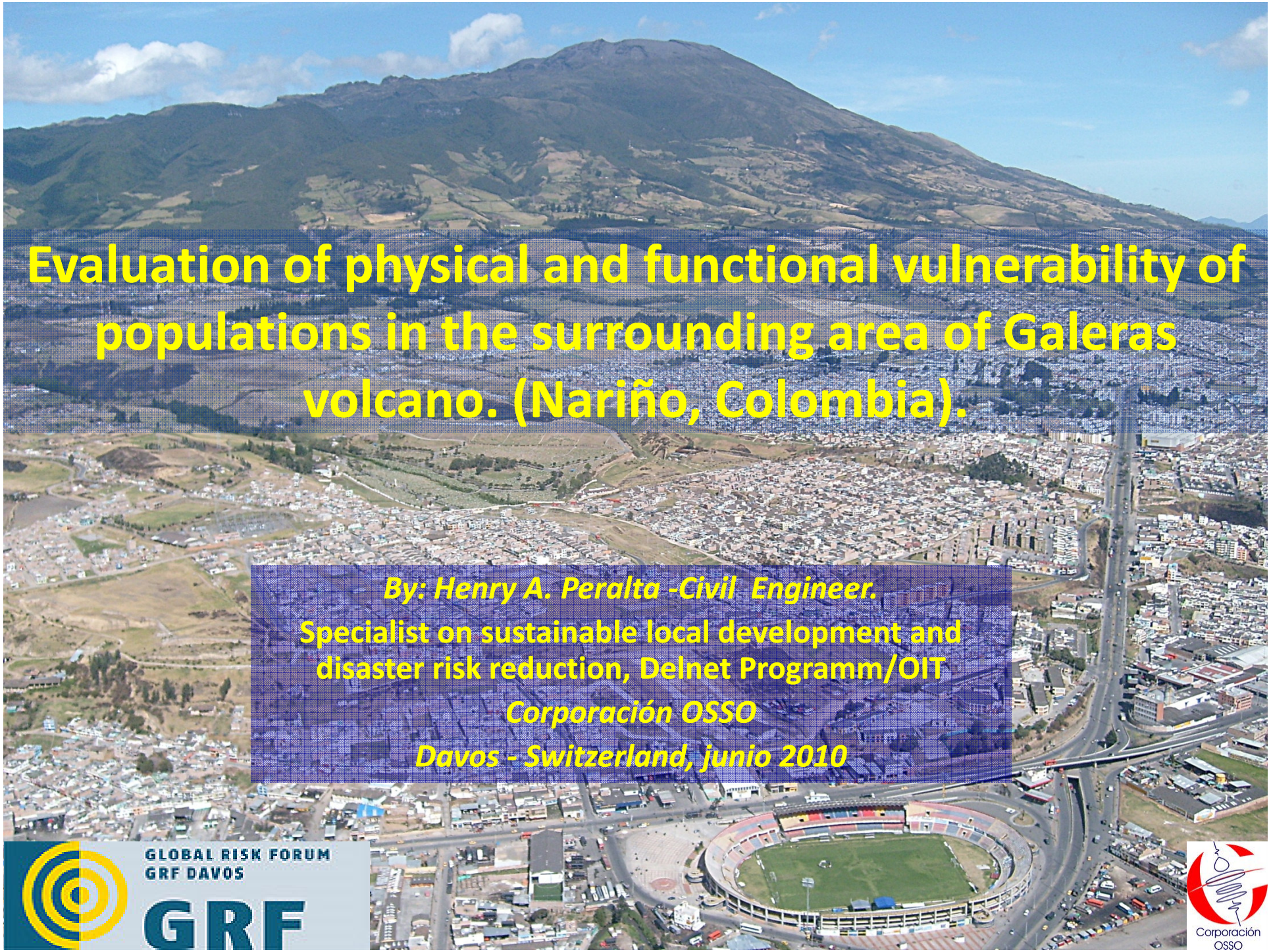

Evaluation of physical and functional vulnerability of populations in the surrounding area of Galeras volcano. (Nariño, Colombia).

By: Henry A. Peralta -Civil Engineer.

Specialist on sustainable local development and disaster risk reduction, Delnet Programm/OIT

Corporación OSSO

Davos - Switzerland, junio 2010

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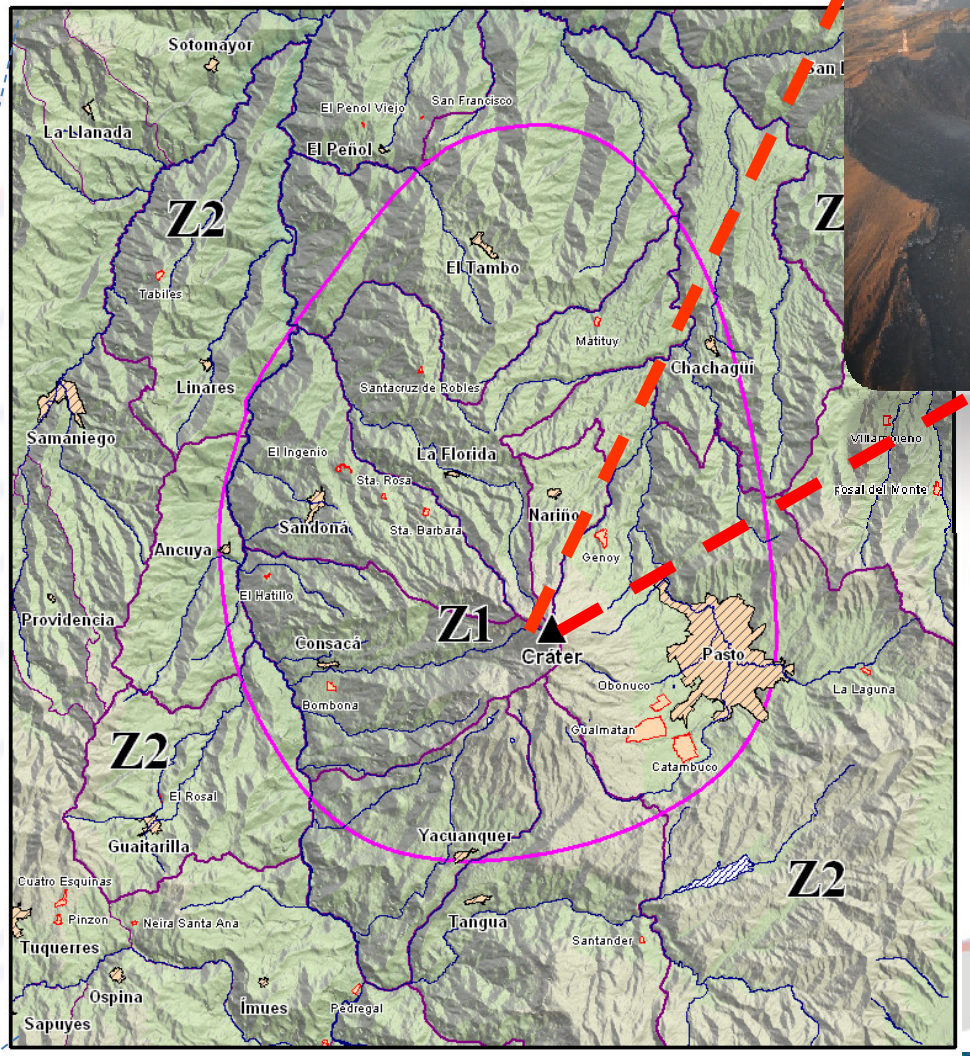
Where is located Galeras volcano?

South America

Colombia

State of Nariño



Galeras Volcano Crater

Galeras volcano is located in the state of Nariño, southwest Colombia in South America. It reaches a height of 4.276 meters.

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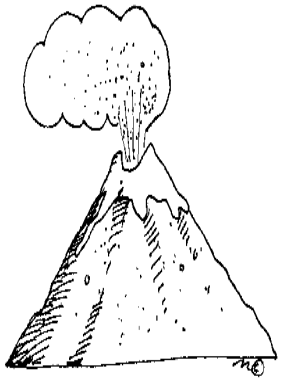
What is the importance of studying the vulnerability?



