Comprehensive vulnerability of the parishes of the canton of Santa Elena: A principal components approach, 2022

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Abstract

There are several ways of calculating the vulnerability of territories, in which socioeconomic, physical, infrastructural and legal aspects, among others, are determined, but no methodology integrates all these aspects into a single function. Under this context, it is proposed to build and apply an integral methodology based on development approaches and other variables that relate the territories' vulnerability with the construction of disaster risk indicators. The proposed methodology is the principal component analysis, which proposes a system of integration of variables and quantitative indicators that involve all the dimensions of the territories' vulnerability explained through their variance. The use of 51 indicators from official statistical sources and in-situ data collection was specified. The main conclusions are that there are differences between the official planning results, in contrast with the proposed model of integral vulnerability; since the evolution and adaptation of the territories are not efficiently reflected in the current methodologies, vulnerability indicators are over- and under-dimensioned, resulting in inefficient disaster risk policies. The proposed model involves many dimensions adapted mathematically so that the territories can identify their vulnerability and thus adequately channel sustainable programs and projects.

Keywords: *integral vulnerability, principal components, disaster risk, territory and explained variance.*

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Resumen

Existen varias formas de calcular la vulnerabilidad de los territorios, en las que se determinan aspectos socioeconómicos, físicos en infraestructuras, legales, entre otras, pero no existe una metodología que integre todos estos aspectos en una misma función. Bajo este contexto, se propone construir y aplicar una metodología integral basada en los enfoques del desarrollo y otras variables que relacione la vulnerabilidad de los territorios con la construcción de indicadores de riesgo de desastres. La metodología propuesta es el análisis de componentes principales, el cual propone un sistema de integración de variables e indicadores cuantitativos que involucren todas las dimensiones de la vulnerabilidad de los territorios explicadas a través de su varianza. Se precisó el uso de 51 indicadores de fuentes estadísticas oficiales y de levantamiento de información in-situ. Las principales conclusiones, es que existen diferencias entre los resultados oficiales de planificación, en contraste con el modelo propuesto de la vulnerabilidad integral, pues la evolución y adaptación de los territorios no se recoge eficientemente en las metodologías actuales, por lo que se sobre y sub dimensiona los indicadores de vulnerabilidad, lo que resulta en políticas de riesgo de desastres ineficientes. El modelo propuesto, involucra muchas dimensiones adaptadas matemáticamente, para que los territorios identifiquen su vulnerabilidad real, y así canalizar adecuadamente programas y proyectos sostenibles.

Palabras Clave: *Vulnerabilidad integral, componentes principales, riesgo de desastres, territorio y varianza explicada.*

1. Introduction

A fundamental reason for social concern for the environment has always been the existence of natural and anthropic threats to life and health since nature is the source of everything humans require for social existence and sustainable development.

Vulnerability is one of the variables that explain the function of disaster risk, together with exposure and hazard. It is related to the characteristics and circumstances of a community, system or asset that make them susceptible to the effects caused by some hazard. Some associated aspects that generate some degree of vulnerability are inefficient protection of assets, inadequate construction of buildings, lack of or insufficient information or public awareness associated with risk and hazards, limited official knowledge of risk, and preparedness measures and rejection of prudent and sensible environmental management (UNDRR, 2021).

The occurrence of natural and anthropic events must be assimilated and transformed into a starting point so that the various social, economic and environmental programs and projects that are promoted in the territories aim to strengthen the social fabric and its institutions so that the occupation of space is sustainable and sustainable, which among other aspects includes developing capacities that reduce vulnerability and therefore the risk of the population and can, in a resilient attitude, recover from the impacts produced by extreme and undesired events. In this context, it is important to mention the risk and its integral management in the territories.

For Wilhelmi & Hayden (2010), the intensity of negative impacts due to climate change variations, specifically those related to heat events, create an ideal scenario for mitigation strategies to be generated through social vulnerability. They establish that, for an adequate level of measurement of this variable, it is important to incorporate quantitative and qualitative methodologies that converge in multidisciplinary sub-variables such as Quantification of weather and climate, the natural environment, social processes and characteristics, interactions with the affected population, contexts of the relationship with society and the territory.

For Rohat et al. (2021), assessing extreme heat risk involves reviewing the alterations caused by this hazard and the vulnerability of the exposed population. Regarding the first scenario related to this hazard, they detail the historical analysis of the consequences of heat in the territories and incorporate future scenarios under climate projection parameters. In contrast, in the case of social vulnerability, they incorporate sub-variables such as economic development, demographic variations and urbanization.

According to Jongman et al. (2015), to measure flood risk, it is vital to determine social vulnerability to historically understand the adverse figures and verify the measures taken to anticipate these scenarios caused by this hazard.

According to Rosete et al. (2012), employing spatial models for the identification of areas most vulnerable to hazards derived from climate change alterations, probability equations are applied that determine from risk to hazard and vulnerability functions. This last variable is measured with factors such as exposure of the population to the hazard, fragility of elements for their infrastructure, type of housing, productive activities, degree of organization, warning systems, and institutional political development, among others.

The case of Ormazábal (2018), for determining vulnerability with a financial approach and by victims, perform an estimation of factors through the product of the variables: Fragility and losses. In the first case, the probability of causing damage by this cause in a certain intensity range is recorded, while the second is the probability of financial losses in terms of damage to buildings. With this index, it was possible to identify the dangerous and safe areas, shelter buildings and evacuation routes.

In general aspects, the Sendai Framework for Disaster Risk Reduction 2015-2030 was the first relevant agreement of a post-2015 development agenda, which details specific actions to protect the progress associated with the development of disaster risk in each of the member countries. In this agenda, the three fundamental dimensions that address the issue of disaster risk are determined: Hazard, Exposure, and Vulnerability. Based on this guideline, the agenda will guarantee the prevention of new risks, reduce existing risks and increase resilience (UNDRR, 2021).

The New Urban Agenda (NUA), signed in 2016, is a document from the United Nations Conference on Housing and Sustainable Urban Development,

which proposes efficient urban planning and development from its creation. As a fundamental axis, it establishes the problems that could be generated from rapid population growth, such as maintaining sustainability in terms of housing, infrastructure, basic services, security, and environment.

The relationship of this Agenda with ISDR is fundamental. Most buildings in Latin America have been constructed without considering the vulnerabilities associated with some type of natural hazard, such as floods, earthquakes, droughts, and climate variations.

This agenda's three main objectives are promoting the population's quality of life, an inclusive and competitive economy, and resilient and sustainable urban development (IDB, 2017).

Regarding the ways of measuring and calculating vulnerability, Jongman et al. (2015) perform aggregate analysis based on their measurement of the indicators described in the national accounts of the country under study, taking as an example the dynamism of the wealth of these through the evolution of the Gross Domestic Product (GDP); while for a more meso and micro approach in its measurement the authors (Rohat et al., 2021; Alfieri et al., 2016; Marín et al. 2018; Montalba et al. 2015; and, Vargas et al., 2018) establish it through its socioeconomic variables such as housing, productive development, demographic variations, urbanization; but for more aggregate analysis, according to Ormazábal (2018); Rosete, Enríquez and Aguirre (2012); Carreño, Barbat and Cardona (2013); Cocuñame and Salcedo (2017), further model it under representations of calculation of exposed elements, their fragility and resilience and response capacity. While Wilhelmi and Hayden (2020); and, Tarazona (2018) evaluate vulnerability with an integral vision, measured through dimensions such as Environmental, Economic and Social.

According to the above, the authors incompletely measure vulnerability since they only incorporate socioeconomic aspects, exposure or response capacity separately or in combinations of two parameters; according to UNDRR (2021), in order to be comprehensive, variables related to susceptibility and response capacity should be incorporated at the same time, even if it refers to disaster risk, aspects related to sustainable development, culture, environment, among other aspects, should be considered.

The main objective of the research is to develop a methodology that integrates aspects related to development approaches and other variables associated with disaster risk management.

