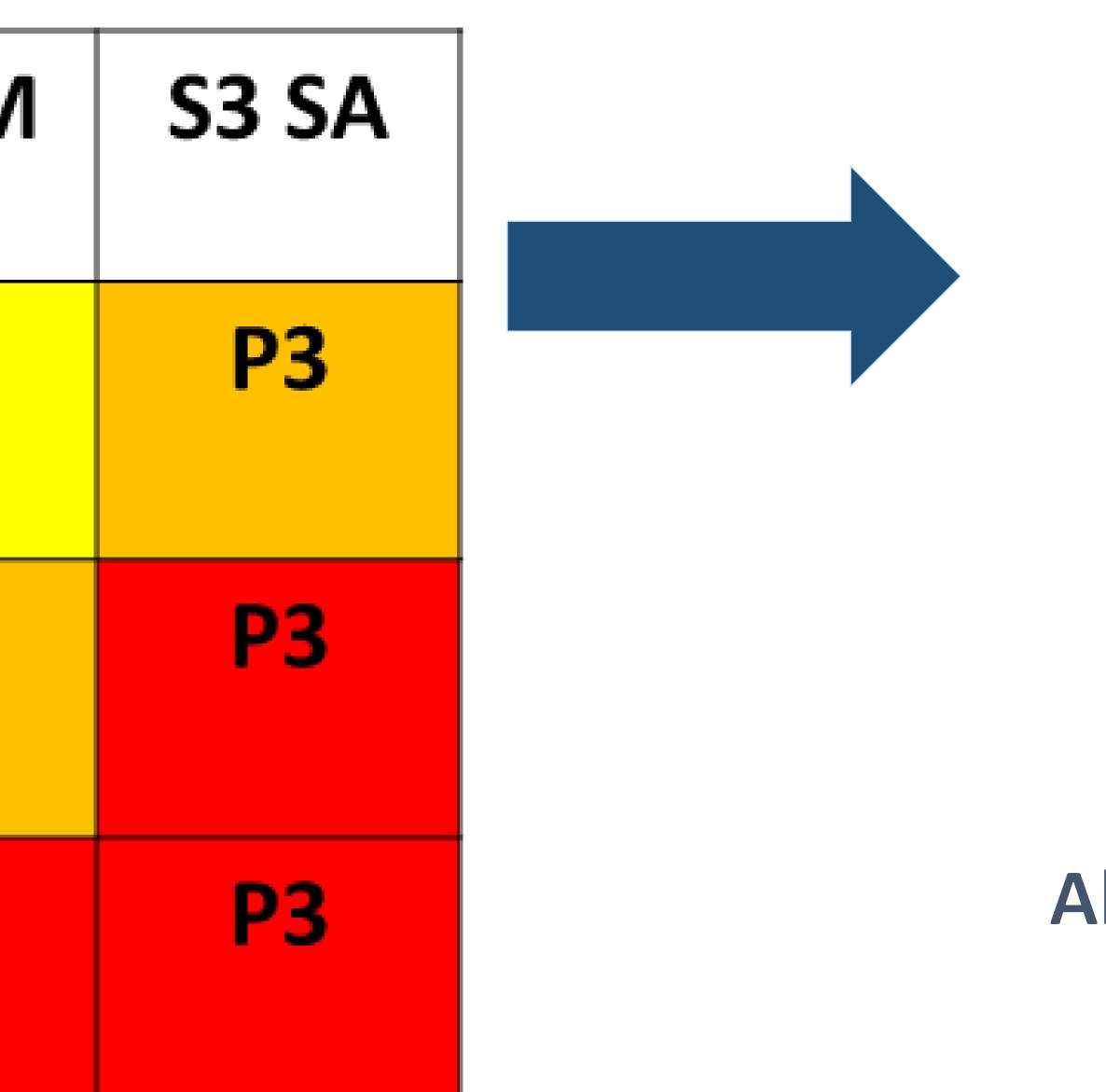
Susceptibility classes (S1, low susceptibility; S2, medium susceptibility; S3, high and very high susceptibility) and,