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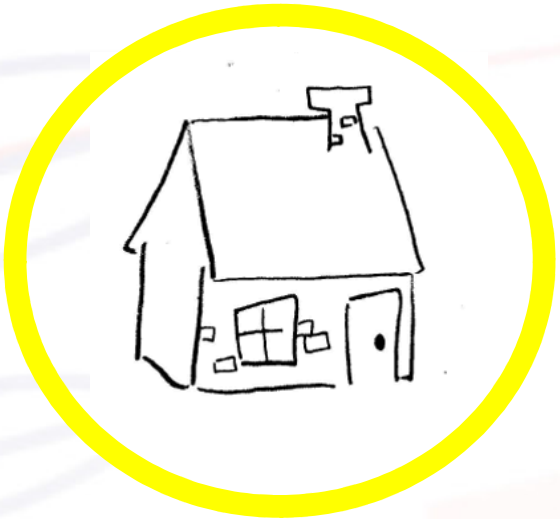

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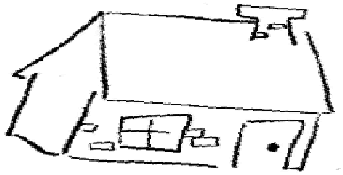


HAZARD **VULNERABILITY** **RISK**

- First , compared with the threats, the vulnerability is a risk factor little studied.
- Also the vulnerability is the result of human actions. And can be controlled and reduced.
- And the most important is reducing the vulnerability, will reduce the risk.

What is the problem?

•Urban growth toward areas of greater volcanic hazard, with population centers near to volcano crater, as a result of a poor spatial planning.

•This is a critical scenary, due to the continues volcanic activity of Galeras since (**1989**).

What is the problem?

- Settlement of Rural population in potential areas of occurrence of pyroclastic flows
- > 500,000 people exposed to various volcanic hazards
- The Economic and productive activities are exposed to volcanic hazards
- Location of physical infrastructure and important vital systems, in areas of volcanic hazards

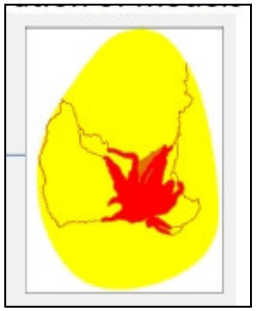
What has been done?

1989

Galeras volcano activation. after the reactivation of Galeras volcano , the Colombian government established a state policy for the assessment and prevention of volcanic hazards.

1997

Volcanic Hazard Map. INGEOMINAS a scientific institute of the government, made the third and current version of the volcanic hazard map for Galeras volcano.



2005

Galeras volcano Eruption. As a result of a new Galeras volcano eruption, the Colombian government made a disaster declaration, in order to initiate a population resettlement program called "**Galeras Process".**

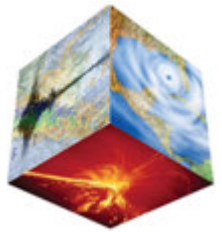
Corporación OSSO

2008

Evaluation of physical and functional vulnerability. The Colombian government delegated to Corporation OSSO to do the physical and functional vulnerability evaluation.

2010

Probabilistic assessment of volcanic hazards with **CAPRA**. **Lastly in the current** year it was possible to initiate a pilot exercise for CAPRA methodology, in Galeras Volcano



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What were the objectives of the study?

1. The first objective was the evaluation of ***Lifelines; essential buildings; housing and population sector, agricultural and industrial sectors; ecological and natural areas, in 11 towns*** around the volcano.

2. The second objective was the Evaluation ***of water sources and systems of water supply***

3. And the third was the Evaluation of possible ***resettlement areas and future developments***

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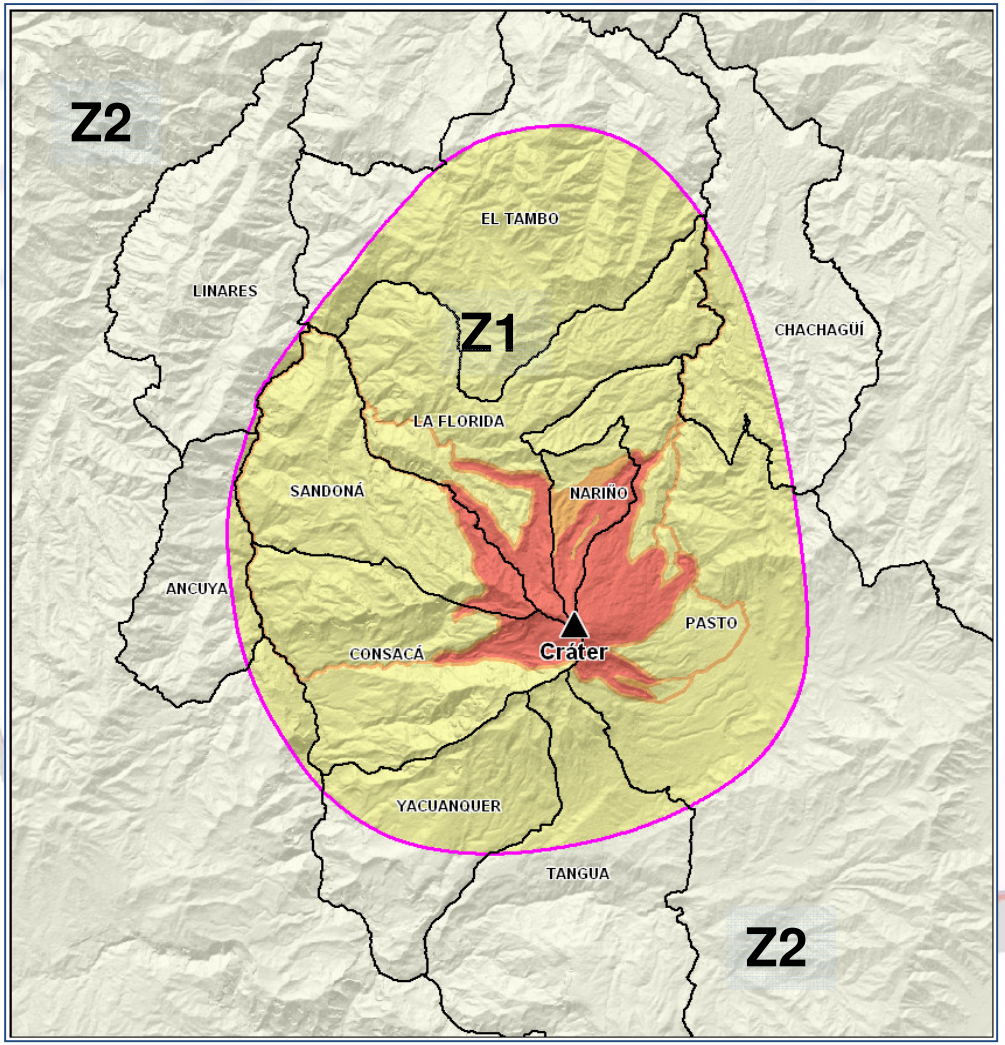
What was the studied area ?

It Corresponds to an 888 km^2 area around volcano Galeras' crater, which was divided in two zones:

Volcanic hazard map



(1). **In Zone one**, the ***Physical and functional Vulnerability Assessment of existing elements***

(2) **In Zone 2**, the ***Evaluation of possible population resettlement areas***

Limited of volcanic hazard area (Ingeominas , 1997)

High threat zone

Medium threat zone

Low threat zone

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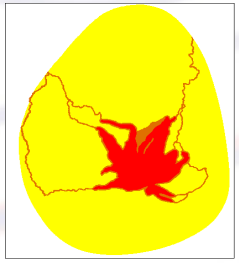
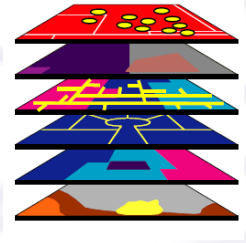
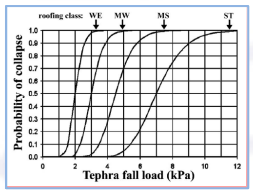
What were the steps to do the study?