Lavell (2001) states that once various disasters have occurred, the scientific trend that explains the damage suffered in the territories from the magnitude, intensity and duration of the adverse event is minimal but rather emphasizes a dominant scientific trend, which analyzes the social, economic and environmental conditions, to find a more precise and detailed explanation.

On the other hand, it suggests that both vulnerabilities and threats are concrete manifestations of human existence or physical nature. They are palpable, analyzable and measurable. They are manifested in different living conditions of the population and have a dynamic, changing and transformable component. These adverse conditions that minimize the quality of life may be a reflection of the different contexts in which a given population is located, manifesting themselves through physical characteristics of the structures, inadequate income, malnutrition, alterations in health, depredation and ignorance of the environment, absence of principles of solidarity and participatory organization in decision making, ideologies that may hinder the internalization of knowledge about disaster risk, and cultural expressions not adapted to the current context.

Vulnerability has evolved in recent years, contributing efficiently to the construction of disaster risk, which, at first, was related only to explaining the context of the physical phenomenon of the event (Paucar, 2016).

The concept of vulnerability was associated only with the physical-structural conditions that minimize natural phenomena' effects (Cardona, 2000). However, as vulnerability studies have progressed, the characteristics, conditions and circumstances in which it occurs in society have evolved, incorporating other elements such as

population, economic activity, and infrastructure, among others.

However, CRED EM-DAT (2020) determines a new dimension of vulnerability in addition to susceptibility, which is the capacity for adequate recovery of the population, infrastructure or system in the face of a materialized hazard.

Each of the references involves dimensions and indicators but with independent methodologies. For example, in land-use planning, it is essential to associate vulnerability with processes that guarantee an adequate estimation of disaster risk to ensure that programs and projects are sustainable over time.

2. Materials and Methods

The vulnerability variable is treated as a constant and transversal axis for all types of existing hazards concerning the processes for calculating disaster risk in the territories. Within this vulnerability approach, society, its livelihoods and infrastructure should be considered (Paucar, 2016).

The proposal to find a function of "Integral Vulnerability (VI)" is based on the fact that there are several ways and types to calculate it, but with statistical methodologies that do not have an integration of processes that result in a complete indicator. Instead, this contribution of its estimation is based on the integration of development approaches theoretically associated with IWRM: sustainable development, human development, territorial development and local development, and the inclusion of other risk-related theories. The process to be followed is as follows.

a: Methodology and selection of variables and indicators

When defining the function of the (VI), although it is expressed as a relationship between dependent and independent variables, it cannot be defined as such since there is no predefined value of the VI. One of the main problems of applying a multiple regression or logistic probability analysis is that the dependent variable must have previously assigned values so that a function that explains them can be modeled from this. At this point, it is not feasible to include these methods with the expression of (VI) since its value is not yet known, and only has data for each of the variables and indicators of the development approaches, among other independent variables. To overcome this problem efficiently and statistically feasible, it is necessary to apply Principal Component Analysis (PCA) (Pérez López, 2005).

The PCA is a multivariate statistical analysis technique that simplifies a database's dimensions containing a large set of quantitative variables (scale or transformation of ordinal averages). The result obtained is the reduction of variables or linear combination of the primitives, whose denomination is the main component or factor, contributing to a simpler and more precise analysis of the problem under study.

Its application in a complex database is feasible, compared to the other methods mentioned above, because it does not imply a priori that the researcher establishes hierarchies between his variables (dependent or independent) since it is not a technique of dependence but rather of interdependence, which is even applicable without the need to check the normality of the distribution of his data (Pérez López, 2005).

In PCA, it allows the structure and interrelationship of the original variables and indicators to be described in a precise and accurate way from a large database to a smaller, more manageable and interpretable database, but with an acceptable proportional explanation of its initial global variance (Pérez López, 2005).

The proposed function for Integral Vulnerability (VI) is based on theoretical approaches to development and other variables that are directly related to ISDR processes. The function of (VI) in matrix form for the inclusion of indicators is as follows:

(1)

$$VI = [I_1\, I_2 \,..\, I_n\,]_{IDS} + [I_1\, I_2 \,..\, I_n\,]_{IDH} + [I_1\, I_2 \,..\, I_n\,]_{IDT} + [I_1\, I_2 \,..\, I_n\,]_{IDL} + [I_1\, I_2 \,..\, I_n\,]_{IO}$$

Where:

VI: Integral Vulnerability.

I_{DS} : Sustainable Development Indicators.

I_{DH} *:* Human Development Indicators.

I_{DT} *:* Territorial Development Indicators.

I_{DL} *:* Local Development Indicators.

I_{DO} *:* Indicators derived from other variables.

$I_1 ; I_2 ; \ldots ; I_n$ *:* Selected indicators for each development approach and other variables.

Within each development approach and other variables, there are common indicators, so the following matrix attempts to unify and list each indicator to be included in the formula estimation (VI).

The main characteristic of the quantitative data of the indicator will be based on official statistical sources (public or private institutions); if this premise does not exist, a qualitative estimate will be presented based on five scales: Strongly Agree; Agree; Indifferent; Disagree; and Strongly Disagree. The latter is included to generalize and standardize the methodology proposed for (VI) and apply it to other contexts. For consolidated variables, dimensions and indicators, see Annex 1.

B: Data processing

The data of the proposed variables and indicators have two characteristics: between indicators 1 to 27, they are of scale measurement, while from 28 to 62, ordinal measurement.

The scale measurement indicators, in this instance, do not require specific processing; they should only be recorded based on their units of measurement. On the other hand, the ordinal measurement indicators require processing for their pairing with the scale indicators for constructing the initial database. This process focuses on the selection of the sample for the data collection.

The quantitative technique to be applied to collect information in the study territory will be the survey. If the statistical population is accessible to obtain information on all its elements, a census will be applied; otherwise, a sampling technique should be applied. In this study, to ensure that the information is representative and can be generalized from the selected sample, it is advisable to apply probability sampling (PS) (Martínez, 2012; Del Salto et al., 2022).

C: Reliability of variables and indicators

The reliability of a set of variables and indicators grouped in a database implies a guarantee that the processes and references from them are statistically robust. To determine reliability, Cronbach's Alpha (CA) is applied, which is an indicator that admits values between zero (0) and one (1); the higher the value, the greater the reliability of the variables and indicators (Welch and Comer, 1988; Arvelo et al., 2022).

Authors such as George and Mallery (2003) propose parameters to evaluate the indicator resulting from CA under the following reference:

Greater than or equal to 0.9, Excellent;

Between 0.8 and 0.89, Good;

Between 0.7 and 0.79, Acceptable;

Between 0.6 and 0.69, Questionable but acceptable;

Between 0.5 and 0.5, Low; and,

Less than 0.49 Very low - Unacceptable.

If the final result of the CA is less than 0.49, it is advisable to identify which variable causes this statistical noise and extract it from the original database to increase the CA indicator. This test is only applied to indicators 28 to 62 of the survey.

In some cases, quantitative data may differ from period due to their availability or to contrast and compare results with qualitative variables, these should be standardized based on their means and standard deviations (data normalization).

D: Methodological process of ACP

The estimation of the VI expression under the first principal component approach is as follows:

(2)

$$Z_1 = u_{11} * [I_1\, I_2 \,..\, I_n\,]_{IDS} + u_{12} * [I_1\, I_2 \,..\, I_n\,]_{IDH} + u_{13} * [I_1\, I_2 \,..\, I_n\,]_{IDT} + u_{14} * [I_1\, I_2 \,..\, I_n\,]_{IDL} + u_{15} * [I_1\, I_2 \,..\, I_n\,]_{IO}$$

Where:

Z1: It is the representation of the first principal component.
U11: u12: u13: u13: u14: u15: Factorial loadings.
IDS: Indicators of Sustainable Development.
HDI: Human Development Indicators.
IDT: Territorial Development Indicators.
IDL: Local Development Indicators.
IDO: Indicators derived from other variables.
I1;I2;...; In: Selected indicators for each development approach and other variables.