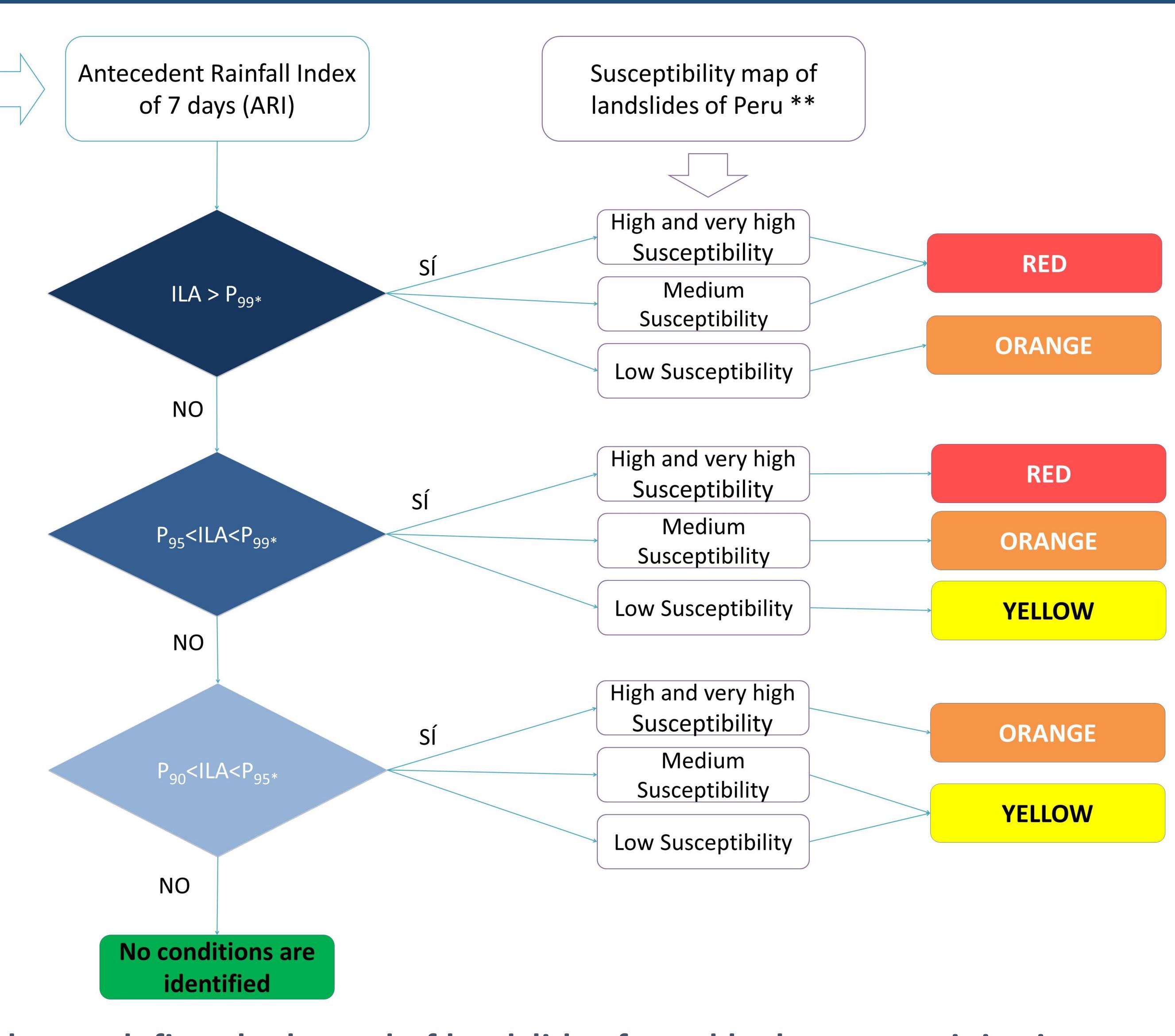
Rainfall index classes (L1, low precipitation; L2, medium precipitation; L3, high precipitation), defines three hazard classes from P1 (moderate danger), P2 (strong danger) and P3 (extreme danger).