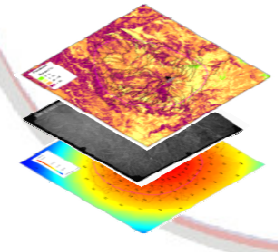
1.DISAGGREGATE THE VOLCANIC MODEL THREAT



2. INVENTORY OF EXPOSED ELEMENTS



3. ATTRIBUTE FOR RATING THE PHYSICAL AND FUNCTIONAL VULNERABILITY



4. SPATIAL ANALYSIS

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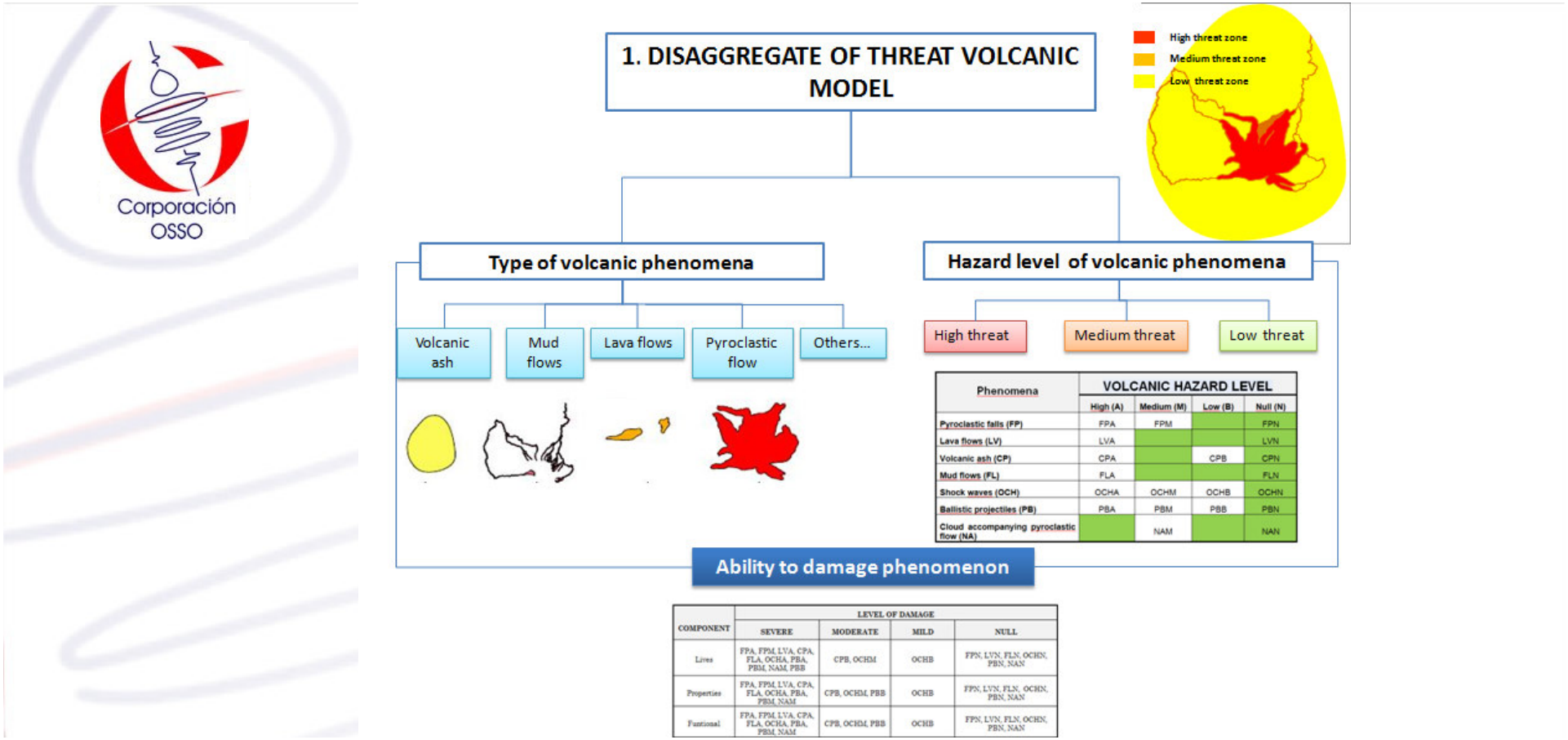
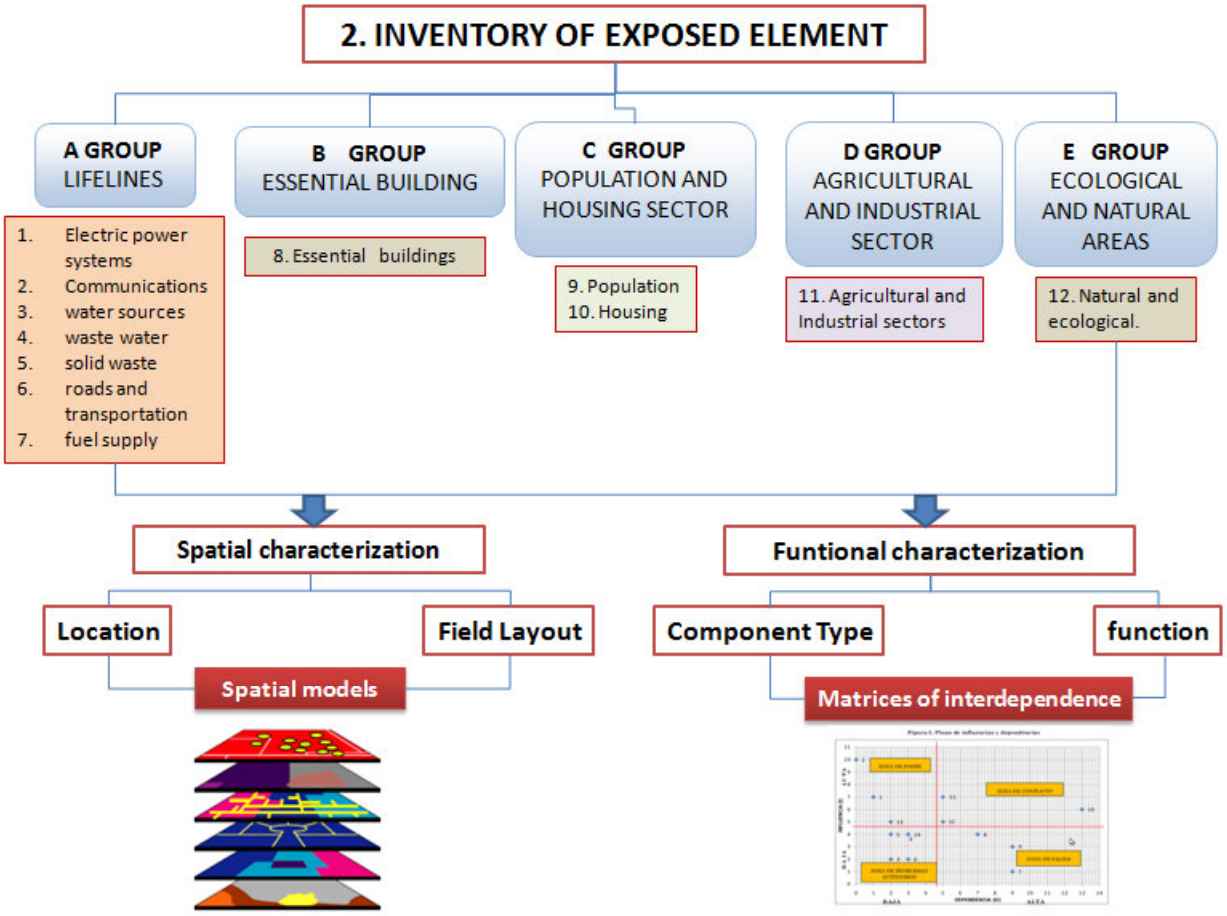


•The first step consisted in disaggregating the model volcanic threat for each type of phenomenon: Lava flows, volcanic ash, mud flows, ballistic projectiles, shock waves, pyroclastic flow and accompanying cloud pyroclastic flow.

•It was also necessary to characterize their threat on the life, property and functionality of the system, accordingly to the volcanic threat level: high, medium and low.