Correlation matrix analysis (KMO): For the PCA process to be efficient, it is important to verify statistically whether the variables or indicators are highly correlated. Otherwise, the factorial process would not capture its maximum explained variance, and therefore the weight assigned to a significant indicator would be similar to a non-significant indicator. To determine this condition, it is necessary to apply the Kaiser-Meyer-Olkin index (KMO), which takes values in a range between zero (0) and one (1); the closer to one the factorial process is, the more statistically robust it will be. If the KMO is not higher than 0.5, the value of the CA will be increased by eliminating the indicators (from 28 to 62) that have a lower individual CA. If the value is low and no variable is to be eliminated, it can be kept in the system, indicating this atypical case.

Extraction of factors: Once the KMO has been verified, the number of grouped components is determined by applying the values of the typed data to be included in the specificity and matrix of factor loadings through the correlation of each data observed in each of the components. The number of components is determined from the sums of the saturations of the extractions; the higher the number of components. The results obtained numerically can be verified graphically through the sedimentation graph. This will be the optimum value to select at the component number where there is a break in the slope of the eigenvalues.

Rotation of factors: Once the components have been determined, we proceed with the rotation of their factors to transform the variance data explained in a better interpretation and for each of the indicators, transforming their matrix structure without altering the values of their internal variance. For the rotation, the maximum variance process is applied under the orthogonal rotation method, which minimizes the number of observed data with volatile variance loads to prevent their atypical weights from affecting the expected result for the estimation of a single indicator for the VI.

Based on the coefficients of the rotated matrix, the VI indicators can be classified into the components found, placing them where the most significant weight (in absolute value) of their coefficients is found.

Each component and the new distribution of indicators can be renamed based on their conceptual association. This resulting product may be different in each of the applied contexts.

Factor scores: Once the indicators have been assigned to their respective components, where their explained variance contributes better, it is important to determine the factor scores of each VI indicator in their respective components. The method used to calculate the scores is multiple regression, based on estimating the intra-group weights of the indicators.

Each factor score of the VI indicators is differentiated for their mean so that scores equal to zero (0) correspond to values equal to the group mean. Positive and negative values are factor scores above and below the mean.

Indicator weights: To establish a single absolute weight for each of the VI indicators, it is proposed to multiply the intra-component weights with their respective variances explained by groups. The following expression is suggested:

(3)

$$I = (A\ \lambda)$$

Where:

I: Resulting matrix of absolute weights per indicator.

A: Matrix of coefficients of the factor scores of the indicators.

λMatrix of percentages of explained variances obtained in the extraction of factors by PCA.

The objective is to obtain a single matrix (I) that shows the absolute weights of each indicator for VI, in relation to its explained variance and not in several weights and in different components. The weights with a positive sign indicate that the variable has a direct incidence in relation to the system (I) of the set of VI indicators, while negative values represent an indirect relationship.

E: Comprehensive Vulnerability Estimation (VI):

To estimate the values of the VI, the study proceeded to determine the sum-product between the data of each of the indicators of the territories by the absolute weights obtained in the matrix expression (I). From these resulting values (MVI), the study proceeded to form the levels (High-Medium-Low) for the VI by applying the frequency table criterion under the following procedure:

-Determine the amplitude of the interval using the expression:

$$Amplitud\ del\ intervalo = \frac{Valor - Valor\ min}{Número\ de\ niveles} \quad (4)$$

Max value: Maximum value of the data range (MVI).

Min value: Minimum value of the data range (MVI).

Number of levels: Three (3) for the categories High-Middle-Low.

-From the number obtained in the amplitude, we proceed to make the frequency table with the three proposed intervals. The final result will be the assignment of the study territory associated with the VI measured under the category High-Medium-Low.

The final product of this subprocess is the cartographic information of vulnerable territorial zones under the new proposal of development approaches and other variables related to disaster risk.

3. Results and Discussion

A: Methodology and selection of the variables and indicators

Based on the official information for the variables, in the case of the canton of Santa Elena and its parishes, 16 secondary quantitative and 35 primary qualitative variables collected in situ are recorded. The consolidation is shown in Annexes 2 and 3.

B: Data processing

The first 16 quantitative variables are scale measures, while the 35 qualitative variables are ordinal.

The scale measurement indicators, in this instance, do not require specific processing but are only recorded based on their units of measurement. On the other hand, the ordinal measurement indicators require processing for their pairing with the scale indicators for constructing the initial database. This process focuses on the selection of the sample for the data collection.

The data collection technique is the survey. The data collection instrument was constructed based on the questions for each of the indicators of the dimensions.

When citing the canton of Santa Elena and its seven (7) parishes as the population, it is assumed that the initial population is segmented, i.e., it has heterogeneous characteristics, and therefore,

when applying a sample selection technique, the correct one would be Stratified Sampling (ST).

The first step in applying EM is calculating a general sample as if the population were not heterogeneous. For this purpose, the Simple Random Sampling (SRS) formula is applied under the following reference:

(5)

$$n = \frac{N * Z^2 * p * q}{e^2 * (N-1) + Z^2 * p * q}$$

Where:

N: Study population, in this case, 144,076.
Z: Recommended normal distribution Z value (1.96).
p: Standard probability of success (0.5).
q: Standard probability of failure (0.5).
e: Recommended statistical error (0.05)
n: Single sample to be drawn from the population.

For a population of 144,076 inhabitants, the result of replacing the parameters described above is 383 inhabitants.

The second step is the treatment of the heterogeneous population, applying the Proportional Allocation (PA) method to extract, from each parish, a sample proportional to the total number of inhabitants. The PA formula is given below:

(6)

$$n_e = \frac{N_L}{N} * n_{MAS}$$

Where:

NL: Total elements of each of the population segments; 53,174 from Santa Elena parish; 3,532 Atahualpa; 31,322 Colonche; 16,363 Chanduy; 29,512 Manglaralto; 3,296 Simón Bolívar; and, 6,877 from San José de Ancón.
N: Consolidated sum of all the elements of each population segment; 144,076 inhabitants.
n (MAS): Result of applying the MAS formula; 383 inhabitants.
ne: Sample to be extracted in each of the population segments.

The result is shown in the following table:

Table 1. Results of applying the MA for each of the parishes in the canton of Santa Elena.

Formula Criteria	STRATA / PARISHES						
	St. Helena	Atahualpa	Colonche	Chanduy	Manglaralto	Simón Bolívar	San José de Ancón
N_L	53,174	3,532	31,322	16,363	29,512	3,296	6,877
n (MAS)	383						
Proportional allocation	**141**	**9**	**83**	**44**	**78**	**9**	**18**

According to the results of Table 01, in the proportional allocation row are the sample amounts to be collected through the survey technique in each of the parishes of the canton.

In order to guarantee the representativeness of the samples to be drawn in the parish territories, it is necessary to divide each of these jurisdictions into census sectors and distribute the PA based on these sectors.

Once the information has been tabulated to generate a single database matched with the quantitative indicators, an average is calculated for each indicator in each census sector of the parishes.

C: Reliability of variables and indicators

The test is only applied to the qualitative indicators in the database. The result is shown below:

Table 2. Results of applying the reliability test

Cronbach's Alpha
0.741

Source: Data processed through the SPSS program based on the data obtained in the in-situ data collection.

According to the results in Table 2, the database obtained from the qualitative indicators is acceptable to be used for robust statistical analysis.

The initial data were standardized in order to be comparable at the time of applying the ACP methodology.

D: Methodological process of ACP

At this point, expression (2) is applied to the variables and dimensions. The result of the KMO index for the original database (without normalization) is 0.619, a robust result for the multidimensional statistical procedure.