	S1 SB	S2 SN
L1 P90- 95	P1	P2
L2 P95-99	P2	P2
L3 >P99	P3	P3

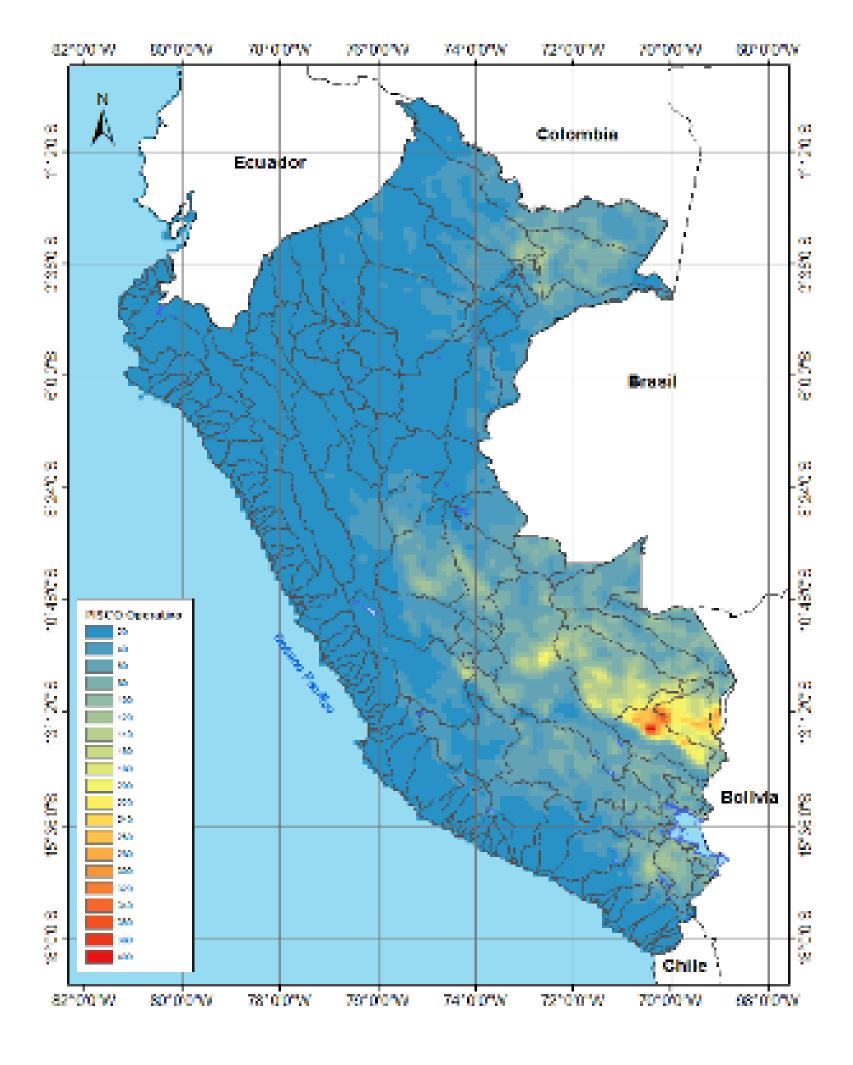


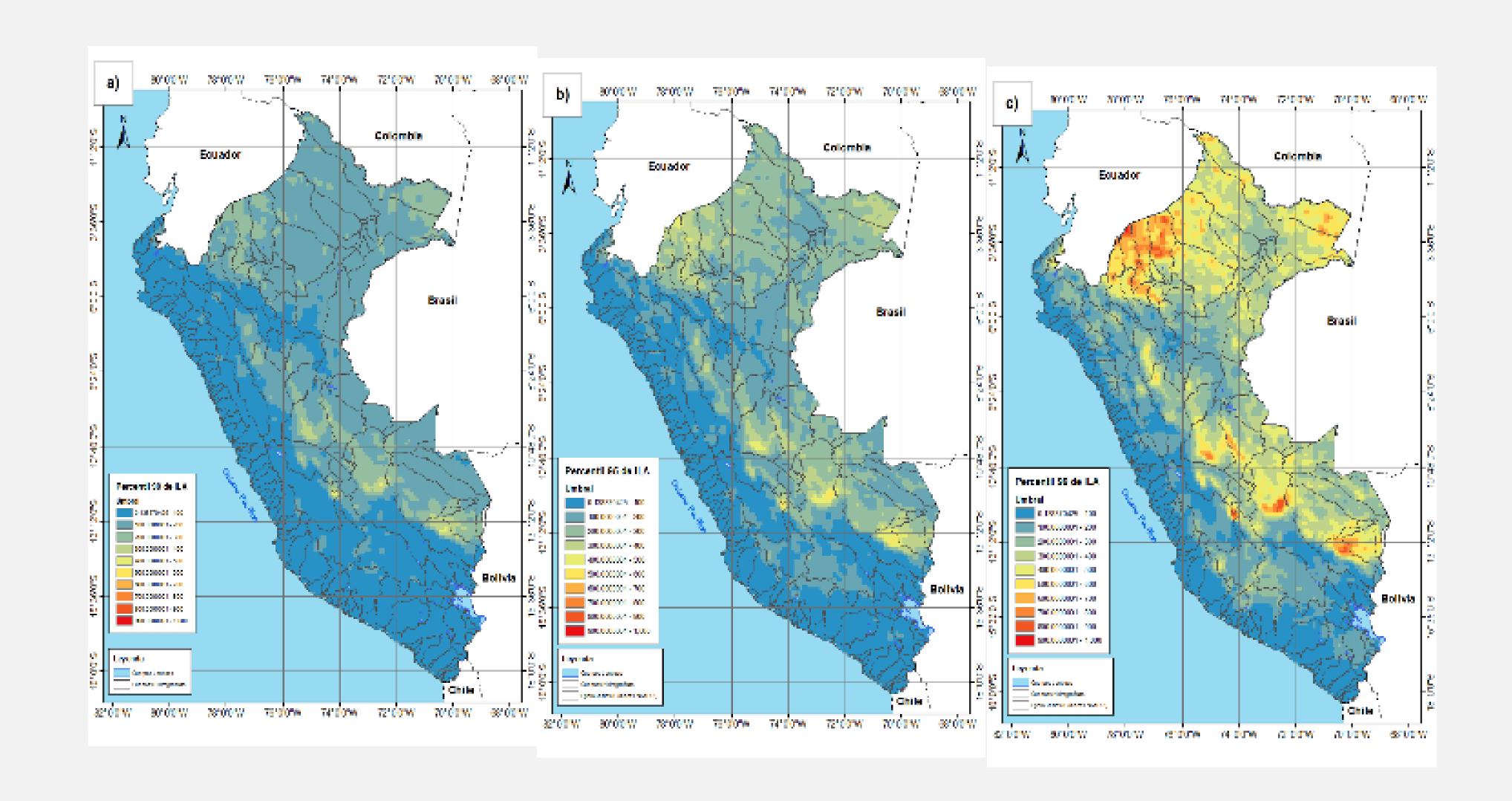