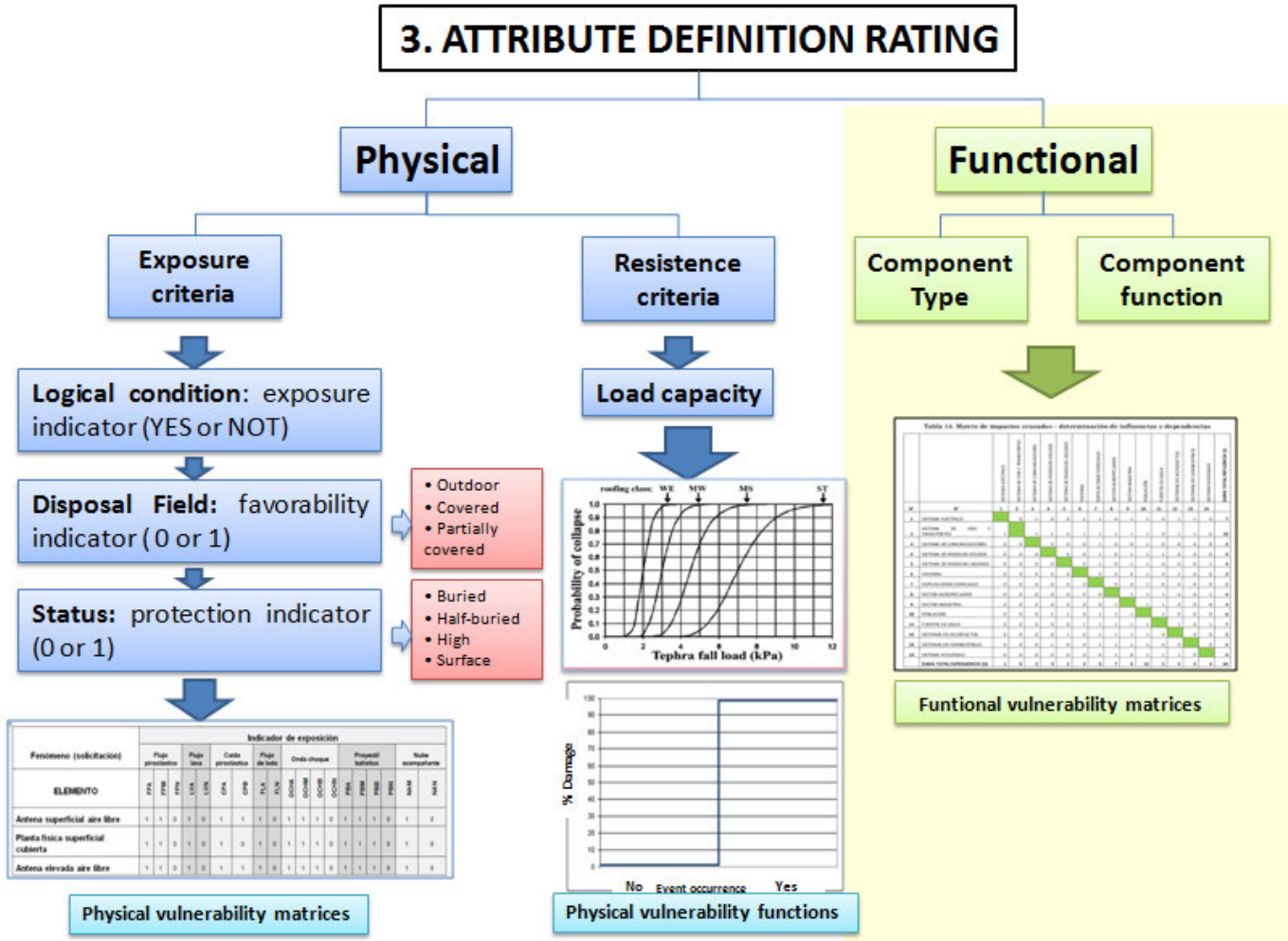
•With these two parameters were defined the damage level (SEVERE, MODERATE, MILD AND NULL)



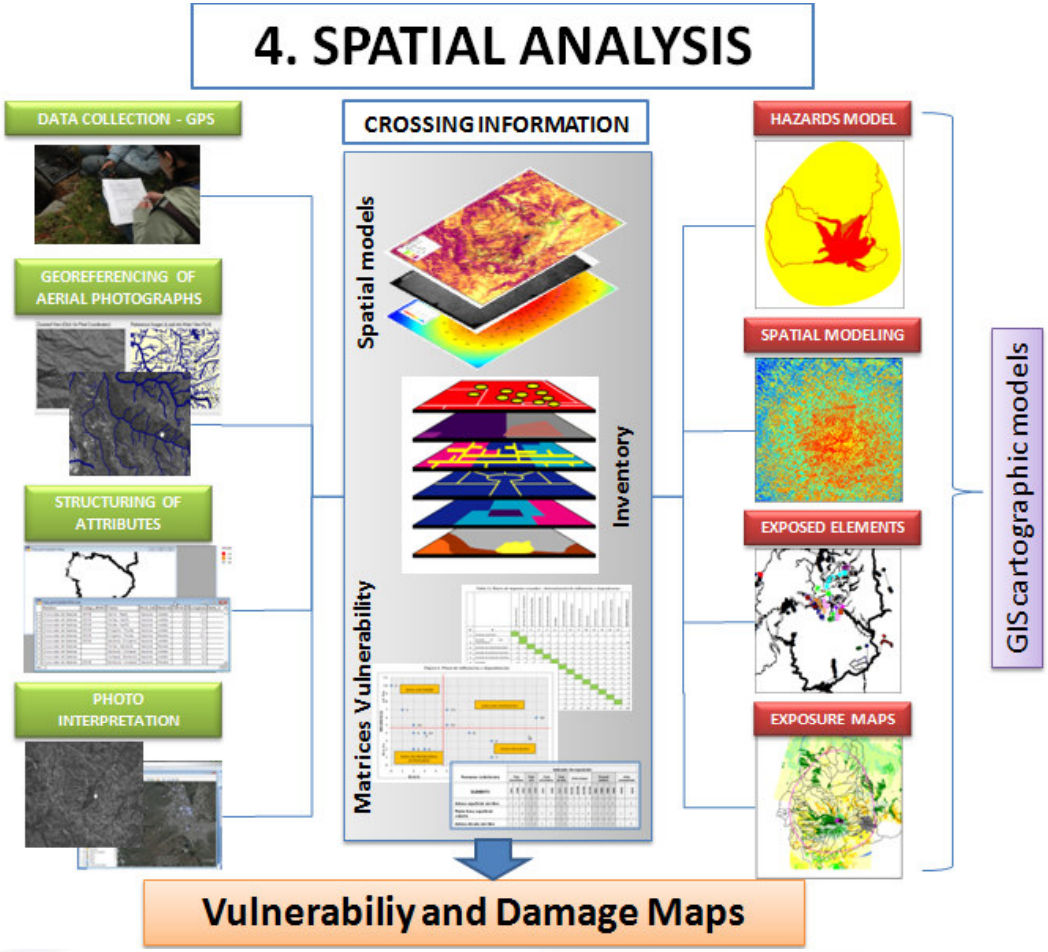
•The second step was the inventory of the elements outlined in the TERRITORIES, using different techniques for the gathering and processing information such as: reviewing existing studies, field surveys with GPS data, photo interpretation of satellite imagery, etc.

•12 types of exposed elements were evaluated

•This information was characterized in terms of the definition of its attributes: SPATIAL AND FUNCTIONAL.



- The third step was to define the attributes to describe the vulnerability, in terms of two criteria: Exposure and resistance, which were represented in functions and / or matrices of vulnerability.
- To evaluate the functional vulnerability was constructed a matrix of interdependence of each system components , using the criterion expert and effects observed in other systems. Two parameters were described: the level of importance and the level of dependence.



- This last step was the combination of all attributes defined : Data collection – GPS, Georreferencing of aerial photographs, Structuring of attributes, Photo interpretation, Hazards models, Spatial modeling, Exposed elements and Exposure maps.

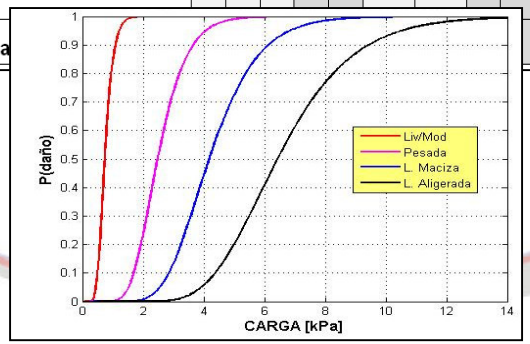
- This information was crossed with: The inventory of exposed elements, the Spatial model and the vulnerability matrices.

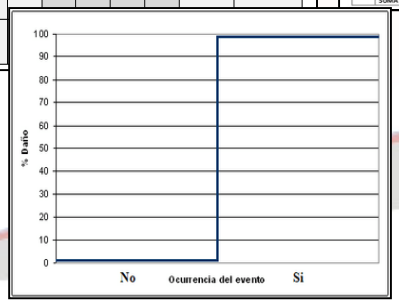
- Finally these were represented on vulnerability and damage maps.

Which were the main results of the study?