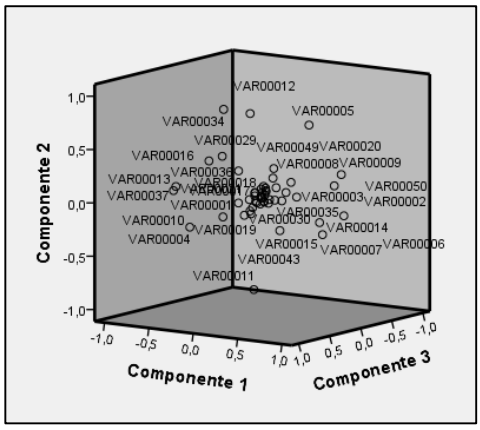
In the case of factor extraction, the total variance of the normalized data is explained by 19 components or clusters, with approximately 75.40% of the sums of squared saturations.

Table 3. Total variance of the normalized database applying the PCA methodology.

Component	Initial eigenvalues			Sums of squared saturations of extraction			Sum of the saturations squared by rotation		
	Total	% of variance	Accumulated	Total	% of variance	Accumulated	Total	% of variance	Accumulated
1	7.327	14.366	14.366	7.327	14.366	14.366	6.843	13.417	13.417
	3.665	7.186	21.553	3.665	7.186	21.553	3.463	6.790	20.207
	3.605	7.068	28.621	3.605	7.068	28.621	3.117	6.113	26.320
	2.687	5.269	33.890	2.687	5.269	33.890	2.891	5.668	31.987
5	2.040	4.001	37.890	2.040	4.001	37.890	1.653	3.241	35.228
	1.699	3.331	41.221	1.699	3.331	41.221	1.624	3.184	38.412
	1.687	3.307	44.528	1.687	3.307	44.528	1.539	3.017	41.429
	1.662	3.260	47.788	1.662	3.260	47.788	1.526	2.993	44.422
	1.624	3.184	50.971	1.624	3.184	50.971	1.513	2.966	47.388
	1.524	2.988	53.960	1.524	2.988	53.960	1.487	2.915	50.303
	1.455	2.853	56.813	1.455	2.853	56.813	1.478	2.899	53.202
	1.390	2.726	59.539	1.390	2.726	59.539	1.467	2.876	56.078
	1.327	2.601	62.140	1.327	2.601	62.140	1.460	2.863	58.941
	1.277	2.504	64.644	1.277	2.504	64.644	1.436	2.815	61.756
	1.265	2.481	67.125	1.265	2.481	67.125	1.432	2.807	64.563
	1.111	2.178	69.303	1.111	2.178	69.303	1.431	2.807	67.370
	1.082	2.121	71.424	1.082	2.121	71.424	1.422	2.789	70.158
	1.026	2.011	73.436	1.026	2.011	73.436	1.399	2.744	72.902
	1.007	1.974	75.409	1.007	1.974	75.409	1.279	2.507	75.409

Source: Data provided by the IBM SPSS for Windows program to develop the integral vulnerability using the ACP methodology.

Figure 1. Component plot in rotated space of the study dimensions.



As for the rotation of factors, Figure 1 shows a uniform behavior both in the center of the components and off-axis, which implies a new reorganization of the distribution of the original dimensions and variables. This process contributes to a better explanation of the groups of variables in a general system, which will be the first approach to estimating the function of (VI).

In the case of the factor scores, according to the proposed methodology, the multiple regression method is applied based on the intra-group weightings of the indicators. Each factor score of the VI indicators is differentiated for their mean so that scores equal to zero (0) correspond to values equal to the group mean. Positive and negative values are factor scores above and below the mean. The results can be verified in Annex 4.

In order to establish a single absolute weight for each of the indicators of (VI), it is proposed to multiply the intra-component weights with their respective variances explained by groups. The following expression (3) is suggested. Where matrix A is the coefficients of Annex 4 and $\boldsymbol{\lambda}$ the percentages of explained variances obtained in extracting factors by PCA from Table 3.

The objective is to obtain a single matrix (I) that shows the absolute weights of each indicator for VI, concerning its explained variance and not in several weights and different components. Weights with a positive sign indicating that said variable maintains a direct incidence about the system (I) of the set of VI indicators, while negative values represent an indirect relationship. The results are shown below:

Table 4. Absolute weights of the indicators for St. Helena and its parishes.

Indicators	Absolute weights	Indicators	Absolute weights
of EAP	1.69	There is no adequate link between the geographic qualities (natural, social, cultural and political conditions) and the development of the study territory.	2.44
% of population not working as a percentage of working-age population	-1.69	There is no socio-territorial justice (equity and territorial integrity of socioeconomic development and coherence of sectoral policies) in the jurisdiction under study.	-1.16
% of the population illiterate	1.85	There is no evidence of a balance between the community and the ecosystem in terms of the rational use of its environmental resources.	1.78
Average years of schooling of the population	-2.50	In the territory under study there is significant social mobility	0.07
% of population not attending educational institutions	1.51	There are no adequate conditions for proper social cohesion in the study territory.	-0.09

Indicators	Absolute weights	Indicators	Absolute weights
% of dwellings with structural deficiencies	0.90	There are no adequate conditions for proper territorial governance (legitimacy, equity, social justice and democracy).	0.72
% of households without access to the public electricity grid	0.84	The study territory does not provide adequate conditions for the conservation of the existing cultural properties.	1.00
% of households without access to the public drinking water network	1.89	There is no development or promotion of ancestral customs in the study territory.	1.07
% of households without access to public sewage system	2.52	In the study territory, the application of ancestral practices in disaster risk issues is not common.	1.66
% of households without access to public solid waste collection	2.07	In the study territory there are no adequate conditions to form micro-enterprises, associations, networks and clusters.	-1.55
% of the population with some type of permanent disability	-0.61	No conditions promote innovation in the various productive activities developed in the territory.	0.12
% of population without access to public health insurance	2.83	There are no conditions to develop the capacity and training of human resources in productive activities/services in the territory.	0.69
% of population without access to private health insurance	-1.14	In the study territory there is no public/private investment for the equipment and construction of infrastructure for local development.	0.64
% of the population poor by UBN	2.80	There are no mechanisms and instruments to promote local endogenous development.	0.56
% of population involved in agricultural activity	1.99	There are no conditions for active citizen participation among the main territorial stakeholders and levels of government.	1.57
% of population engaged in manufacturing activity	-1.74	There are no adequate conditions (transparency, integrity, legality, sound policies, participation, accountability and responsiveness) to demonstrate efficient governance in the study territory.	0.65
Have the bodies of water (rivers, lakes, lagoons, estuaries, among others) in the	1.50	When a natural or anthropogenic hazard materialized in the study territory, there was no adequate	1.93

Indicators	Absolute weights	Indicators	Absolute weights
study territory been affected by any type of contamination?		humanitarian assistance to improve the disaster situation.	
Have the species been significantly affected in their natural habitat by any external problems?	0.52	When a natural or anthropogenic risk materialized in the study territory, there was no adequate international cooperation to improve the disaster situation.	0.11
Has air quality in the study territory declined in recent years?	-0.12	In the study territory there are no guarantees of a policy and/or strategies to minimize the context of citizen insecurity.	0.90
There is no solid waste processing plant or project in the study territory.	1.10	The community, within the study territory, is unaware of the evaluations, actions and strategies to be followed in relation to the IRDM.	1.70
In the territory under study there are no adequate conditions to exercise political freedom.	0.95	The community, within the study territory, has different perceptions about the context of disaster risk.	0.38
Human rights are not put into practice in the territory under study.	2.08	Within the study territory, society applies empirical knowledge that is little or not related to IRDM.	1.37
In the study territory there are no socioeconomic conditions for a dignified life.	4.23	The existing infrastructure in the study territory was not built under seismic resistance conditions.	1.61
In the study territory, there is no adequate context for human capacity development.	0.09	In the study territory, there are human settlements in disaster risk zones.	0.40
In the territory under study there is not an adequate average monthly income for the various needs of the families.	2.86	In the territory under study, no political or territorial planning instruments are directly related to IRDM.	2.50
In the territory under study, no conditions guarantee adequate social inclusion.	2.41		

E: Integral Vulnerability Estimation (VI)

To estimate the values of the VI, the study determined the sum-product between the data of each of the indicators of the variables under study by the absolute weights obtained in the matrix expression (I). The result is as follows:

Table 5. Results of the sum-product between the indicators of the variables and the absolute weights for the case of Santa Elena and its parishes (census sectors).