PISCO Operational version





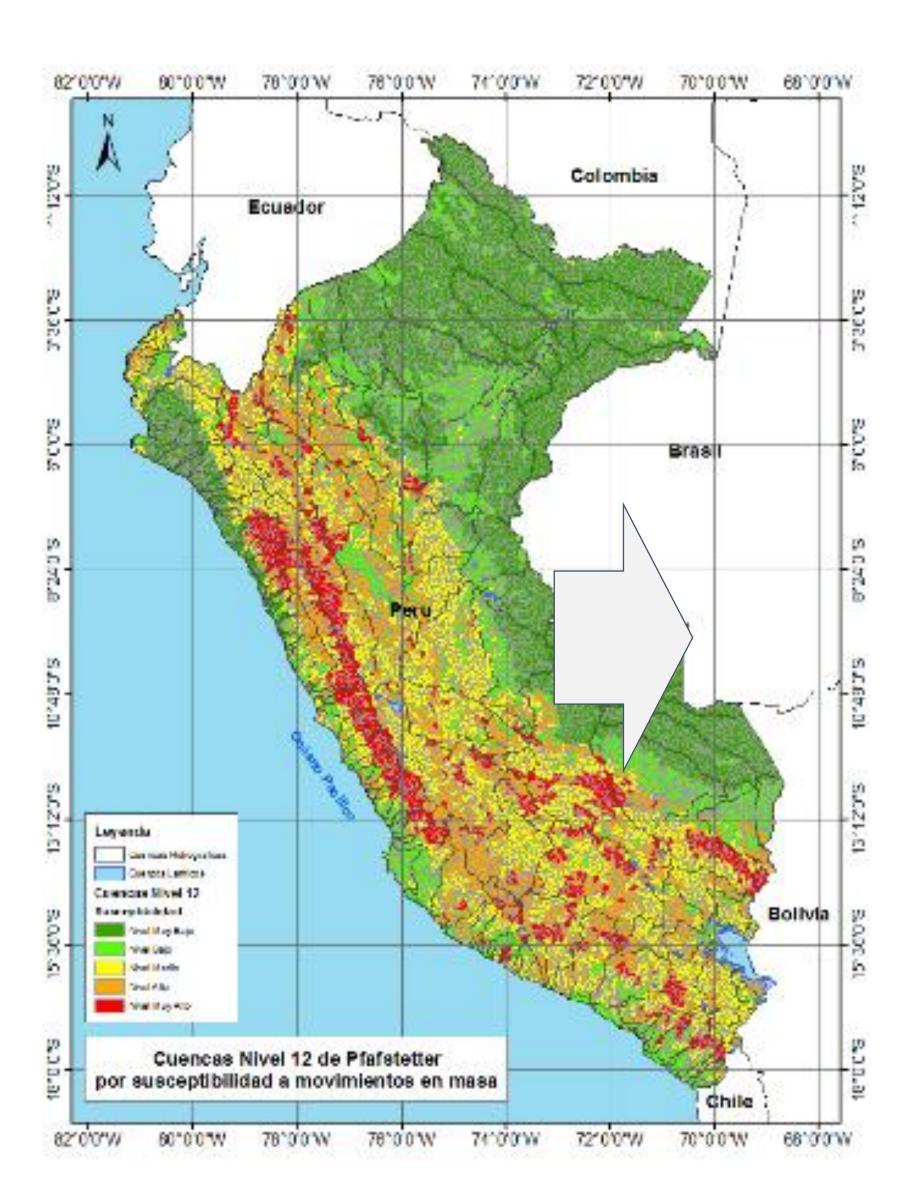
Algorithm to define the hazard of landslides forced by heavy precipitations