•First, according to the variables that describe the physical and functional vulnerability, based on analysis of impact scenarios for volcanic phenomena, were expressed **in vulnerability matrices for the most exposed elements and vulnerability functions.**

Fenómeno (solicitación)	Indicador de exposición																	
	Flujo piroclástico			Flujo lava		Caída piroclástica		Flujo de lodo		Onda choque				Proyectil balístico				Nube acompañante	
ELEMENTO	FPA	FPM	FPN	LVA	LVN	CPA	CPB	FLA	FLN	OCHA	OCHM	OCHB	OCHN	PBA	PBM	PBB	PBN	NAM	NAN
Antena superficial aire libre	1	1	0	1	0	1	1	1	0	1	1	1	0	1	1	1	0	1	0
Planta física superficial cubierta	1	1	0	1	0	1	0	1	0	1	1	1	0	1	1	1	0	1	0
Antena eleva										1	1	1							





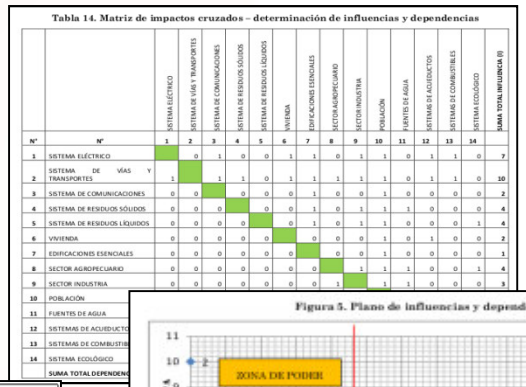
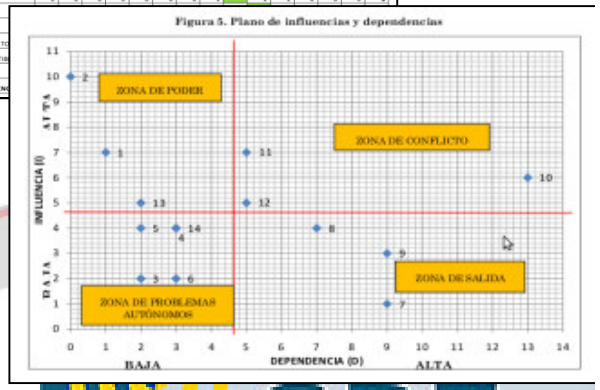


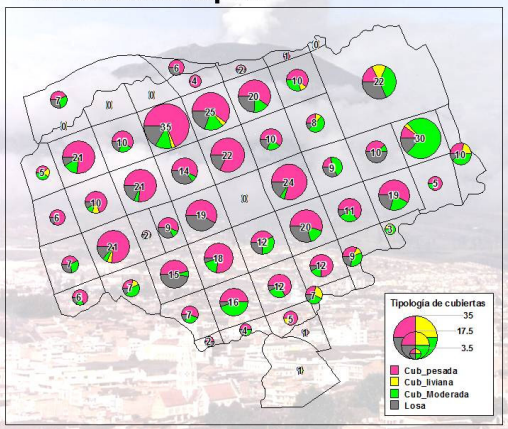
Tabla 14. Matriz de impactos cruzados – determinación de influencias y dependencias



•Secondly, in terms of mapping and GIS model. It also identifies priorities for detailed analysis involving modeling and quantitative analysis point, which would be the subject of future studies.

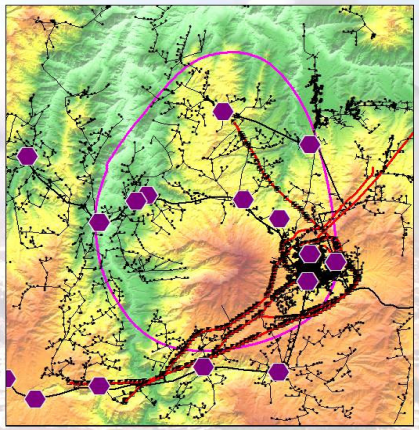
Viviendas (2009)

12 cabeceras municipales



Municipio	Viviendas
Ancuya	470
Chachagüí	621
El Tambo	925
Linares	419
Sandoná	1580
Consacá	536
Bomboná	317
Yacuanquer	655
Tangua	443
Nariño	631
Nariño rural	286
La Florida	317
Pasto	
Total	7200

Sistema eléctrico (2009)



Integración de cartografía de CEDENAR

Recorridos de campo apoyados con Equipos de GPS de última generación con posicionamiento en tiempo real sobre cartografía integrada.

Fotointerpretación de imágenes satelitales de alta resolución espacial (10 m) y temporal (< 3 años).

Fotointerpretación de mosaico de fotografías aéreas del IGAC de alta resolución espacial y temporal.

Subestaciones: 15
Torres de alta y media tensión: 171
Transformadores de media tensión: 2385
Redes de alta tensión: más de 200 km
Redes de media tensión: más de 300 km

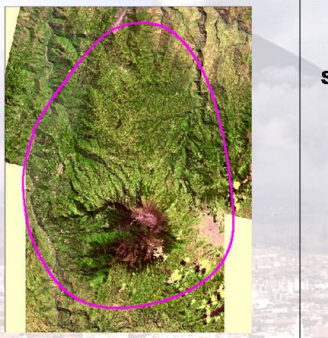


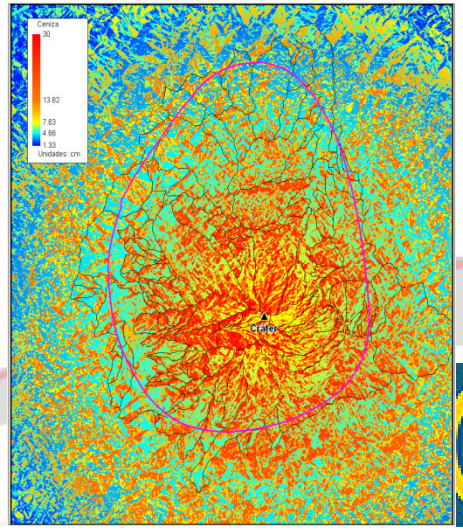
Imagen satelital
Matriz de 3468 columnas x 4452 filas
(15.439.536 *pixeles*)

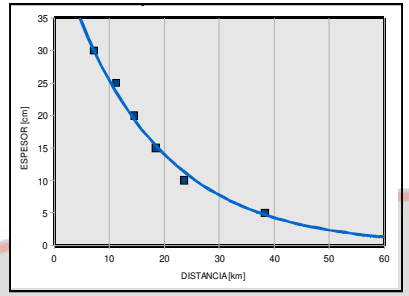
Sinergia bandas X1, X2, X3, Pancromática
Satélite SPOT

Resolución espectral: 24 bits
Resolución x,y: 10 m
Resolución T: < 4 años

Fuente cartográfica: SPOT – IGAC, PNN, 2005

Fuente SIG: Corporación OSSO, 2009





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Which were the main results of the study?

- In general, **the volume of exposed elements to physical vulnerability were high**.

San Juan de Pasto City

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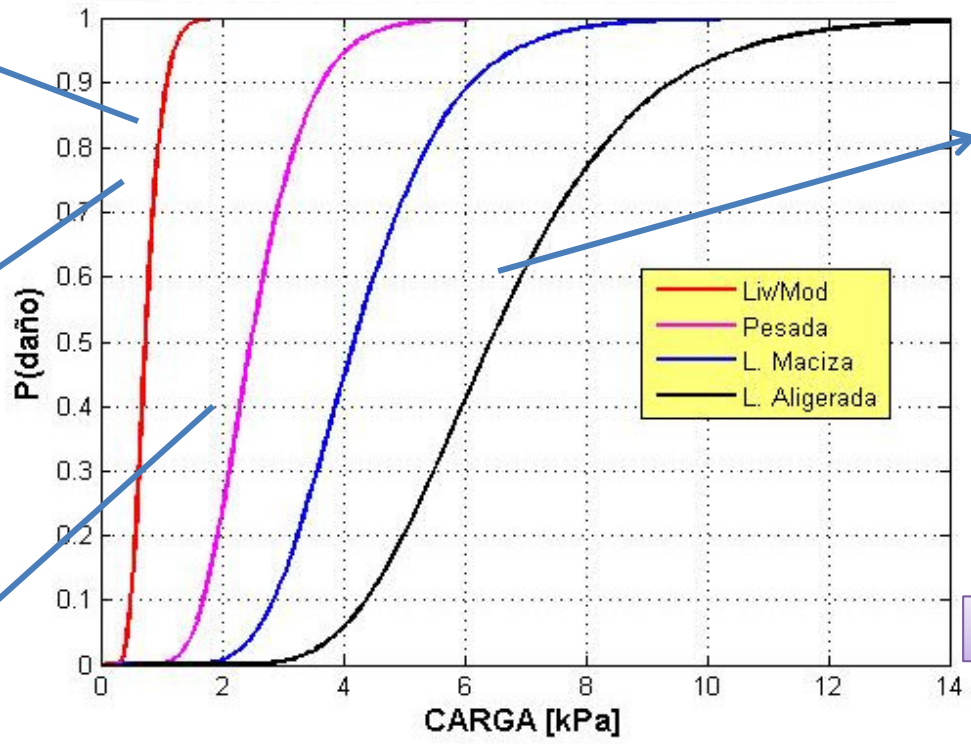
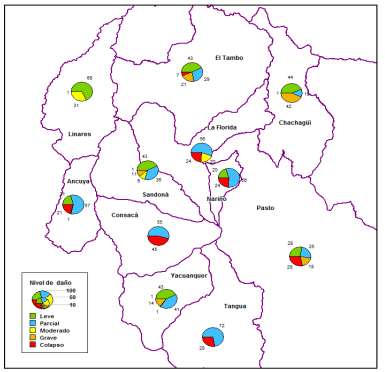
Which were the main results of the study?