Parish	Census sector	Resulting values for (MVI)	Parish	Census sector	Resulting values for (MVI)
St. Helena	SE-1	2378.35	Colonche	C-29	2643.55
Simón Bolívar (Julio Moreno)	SBJM-1	2482.56	Colonche	C-30	2396.99
Simón Bolívar (Julio Moreno)	SBJM-2	2829.03	Colonche	C-31	2623.65
Simón Bolívar (Julio Moreno)	SBJM-3	2337.82	Colonche	C-32	2668.25
Simón Bolívar (Julio Moreno)	SBJM-4	2538.10	Colonche	C-33	2616.72
Simón Bolívar (Julio Moreno)	SBJM-5	2364.60	Colonche	C-34	2623.21
Simón Bolívar (Julio Moreno)	SBJM-6	2653.09	Colonche	C-35	2524.49
Simón Bolívar (Julio Moreno)	SBJM-7	2361.61	Colonche	C-36	2543.69
San José de Ancón	SJA-1	1916.41	Colonche	C-37	2640.18
Chanduy	CH-1	2523.61	St. Helena	SE-2	2242.21
Chanduy	CH-2	2596.36	St. Helena	SE-3	2346.29
Chanduy	CH-3	2725.85	St. Helena	SE-4	2364.70
Chanduy	CH-4	2704.46	St. Helena	SE-5	2346.89
Chanduy	CH-5	2812.05	St. Helena	SE-6	2313.78
Chanduy	CH-6	2609.31	St. Helena	SE-7	2281.55
Chanduy	CH-7	2573.86	St. Helena	SE-8	2357.44
Chanduy	CH-8	2710.23	St. Helena	SE-9	2391.79
Chanduy	CH-9	2573.87	St. Helena	SE-10	2266.18
Chanduy	CH-10	2781.07	Manglaralto	M-13	2277.05
Chanduy	CH-11	2629.95	Manglaralto	M-14	2542.15
Chanduy	CH-12	2708.78	Manglaralto	M-15	2565.17
Chanduy	CH-13	2749.11	Manglaralto	M-16	2450.32
Chanduy	CH-14	2634.56	Manglaralto	M-17	2490.66
Chanduy	CH-15	2453.50	Manglaralto	M-18	2380.70
Chanduy	CH-16	2664.38	Manglaralto	M-19	2450.31
Chanduy	CH-17	2480.15	Manglaralto	M-20	2400.94
Chanduy	CH-18	2827.59	Manglaralto	M-21	2203.59
Manglaralto	M-1	2243.62	Colonche	C-38	2737.91
Manglaralto	M-2	2547.80	Manglaralto	M-22	2451.58
Manglaralto	M-3	2375.63	Manglaralto	M-23	2417.24
Manglaralto	M-4	2315.21	Colonche	C-39	2440.61
Manglaralto	M-5	2846.12	Colonche	C-40	2617.34
Manglaralto	M-6	2673.99	Colonche	C-41	2483.82
Manglaralto	M-7	2291.19	Colonche	C-42	2655.99
Manglaralto	M-8	2563.28	Colonche	C-43	2492.58
Manglaralto	M-9	2467.93	Colonche	C-44	2471.18
Manglaralto	M-10	2300.76	Colonche	C-45	2498.32
Manglaralto	M-11	2335.23	Colonche	C-46	2572.12

Parish	Census sector	Resulting values for (MVI)	Parish	Census sector	Resulting values for (MVI)
Manglaralto	M-12	2232.67	Colonche	C-47	2617.70
Atahualpa	A-1	1868.38	Simón Bolívar (Julio Moreno)	SBJM-8	2682.93
Colonche	C-1	2516.93	Simón Bolívar (Julio Moreno)	SBJM-9	2544.66
Colonche	C-2	2612.91	Simón Bolívar (Julio Moreno)	SBJM-10	2620.07
Colonche	C-3	2491.79	Simón Bolívar (Julio Moreno)	SBJM-11	2693.33
Colonche	C-4	2629.36	Chanduy	CH-19	2599.69
Colonche	C-5	2515.75	Chanduy	CH-20	2613.99
Colonche	C-6	2622.67	Chanduy	CH-21	2709.22
Colonche	C-7	2754.34	Chanduy	CH-22	2753.69
Colonche	C-8	2593.68	St. Helena	SE-11	2390.42
Colonche	C-9	2688.51	Chanduy	CH-23	2728.37
Colonche	C-10	2520.47	Chanduy	CH-24	2666.67
Colonche	C-11	2729.08	Chanduy	CH-25	2632.03
Colonche	C-12	2402.01	Chanduy	CH-26	2836.62
Colonche	C-13	2611.49	Chanduy	CH-27	2867.19
Colonche	C-14	2365.77	St. Helena	SE-12	2163.07
Colonche	C-15	2520.08	St. Helena	SE-13	2165.31
Colonche	C-16	2502.43	St. Helena	SE-14	2387.03
Colonche	C-17	2520.15	Atahualpa	A-2	1774.57
Colonche	C-18	2438.66	St. Helena	SE-15	2310.24
Colonche	C-19	2543.41	St. Helena	SE-16	2579.88
Colonche	C-20	2592.80	San José de Ancón	SJA-2	1972.43
Colonche	C-21	2685.89	San José de Ancón	SJA-3	2033.81
Colonche	C-22	2582.72	San José de Ancón	SJA-4	1979.22
Colonche	C-23	2785.56	St. Helena	SE-17	2503.83
Colonche	C-24	2565.44	St. Helena	SE-18	2203.47
Colonche	C-25	2739.64	St. Helena	SE-19	2295.22
Colonche	C-26	2534.52	St. Helena	SE-20	2049.84
Colonche	C-27	2316.09	St. Helena	SE-21	1884.68
Colonche	C-28	2589.49			

From these resulting values (MVI), we proceed to form the levels (High-Medium-Low) for the (VI) by applying the frequency table criterion.

Where:

Max value: Maximum value of the data range (MVI); corresponding to census sector CH-27 of Chanduy parish with the MVI value of 2,867.19.
Min value: Minimum value of the data range (MVI); corresponding to census sector A-2 of Atahualpa parish with the MVI value of 1,774.57.
Number of levels: Three (3) for the categories High-Middle-Low.

The result of the interval width between the lower and upper limit corresponds to 364.21.

The frequency table is made with the three proposed intervals from the number obtained in the amplitude. The final result will be the assignment of the study territory associated with the VI measured under the category High-Medium-Low. The results are shown below:

Table 6. Categorization results based on Mvi intervals.