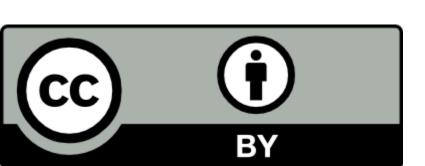




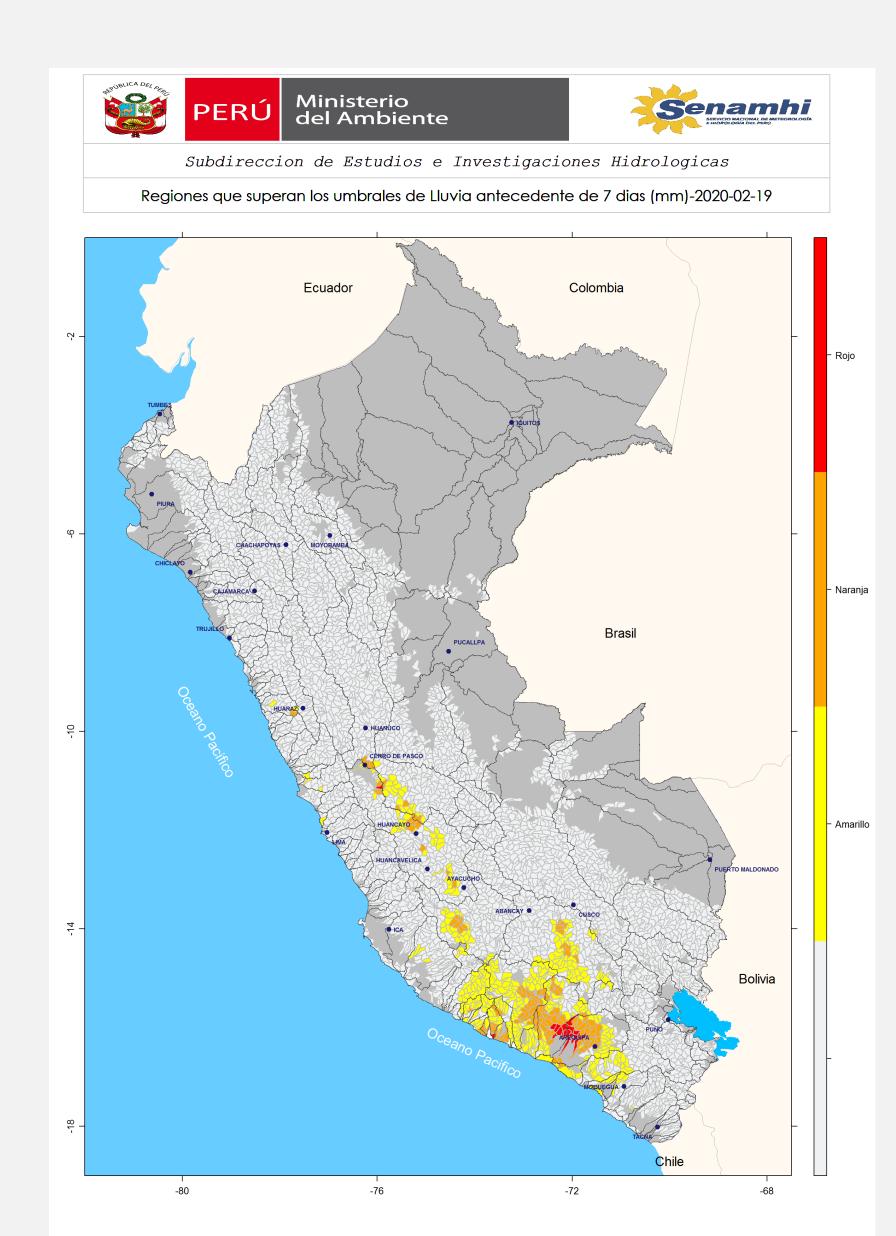
PISCO Operational Grid precipitation data