•The predominant **physical vulnerability was for roofs** with low slopes and weak structures susceptible to collapse due to ash accumulation in the maximum scenario of threat.





Damage map in roofs

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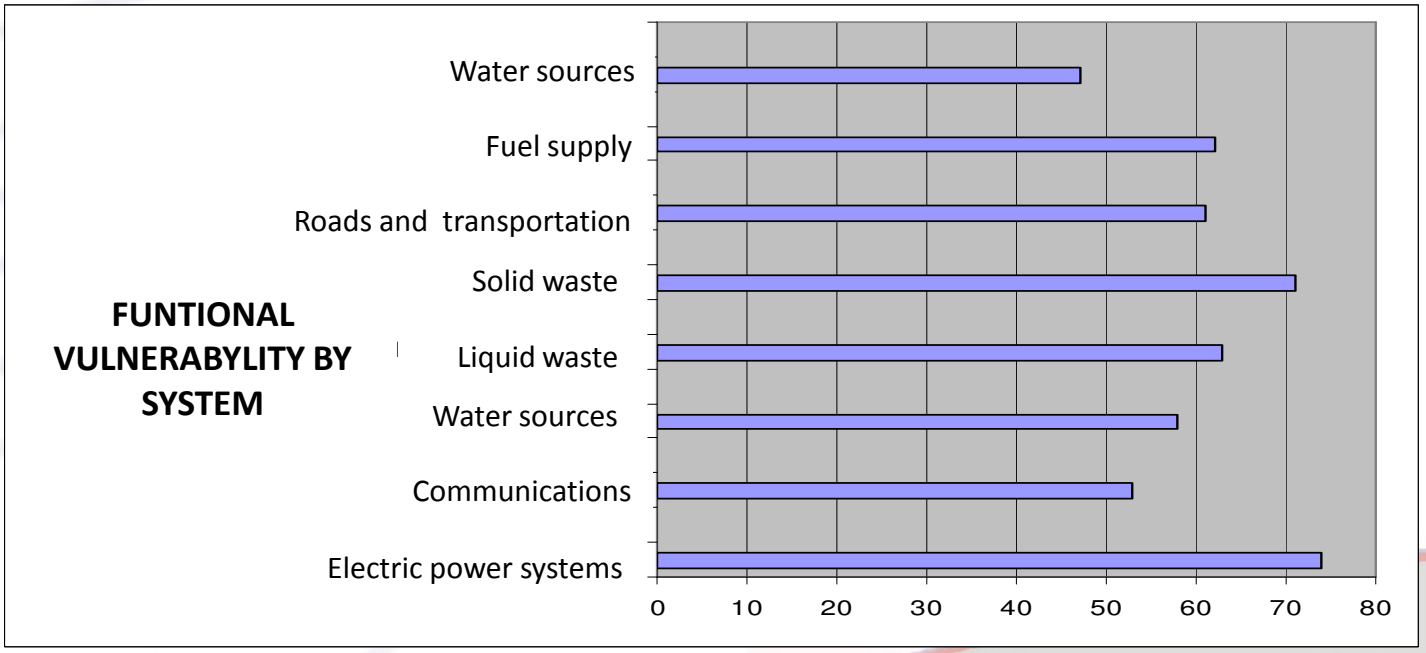
Which were the main results of the study?

•The higher functional vulnerability was for the Liquid and Solid Waste, the Electrical and Aqueduct systems, due to lack of redundancy factor.



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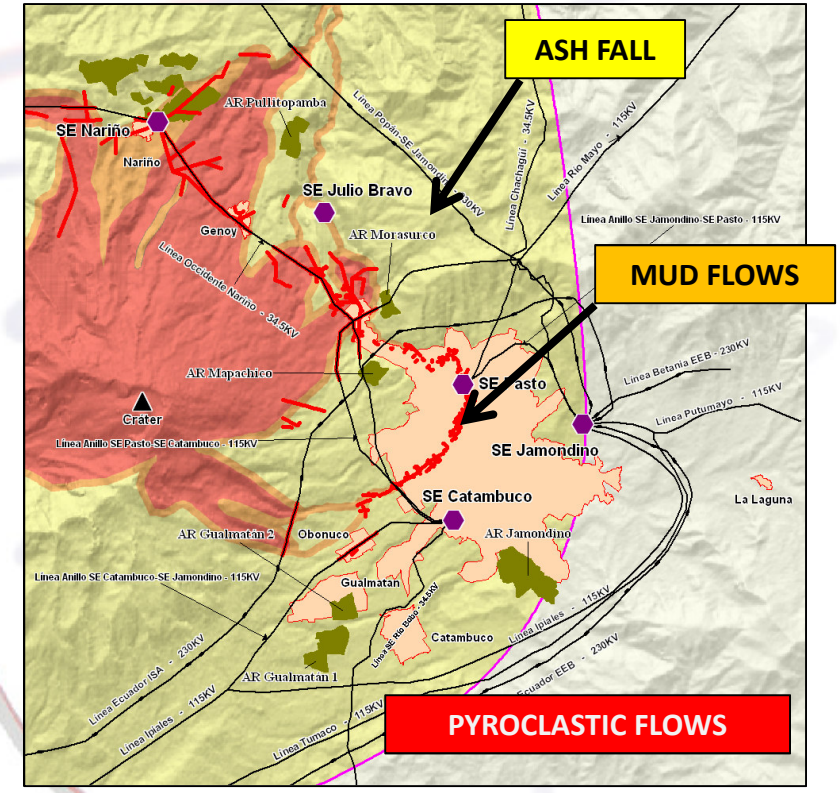
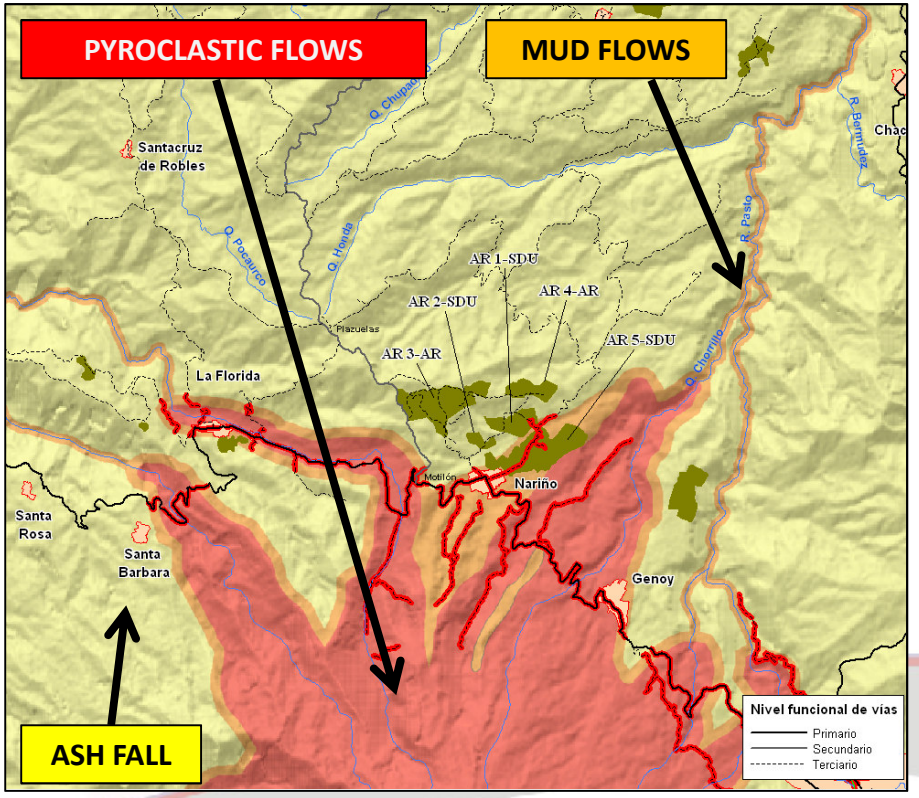
Which were the main results of the study?