Intervals M_{MI}	Census sectors	Percentage	Scale	Levels
1774.57 - 2139.57	8	5.93%	LOW	1
2139.57 - 2504.57	53	39.26%	MEDIO	
2504.57 - 2869.57	74	54.81%	HIGH	
Grand total	**135**	**100.00%**		

Based on this categorization, we proceeded to identify the values of (VI) for each census sector corresponding to the parishes of the canton of Santa Elena. The results are shown below:

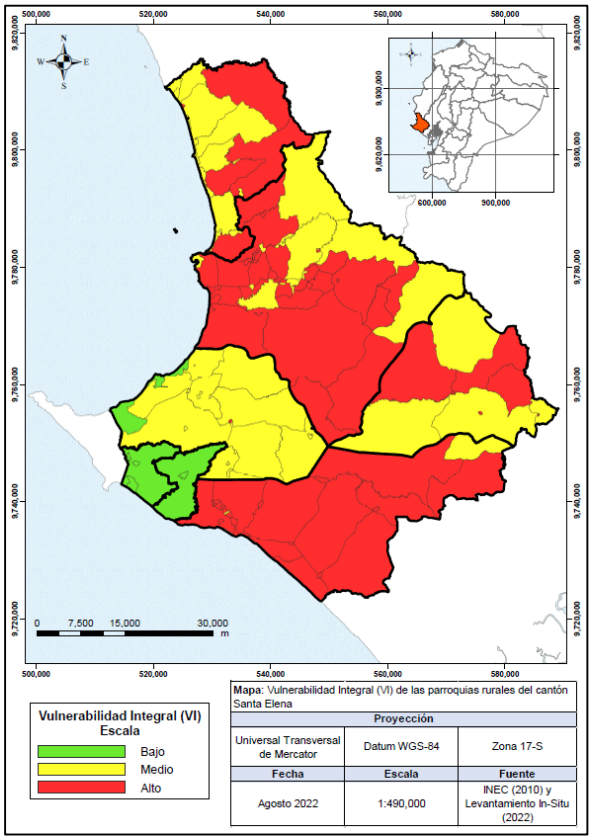
Table 7. Levels and scale of the VI for the parishes of the canton of Santa Elena (census sectors)

Parish	Census sector	M_{VI}	Levels	Scale	Parish	Census sector	M_{VI}	Levels	Scale
St. Helena	SE-1	2378.35		MEDIUM	Colonche	C-29	2643.55		HIGH
Simón Bolívar (Julio Moreno)	SBJM-1	2482.56		MEDIUM	Colonche	C-30	2396.99		MEDIUM
Simón Bolívar (Julio Moreno)	SBJM-2	2829.03		HIGH	Colonche	C-31	2623.65		HIGH
Simón Bolívar (Julio Moreno)	SBJM-3	2337.82		MEDIUM	Colonche	C-32	2668.25		HIGH
Simón Bolívar (Julio Moreno)	SBJM-4	2538.10		HIGH	Colonche	C-33	2616.72		HIGH
Simón Bolívar (Julio Moreno)	SBJM-5	2364.60		MEDIUM	Colonche	C-34	2623.21		HIGH
Simón Bolívar (Julio Moreno)	SBJM-6	2653.09		HIGH	Colonche	C-35	2524.49		HIGH
Simón Bolívar (Julio Moreno)	SBJM-7	2361.61		MEDIUM	Colonche	C-36	2543.69		HIGH
San José de Ancón	SJA-1	1916.41	1	LOW	Colonche	C-37	2640.18		HIGH
Chanduy	CH-1	2523.61		HIGH	St. Helena	SE-2	2242.21		MEDIUM
Chanduy	CH-2	2596.36		HIGH	St. Helena	SE-3	2346.29		MEDIUM
Chanduy	CH-3	2725.85		HIGH	St. Helena	SE-4	2364.70		MEDIUM
Chanduy	CH-4	2704.46		HIGH	St. Helena	SE-5	2346.89		MEDIUM
Chanduy	CH-5	2812.05		HIGH	St. Helena	SE-6	2313.78		MEDIUM
Chanduy	CH-6	2609.31		HIGH	St. Helena	SE-7	2281.55		MEDIUM
Chanduy	CH-7	2573.86		HIGH	St. Helena	SE-8	2357.44		MEDIUM
Chanduy	CH-8	2710.23		HIGH	St. Helena	SE-9	2391.79		MEDIUM
Chanduy	CH-9	2573.87		HIGH	St. Helena	SE-10	2266.18		MEDIUM
Chanduy	CH-10	2781.07		HIGH	Manglaralto	M-13	2277.05		MEDIUM
Chanduy	CH-11	2629.95		HIGH	Manglaralto	M-14	2542.15		HIGH
Chanduy	CH-12	2708.78		HIGH	Manglaralto	M-15	2565.17		HIGH

Parish	Census sector	M_{VI}	Levels	Scale	Parish	Census sector	M_{VI}	Levels	Scale
Chanduy	CH-13	2749.11		HIGH	Manglaralto	M-16	2450.32		MEDIUM
Chanduy	CH-14	2634.56		HIGH	Manglaralto	M-17	2490.66		MEDIUM
Chanduy	CH-15	2453.50		MEDIUM	Manglaralto	M-18	2380.70		MEDIUM
Chanduy	CH-16	2664.38		HIGH	Manglaralto	M-19	2450.31		MEDIUM
Chanduy	CH-17	2480.15		MEDIUM	Manglaralto	M-20	2400.94		MEDIUM
Chanduy	CH-18	2827.59		HIGH	Manglaralto	M-21	2203.59		MEDIUM
Manglaralto	M-1	2243.62		MEDIUM	Colonche	C-38	2737.91		HIGH
Manglaralto	M-2	2547.80		HIGH	Manglaralto	M-22	2451.58		MEDIUM
Manglaralto	M-3	2375.63		MEDIUM	Manglaralto	M-23	2417.24		MEDIUM
Manglaralto	M-4	2315.21		MEDIUM	Colonche	C-39	2440.61		MEDIUM
Manglaralto	M-5	2846.12		HIGH	Colonche	C-40	2617.34		HIGH
Manglaralto	M-6	2673.99		HIGH	Colonche	C-41	2483.82		MEDIUM
Manglaralto	M-7	2291.19		MEDIUM	Colonche	C-42	2655.99		HIGH
Manglaralto	M-8	2563.28		HIGH	Colonche	C-43	2492.58		MEDIUM
Manglaralto	M-9	2467.93		MEDIO	Colonche	C-44	2471.18		MEDIO
Manglaralto	M-10	2300.76		MEDIO	Colonche	C-45	2498.32		MEDIO
Manglaralto	M-11	2335.23		MEDIO	Colonche	C-46	2572.12		HIGH
Manglaralto	M-12	2232.67		MEDIO	Colonche	C-47	2617.70		HIGH
Atahualpa	A-1	1868.38	1	LOW	Simón Bolívar (Julio Moreno)	SBJM-8	2682.93		HIGH
Colonche	C-1	2516.93		HIGH	Simón Bolívar (Julio Moreno)	SBJM-9	2544.66		HIGH
Colonche	C-2	2612.91		HIGH	Simón Bolívar (Julio Moreno)	SBJM-10	2620.07		HIGH
Colonche	C-3	2491.79		MEDIUM	Simón Bolívar (Julio Moreno)	SBJM-11	2693.33		HIGH
Colonche	C-4	2629.36		HIGH	Chanduy	CH-19	2599.69		HIGH
Colonche	C-5	2515.75		HIGH	Chanduy	CH-20	2613.99		HIGH
Colonche	C-6	2622.67		HIGH	Chanduy	CH-21	2709.22		HIGH
Colonche	C-7	2754.34		HIGH	Chanduy	CH-22	2753.69		HIGH
Colonche	C-8	2593.68		HIGH	St. Helena	SE-11	2390.42		MEDIUM
Colonche	C-9	2688.51		HIGH	Chanduy	CH-23	2728.37		HIGH
Colonche	C-10	2520.47		HIGH	Chanduy	CH-24	2666.67		HIGH
Colonche	C-11	2729.08		HIGH	Chanduy	CH-25	2632.03		HIGH
Colonche	C-12	2402.01		MEDIUM	Chanduy	CH-26	2836.62		HIGH
Colonche	C-13	2611.49		HIGH	Chanduy	CH-27	2867.19		HIGH
MEDIUM MEDIUM Colonche	C-14	2365.77		MEDIO	St. Helena	SE-12	2163.07		MEDIUM
Colonche	C-15	2520.08		HIGH	St. Helena	SE-13	2165.31		MEDIUM
Colonche	C-16	2502.43		MEDIO	St. Helena	SE-14	2387.03		MEDIUM
Colonche	C-17	2520.15		HIGH	Atahualpa	A-2	1774.57	1	LOW
Colonche	C-18	2438.66		MEDIUM	St. Helena	SE-15	2310.24		MEDIUM
Colonche	C-19	2543.41		HIGH	St. Helena	SE-16	2579.88		HIGH
Colonche	C-20	2592.80		HIGH	San José de Ancón	SJA-2	1972.43	1	LOW