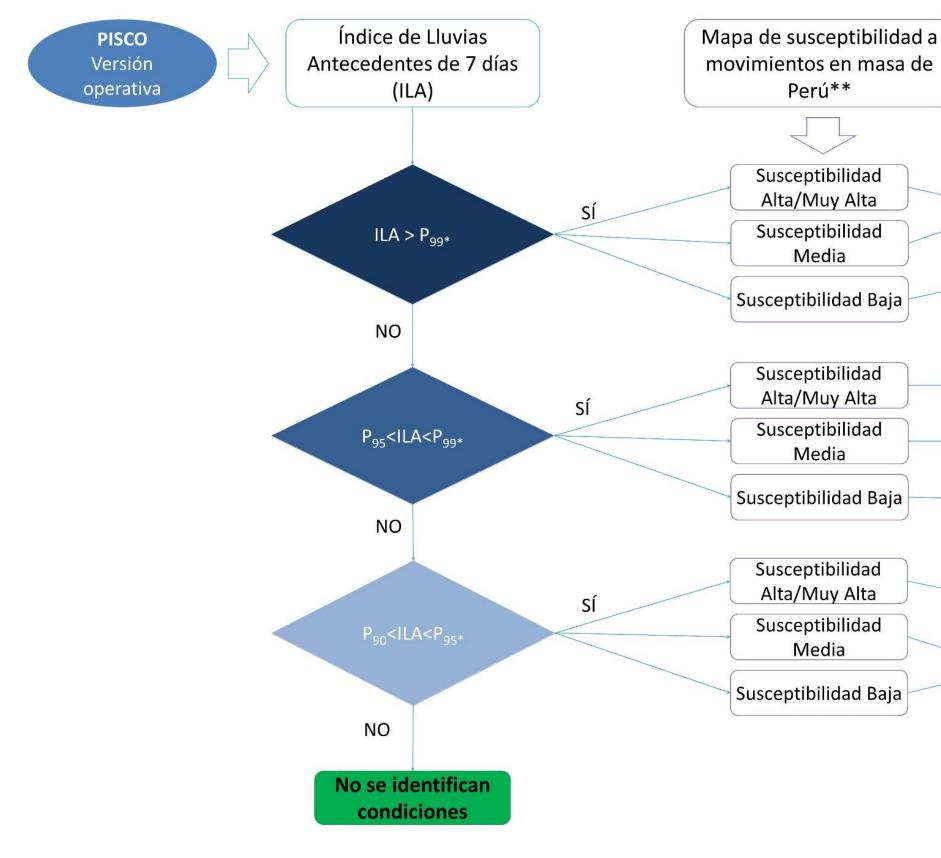
LANDSLIDE SUSCEPTIBILITY



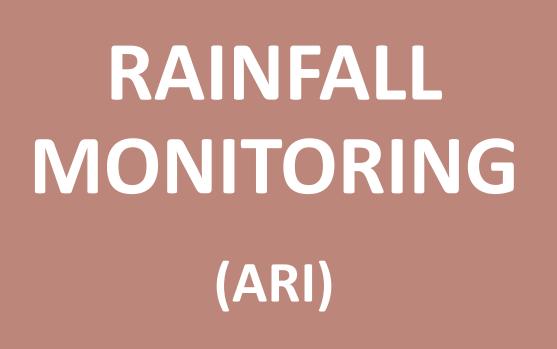


RAINFALL THRESHOLDS





* P99%, P95% Y P90%: Percentiles de ILA sobre la época de lluvia (NDEFMA) **Mapa de susceptibilidad del INGEMMET (2010)



HAZARD CLASSIFICATION

movimientos en masa de Perú** Susceptibilidad Alta/Muy Alta ROJO Susceptibilidad Media NARANJA Susceptibilidad Baja Susceptibilidad ROJO Alta/Muy Alta Susceptibilidad NARANJA Media Susceptibilidad Baja AMARILLO Susceptibilidad Alta/Muy Alta NARANJA Susceptibilidad Media AMARILLO

SILVIA

Seenamhi servicio Marcianal De Metroprología

Ministerio del Ambiente

Subdireccion de Estudios e Investigaciones Hidrologicas Peligro de movimientos en masa por lluvias intensas-2020-02-19

Ecuador Colombia Brasil

-76

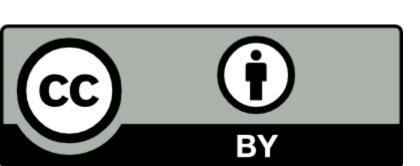
-80

RESULTS: Platform for the Monitoring and Forecasting System of Potential Mass Movements generated by Heavy Rainfall (SILVIA)

next link:

SILVIA was improved using precipitation daily forecasting and was implemented as a warning system generating a daily-time system to cope with streams activation in subbasins ("Activación de quebradas", https://www.senamhi.gob.pe/?p=aviso-activacion-

quebrada.



This work is showed at the web of SENAMHI, as a tool to monitoring the favourable conditions for landslides triggered by antecedent rainfall, at the

https://www.senamhi.gob.pe/?p=monitoreo-silvia

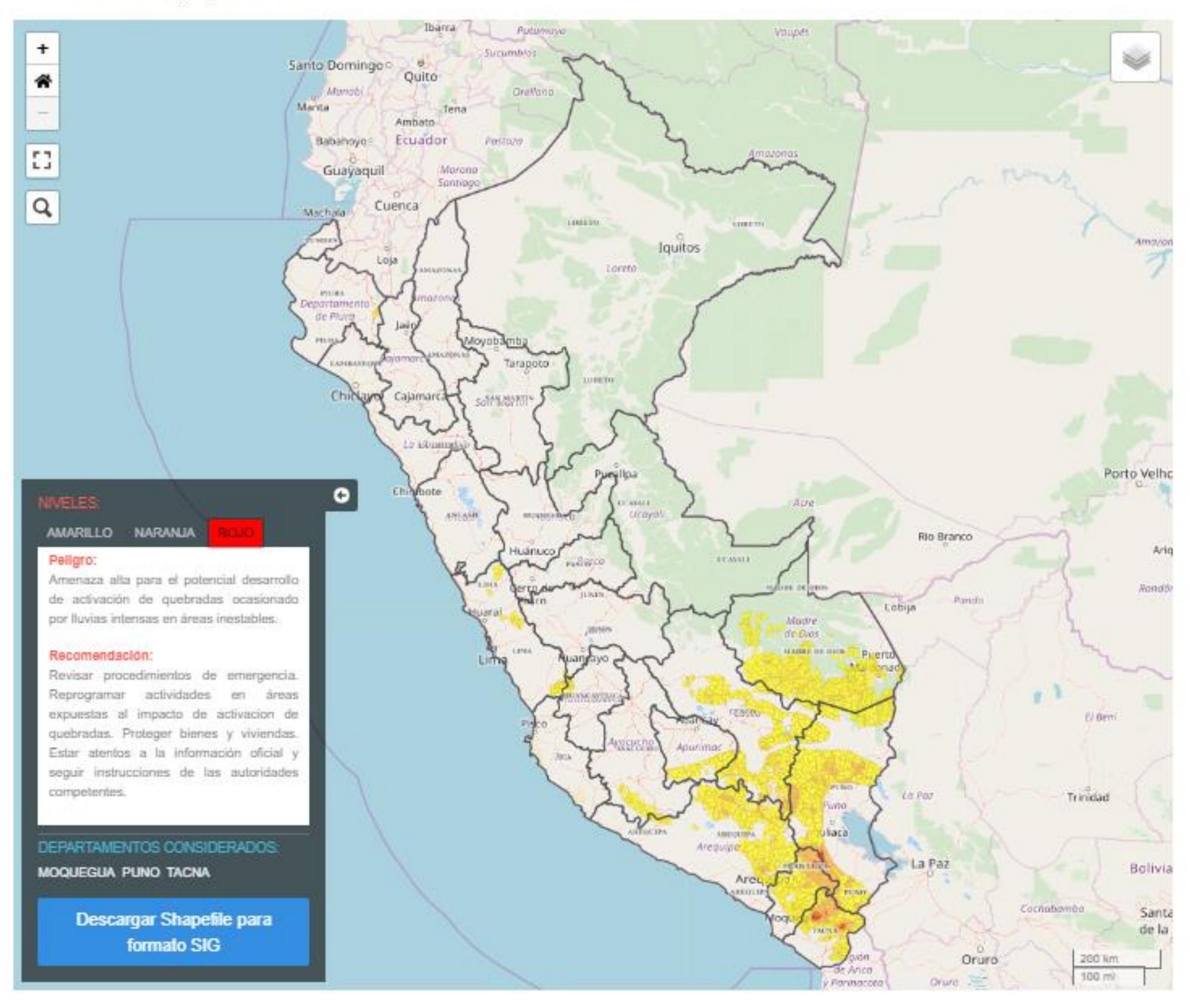
AVISO ANTE POSIBLE ACTIVACIÓN DE QUEBRADAS