•The higher physical vulnerability was for the **Electrical, Water Resources, Roads , transportation and Solid Waste systems**.



Damage map in **electric power systems**



Damage map in **Roads and transportation**

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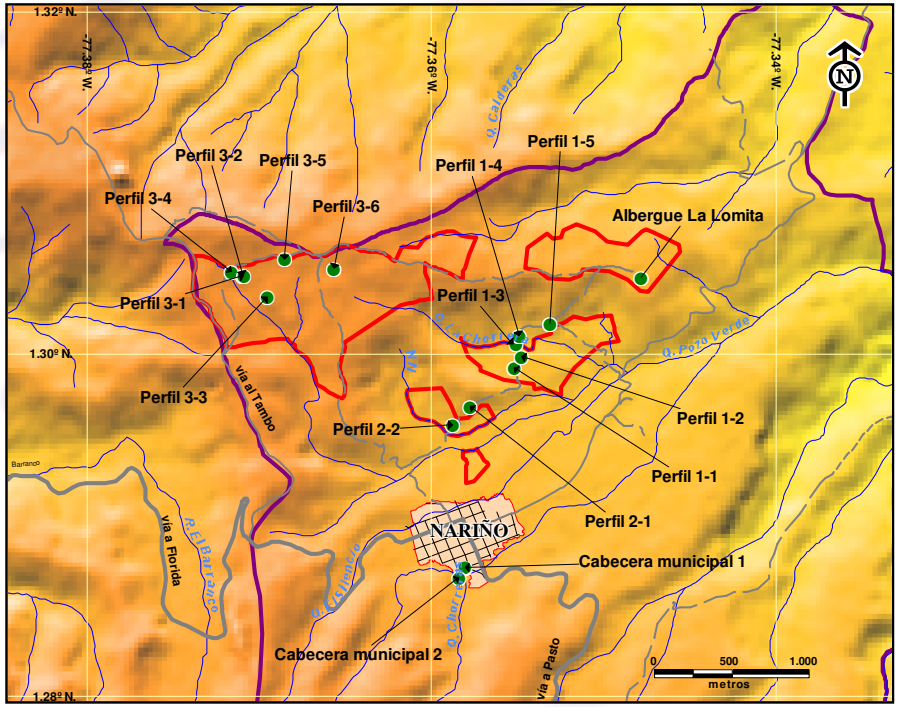
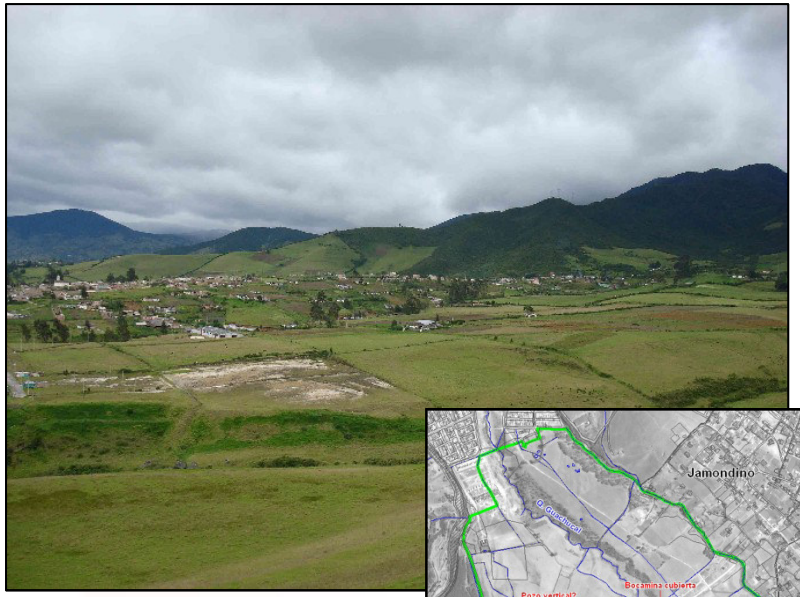
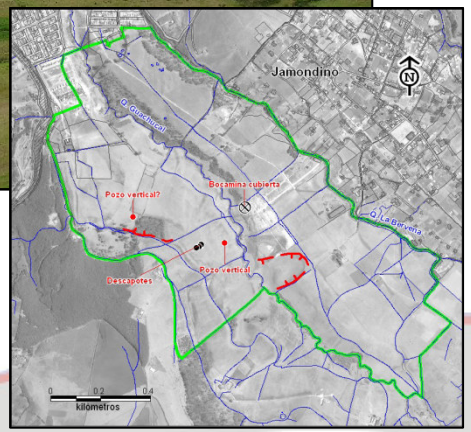
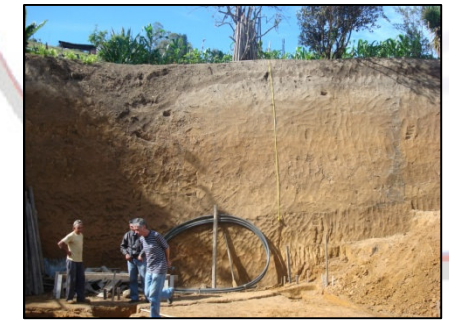
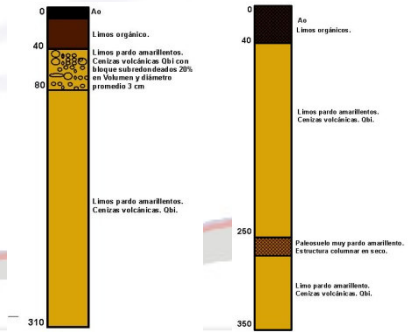
In relation with **'Evaluation of potential development areas'** in less dangerous volcanic areas, we found that most of evaluated areas, had the necessary geological conditions for resettlement use.