Parish	Census sector	M_{VI}	Levels	Scale	Parish	Census sector	M_{VI}	Levels	Scale
Colonche	C-21	2685.89		HIGH	San José de Ancón	SJA-3	2033.81	1	LOW
Colonche	C-22	2582.72		HIGH	San José de Ancón	SJA-4	1979.22	1	LOW
Colonche	C-23	2785.56		HIGH	St. Helena	SE-17	2503.83		MEDIUM
Colonche	C-24	2565.44		HIGH	St. Helena	SE-18	2203.47		MEDIUM
Colonche	C-25	2739.64		HIGH	St. Helena	SE-19	2295.22		MEDIUM
Colonche	C-26	2534.52		HIGH	St. Helena	SE-20	2049.84	1	LOW
Colonche	C-27	2316.09		MEDIUM	St. Helena	SE-21	1884.68	1	LOW
Colonche	C-28	2589.49		HIGH					

Figure 2. Map of VI of the parishes of the canton of Santa Elena.



4. Conclusions

Following the proposed methodology, a different and integrating estimate for vulnerability called (VI) is proposed. As mentioned, the current references for this variable in terms of its calculation are not efficient since they define it under a specific theme. Therefore, for determining disaster risk, its estimation should be considered integrally to guarantee a real context in the territories under study.

The selection of the PCA methodology implies an adequate reference due to the non-discrimination between dependent and independent variables since it proposes to analyze the variables in a single set or system, something that is not obtained with methodologies such as regression analysis or logistic equations.

Including both quantitative and qualitative variables proposes that the methodology of (VI) is consistent and estimates exactly what happens in the parish territories of St. Helena, something that

can be visualized both in the frequency results and the sectoral map of results.

The highest (VI) parishes in HIGH scale are Chanduy and Colonche; the least vulnerable are the parishes of San José de Ancón and Atahualpa parishes.

The disaggregation by census sectors estimates a more accurate distribution of the values of (VI) in the parishes of the canton, so it collects and disaggregates the information at a smaller scale, accepted by government statistical institutions, in the case of Ecuador, the INEC.

The estimation and evaluation of disaster risk in the territories are more precise since vulnerability will no longer be measured only under a thematic approach but also by development approaches and other variables that theoretically explain disaster risk.

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7. Annex

Annex 1. Variables, dimensions and general indicators of the VI model.

No.	Development approach	Variable	Dimension	Adapted indicator
1	Sustainable Development	Employment	Economically Active Population (EAP)	of EAP
			Unemployment	% of population not working in relation to persons of working age
		Education	Illiteracy	% of the population illiterate
			Schooling	Average years of schooling of the population
5			Assistance to educational institutes	% of population not attending educational institutions
		Housing	Physical condition of the dwelling	% of dwellings with structural deficiency
		Basic services	Electricity	% of households without access to the public power grid
			Drinking water	% of households without access to the public drinking water network
			Sewer	% of households without access to public sewage system
			Solid waste collection	% of households without access to public solid waste collection
		Health and Disability	Infant mortality	infant mortality rate
			Catastrophic disease	% of the population with catastrophic diseases
			Permanent disability	% of the population with some type of permanent disability
			Public health insurance	% of population without access to public health insurance
			Private health insurance	% of the population without access to private health insurance
		Poverty	Unsatisfied Basic Needs (UBN)	% of the population poor by UBN
			Poverty threshold	% of the population living on 1 dollar a day or less
		Production and Consumption Goods-Services	Gross Value Added (GVA)	Monetary value of the region's GVA
			Inflation	of inflation in the region
			Agropecuario	% of population involved in agricultural activity
			Mining	% of population involved in mining activity
			Manufacturing	% of population engaged in manufacturing activities
			Tourism	% of the population involved in tourism activities
			Transportation	% of the population involved in the transport activity
			Productive loans	% of the population without access to productive credit
			Protected area	% of protected areas affected

No.	Development approach	Variable	Dimension	Adapted indicator
		Environment	Territorial area affected by oil residues	of land area affected by oil residues
			Contaminated water bodies	Have the bodies of water (rivers, lakes, lagoons, estuaries, among others) in the study territory been affected by any type of contamination?
			Fauna	Have the species been significantly affected in their natural habitat by any external problems?
			Air quality	Has air quality in the study territory declined in recent years?
			Waste treatment	There is no solid waste processing plant or project in the study territory.
	Human Development	**Rights and Necessary Conditions**	Political freedom	In the territory under study there are no adequate conditions to exercise political freedom.
			Human rights	Human rights are not put into practice in the territory under study.
			Dignified life	In the study territory there are no socioeconomic conditions for a dignified life.
			Human capacity	In the territory under study there is no adequate context for the development of human capacity.
			Revenues	In the territory under study there is not an adequate average monthly income for the various needs of the families.
			Social inclusion	In the territory under study there are no conditions that guarantee adequate social inclusion.
	Territorial Development	**Geographic**	Territoriality	There is no adequate link between the geographic qualities (*natural, social, cultural and political conditions*) and the development of the study territory.
			Territorial cohesion	There is no socio-territorial justice (*equity and territorial integrity of socioeconomic development and coherence of sectoral policies*) in the jurisdiction under study.
		Environmental	Ecodevelopment	There is no evidence of a balance between the community and the ecosystem in terms of the rational use of its environmental resources.
		Human	Social mobility	In the territory under study, there is significant social mobility
42			Social cohesion	There are no adequate conditions for proper social cohesion in the study territory.
43		**Policy**	Territorial governance	There are no adequate conditions for proper territorial governance (*legitimacy, equity, social justice and democracy*).
	Local Development	**Culture**	Cultural assets	The study territory does not provide adequate conditions for the conservation of the existing cultural properties.
45			Ancestral customs	There is no development or promotion of ancestral customs in the study territory.
46			Ancestral practices	In the study territory, the application of ancestral practices in disaster risk issues is not common.

No.	Development approach	Variable	Dimension	Adapted indicator
		Political-Administrative	Corporate	In the study territory there are no adequate conditions to form micro-enterprises, associations, networks and clusters.
			Innovation	There are no conditions that promote innovation in the various productive activities developed in the territory.
			Qualification	There are no conditions to develop the capacity and training of human resources in productive activities/services in the territory.
			Local equipment	In the study territory there is no public/private investment for the equipment and construction of infrastructure for local development.
51			Endogenous capacity	There are no mechanisms and instruments to promote local endogenous development.
52	**Other theories**	**Governance**		There are no conditions for active citizen participation among the main territorial stakeholders and levels of government.
		Governance		There are no adequate conditions (*transparency, integrity, legality, sound policies, participation, accountability and responsiveness*) to demonstrate efficient governance in the study territory.
		Humanitarian Assistance		When a natural or anthropogenic hazard materialized in the study territory, there was no adequate humanitarian assistance to improve the disaster situation.
		International Cooperation		When a natural or anthropogenic risk materialized in the study territory, there was no adequate international cooperation to improve the disaster situation.
		Society and global risk		In the study territory there are no guarantees of a policy and/or strategies to minimize the context of citizen insecurity.
				The community, within the study territory, is unaware of the evaluations, actions and strategies to be followed in relation to the IRDM.
58				The community, within the study territory, has different perceptions about the context of disaster risk.
				Society, within the study territory, applies empirical knowledge little or not at all related to IRDM.
				The infrastructures, existing in the study territory, were not built under seismic resistance conditions.
				In the study territory, there are human settlements in disaster risk zones.
				In the territory under study, there are no political or territorial planning instruments directly related to IRDM.