Fecha de inicio: Duracion: Plazo:

Martes, 21 de Enero de 2020 (12:00) horas 24 hrs Corto Plazo

Estos avisos indican la posibilidad de activación de quebradas asociada a las lluvias pronosticadas para las siguientes 24 horas (aviso de corto plazo), considerando la lluvia de los 7 días antecedentes y la susceptibilidad a movimientos en masa.

En el contexto de estos avisos, la activación de quebradas (o huaycos) se refiere a los flujos de agua y movimientos en masa rápidos en quebradas o cuencas pequeñas resultantes de la acción de las lluvias precedentes y actuales y las condiciones geológicas. Incluye flujos de lodo, crecidas de detritos, y flujo de detritos.

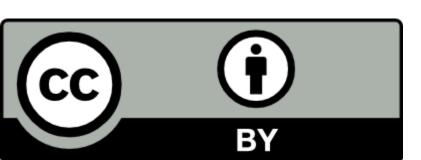


Aviso N°023

NIVEL ROJO

DISCUSSION

The level of representativeness, resolution and reliability of the variables: susceptibility to landslides and rain, are important for the reliability of SILVIA. SILVIA only considers antecedent rain as a triggering factor, and although rain has been determined to be the most important factor in causing mass movements, there are other temporal hydrometeorological variables that provide insight into how conditions develop. activation reviews. SILVIA considers rainfall thresholds that exceed the 90th, 95th and 99th percentiles of the accumulated series, according a global threshold, which must be updated and adjusted to regional thresholds estimated from monitored events.



PERSPECTIVES AND FUTURE WORKS

information.

This database, will be use to:

- calibrate and validate SILVIA



Registro de eventos de huaycos 2019

Registro donde se colocara los eventos de huaycos ocurridos en el 2019 ATENCION SOLO CAUSADOS POR LLUVIAS INTENSAS

*Obligatorio

Dirección de correo electrónico

Tu dirección de correo electrónico

Fecha*

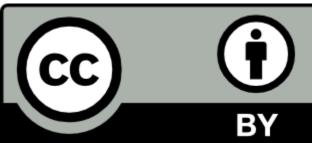
Fecha

dd/mm/aaaa

Hora

Hora

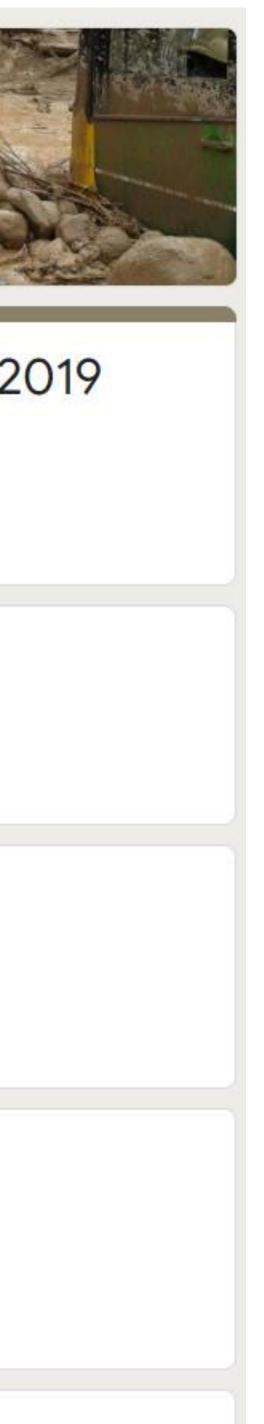
· _ · _ _



Poblacion mas cercana(pueblo, distrito)