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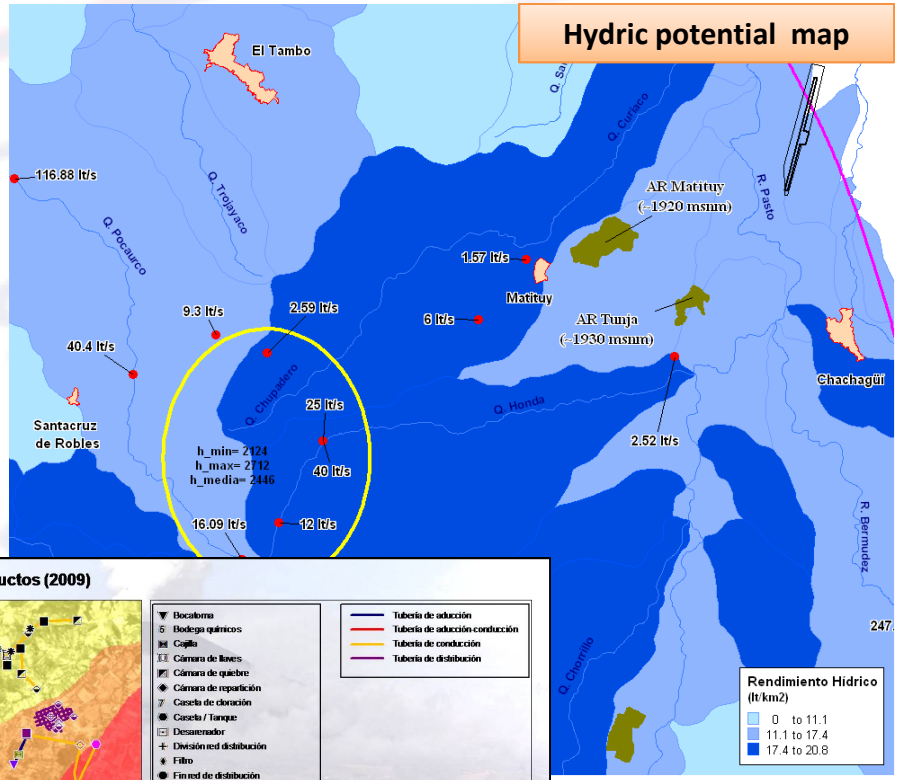
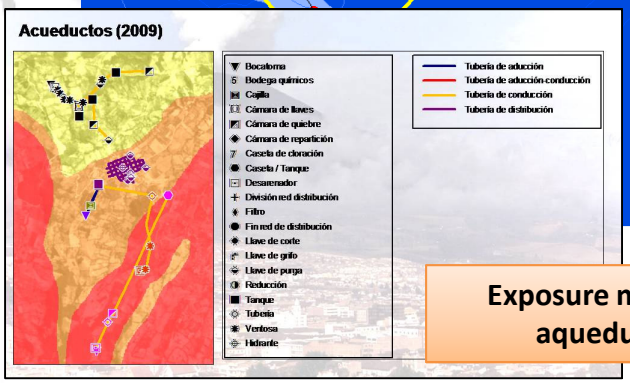
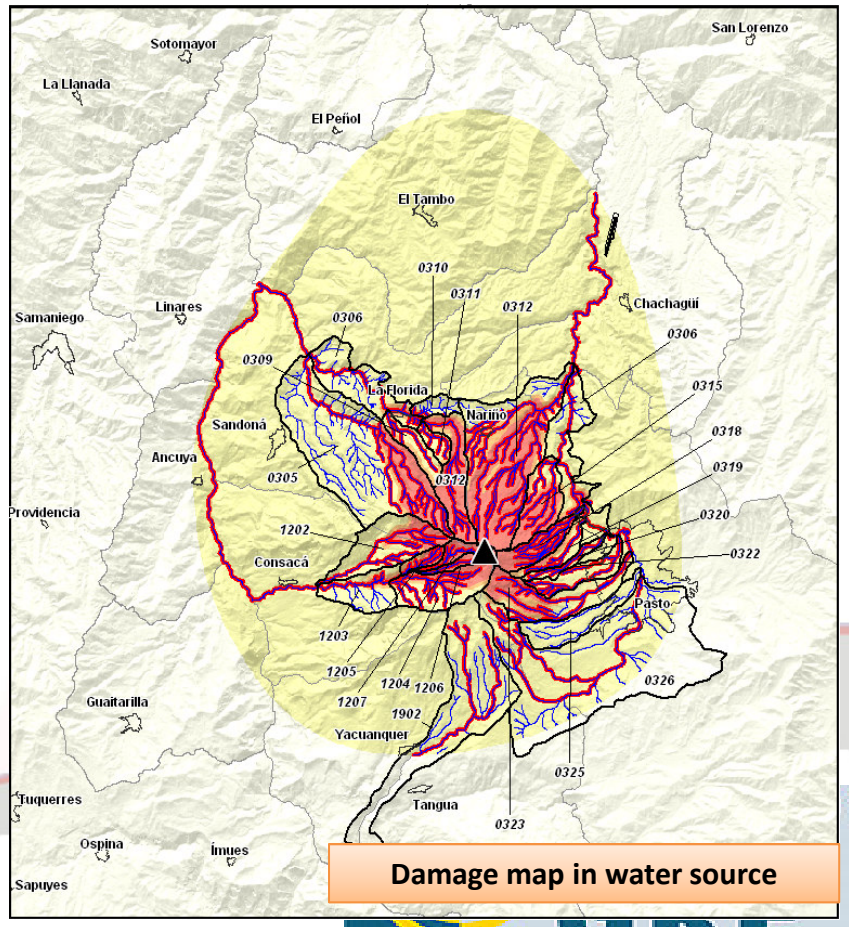
The **water sources and water supply** systems could have total destruction of their components mainly in the areas of direct influence of the pyroclastic flows.



Hydric potential map

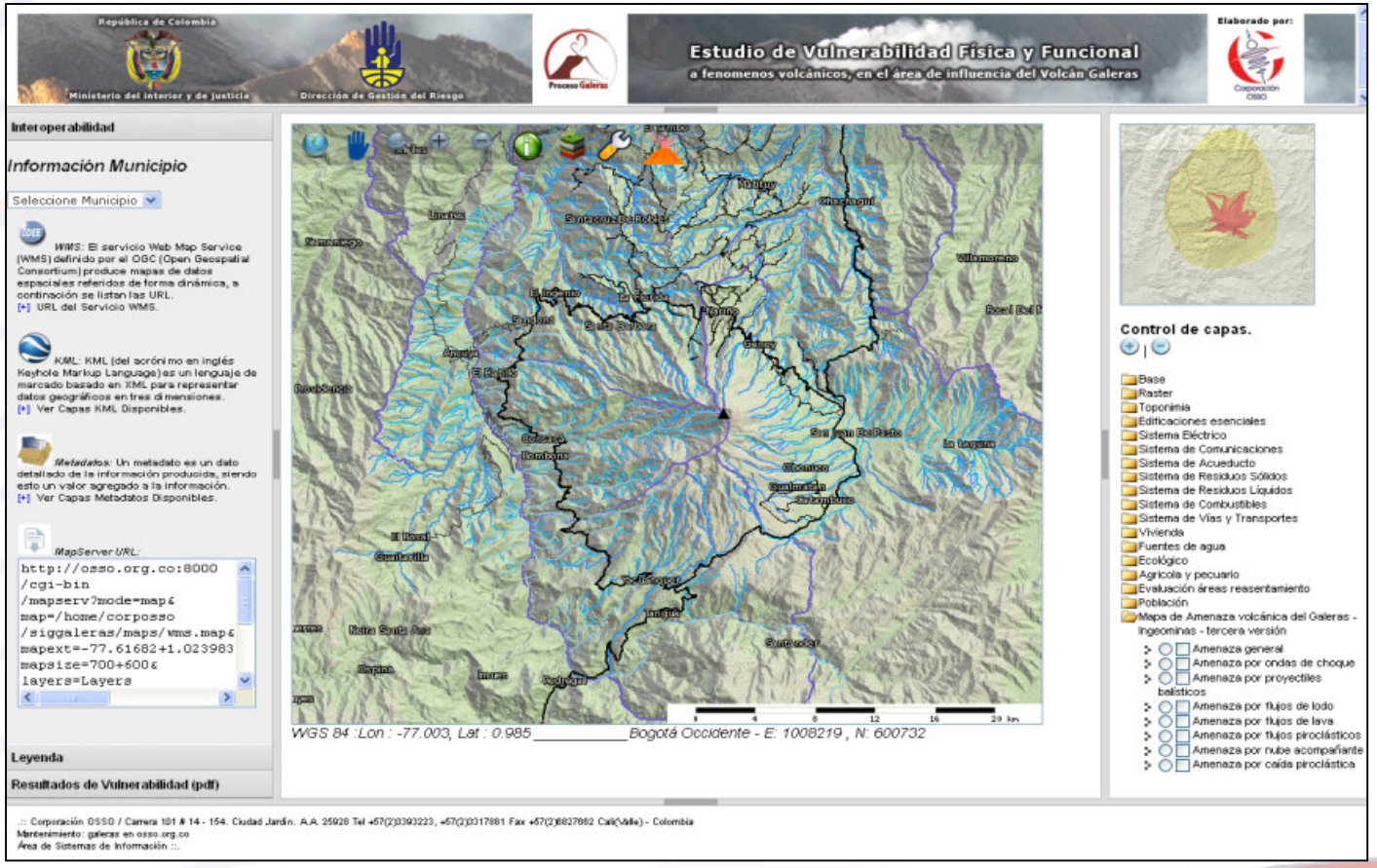


Exposure map of aqueduct



Damage map in water source

All inputs and results of the study were systematized in a database and public domain GIS, called **"SIGVULGALERAS"**



http://sigvulgaleras.osso.org.co

What were the main conclusion of the study?

•The results of an evaluation of physical and functional vulnerability can be applied to several purposes: to estimate the risk (probability of loss), together with a hazard model, the design of plans and actions to reduce vulnerabilities of the exposed elements, and also design measures to control the vulnerabilities of future elements in exposed areas.

•The study results are accessible to all sectors of the population (communities, institutions, academies, etc.), to allow them to have the knowledge about vulnerability conditions. In order to identify mitigation measures, defining capabilities and responsibilities.

• The study seeks to implement actions to prevent, control, manage and / or reduce volcanic risk in the influence area of Galeras volcano, which may involve different **strategies within a range of actions such as: control, escape, evasion, avoidance, preparedness, redundancy, transfer of risk, among others.**

Thank you very much…

For more information:

Henry A. Peralta. heperalt@osso.org.co
Civil Engineer. Specialist on sustainable local development and disaster risk reduction, Delnet Programm. Corporación OSSO, Cali – Colombia – South America
http://www.osso.org.co

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