SENAMHI implemented a landslides registration system to get a landslide triggered by rainfall database, with a relevant

adjust and generate new thresholds at regional scale

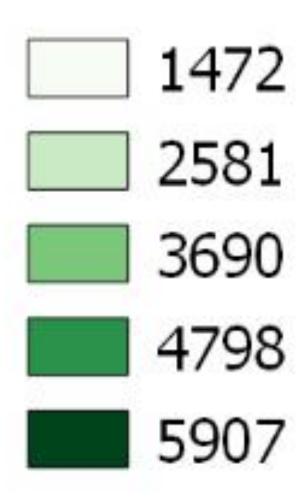


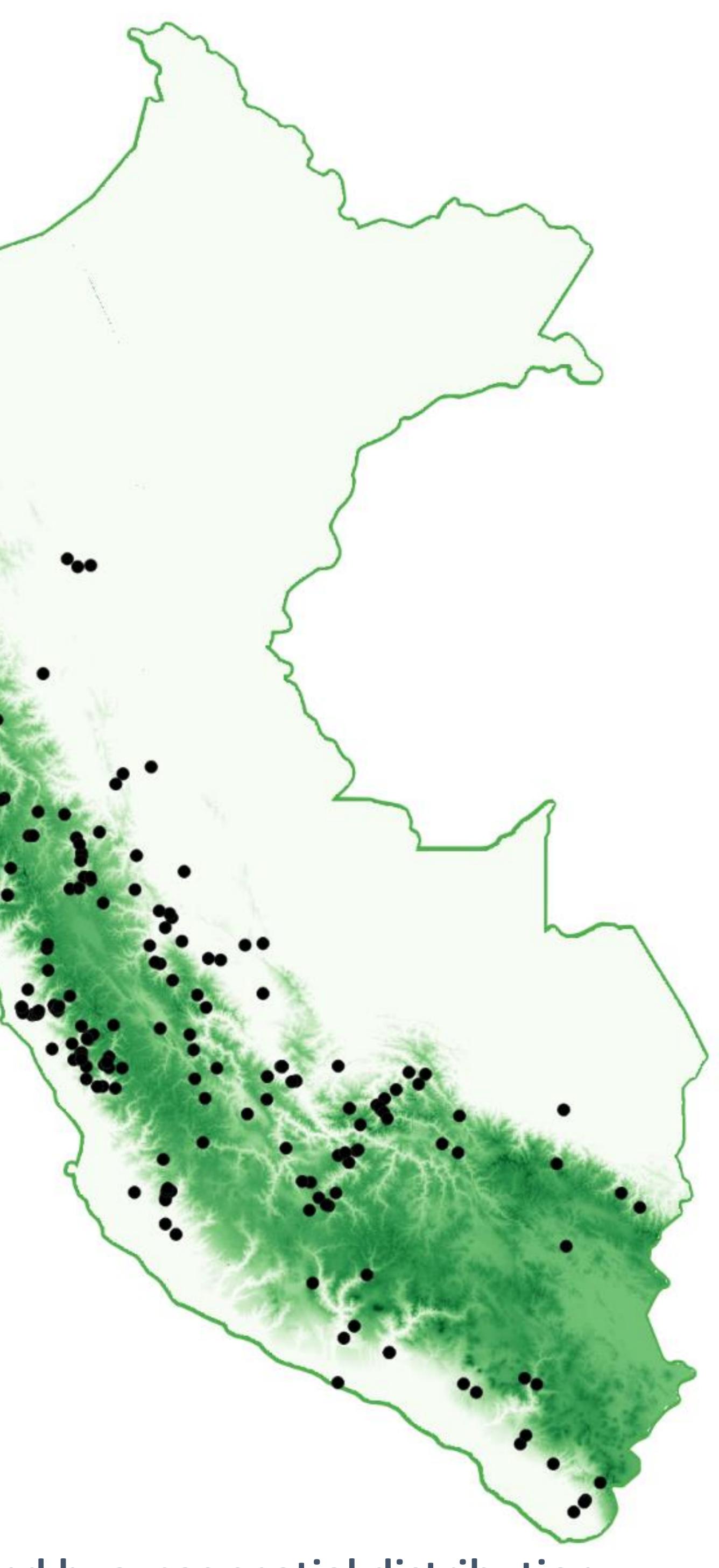
229 events registered to date: 63 events during 2017 42 events during 2018 124 events during 2019



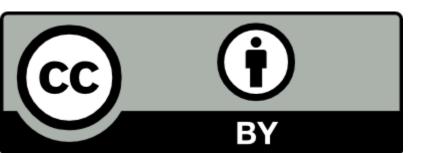


Altitud





Landslides and huaycos spatial distribution



GRACIAS DANKE THANKS

Questions and suggestions are welcome: cmillan@senamhi.gob.pe