Annex 2. Quantitative variables to be applied to the case study.

Variable	Dimension	Adapted indicator
Employment	Economically Active Population (EAP)	of EAP
	Unemployment	% of population not working as a percentage of working-age population
Education	Illiteracy	% of population illiterate
	Schooling	Average years of schooling of the population
	Assistance to educational institutes	% of population not attending educational institutions
Housing	Physical condition of the dwelling	% of dwellings with structural deficiency
Basic services	Electricity	% of households without access to the public electricity grid
	Drinking water	% of households without access to the public drinking water network
	Sewer	% of households without access to public sewage system
	Solid waste collection	% of households without access to public solid waste collection
Health and Disability	Permanent disability	% of the population with some type of permanent disability
	Public health insurance	% of the population without access to public health insurance
	Private health insurance	% of population without access to private health insurance
Poverty	Unsatisfied Basic Needs (UBN)	% of the population poor by UBN
Production and Consumption Goods-Services	Agropecuario	% of population involved in agricultural activity
	Manufacturing	% of the population engaged in manufacturing activity

Annex 3. Qualitative variables to be applied to the case study.

Variable	Dimension	Adapted indicator
Environment	Contaminated water bodies	Have the bodies of water (rivers, lakes, lagoons, estuaries, among others) in the study territory been affected by any type of contamination?
	Fauna	Have the species been significantly affected in their natural habitat by any external problems?
	Air quality	Has air quality in the study territory declined in recent years?
	Waste treatment	There is no solid waste processing plant or project in the study territory.
	Political freedom	In the territory under study there are no adequate conditions to exercise political freedom.

Variable	Dimension	Adapted indicator
Rights and Necessary Conditions	Human rights	Human rights are not put into practice in the territory under study.
	Dignified life	In the study territory there are no socioeconomic conditions for a dignified life.
	Human capacity	In the study territory, there is no adequate context for human capacity development.
	Revenues	In the territory under study there is not an adequate average monthly income for the various needs of the families.
	Social inclusion	In the territory under study there are no conditions that guarantee adequate social inclusion.
Geographic	Territoriality	There is no adequate link between the geographic qualities (*natural, social, cultural and political conditions*) and the development of the study territory.
	Territorial cohesion	There is no socio-territorial justice (*equity and territorial integrity of socioeconomic development and coherence of sectoral policies*) in the jurisdiction under study.
Environmental	Ecodevelopment	There is no evidence of a balance between the community and the ecosystem in terms of the rational use of its environmental resources.
Humana	Social mobility	In the territory under study, there is significant social mobility
	Social cohesion	There are no adequate conditions for proper social cohesion in the study territory.
Policy	Territorial governance	There are no adequate conditions for proper territorial governance (*legitimacy, equity, social justice and democracy*).
Culture	Cultural assets	The study territory does not provide adequate conditions for the conservation of the existing cultural properties.
	Ancestral customs	There is no development or promotion of ancestral customs in the study territory.
	Ancestral practices	In the study territory, the application of ancestral practices in disaster risk issues is not common.
Political-Administrative	Corporate	In the study territory there are no adequate conditions to form micro-enterprises, associations, networks and clusters.
	Innovation	There are no conditions that promote innovation in the various productive activities developed in the territory.
	Qualification	There are no conditions to develop the capacity and training of human resources in productive activities/services in the territory.
	Local equipment	In the study territory there is no public/private investment for the equipment and construction of infrastructure for local development.
	Endogenous capacity	There are no mechanisms and instruments to promote local endogenous development.
Governance		There are no conditions for active citizen participation among the main territorial stakeholders and levels of government.
Governance		There are no adequate conditions (*transparency, integrity, legality, sound policies, participation, accountability and*

Variable	Dimension	Adapted indicator
		responsiveness) to demonstrate efficient governance in the study territory.
Humanitarian Assistance		When a natural or anthropogenic hazard materialized in the study territory, there was no adequate humanitarian assistance to improve the disaster situation.
International Cooperation		When a natural or anthropogenic risk materialized in the study territory, there was no adequate international cooperation to improve the disaster situation.
Society and global risk		In the study territory there are no guarantees of a policy and/or strategies to minimize the context of citizen insecurity.
		The community, within the study territory, is unaware of the evaluations, actions and strategies to be followed in relation to the IRDM.
		The community, within the study territory, has different perceptions about the context of disaster risk.
		Society, within the study territory, applies empirical knowledge little or not at all related to IRDM.
		The infrastructures, existing in the study territory, were not built under seismic resistance conditions.
		In the study territory, there are human settlements in disaster risk zones.
		In the territory under study, no political or territorial planning instruments are directly related to IRDM.

Annex 4. Matrix of coefficients of the factor scores for each indicator of the variables for the case study.

Indicators	Components																		
	1				5														
of EAP	.008	-.021	.007	.352	.098	-.036	.033	.011	-.029	.008	-.075	-.006	.023	-.034	-.012	-.083	.015	-.076	.038
% of population not working as a percentage of working-age population	-.008	.021	-.007	-.352	-.098	.036	-.033	-.011	.029	-.008	.075	.006	-.023	.034	.012	.083	-.015	.076	-.038
% of the population illiterate	.026	-.009	-.015	.059	.274	.023	.049	.097	-.030	-.080	-.073	-.009	.041	.037	.002	-.118	.218	-.001	-.074
Average years of schooling of the population	-.128	-.096	.041	-.053	.022	-.020	-.036	.020	-.010	-.044	.011	.041	-.014	.109	-.008	-.021	.015	-.109	.043
% of population not attending educational institutions	.046	.186	-.041	-.010	.084	.060	-.021	-.015	-.022	.059	-.130	-.003	.016	-.017	.008	-.091	-.056	-.035	.040
% of dwellings with structural deficiencies	.112	-.033	-.025	-.050	.070	-.002	.011	-.014	-.041	.014	-.065	.021	-.005	.010	-.005	-.027	.017	-.059	.031

Indicators	Components																		
	1				5														
% of households without access to the public power grid	.097	-.068	.071	-.036	.097	-.105	.046	.015	-.031	.007	-.124	.049	.006	-.011	-.036	-.082	-.019	-.019	.025
% of households without access to the public drinking water network	.068	.043	-.051	.172	-.171	.206	-.109	-.053	.068	.007	.071	-.001	-.040	-.035	.037	.086	-.078	.126	-.013
% of households without access to public sewage system	.147	.075	-.050	.069	-.067	.119	-.092	-.022	.001	.016	-.002	-.023	-.035	-.021	.029	.040	-.014	.026	.036
% of households without access to public solid waste collection	.012	-.010	.300	.015	-.006	.000	-.034	.012	.021	-.002	-.050	-.011	.012	-.012	.043	-.043	-.041	.046	-.018
% of the population with some type of permanent disability	-.007	-.268	.068	-.022	.056	.187	-.004	-.003	.022	.051	-.021	-.083	.002	-.025	.033	.081	.041	-.039	.041
% of population without access to public health insurance	.020	.256	.059	.025	-.107	-.031	-.025	.005	-.004	-.006	.160	-.018	.010	.042	.038	.058	.031	-.020	.000
% of population without access to private health insurance	-.134	.002	.058	-.040	-.039	.084	-.026	.028	-.007	.000	.135	-.080	.007	.029	.021	.060	.055	-.037	-.017
% of the population poor by UBN	.148	-.023	.050	.054	-.112	.003	-.015	.000	-.011	-.019	.130	.034	-.004	.002	-.018	.084	.050	.030	.012
% of population involved in agricultural activity	.070	-.046	.216	-.045	.050	-.003	.030	.016	-.011	.005	-.049	.005	-.011	-.002	.001	-.042	.003	-.028	.005
% of population engaged in manufacturing activity	-.117	.053	-.043	.035	.072	.029	.029	-.039	.073	.002	-.176	.039	-.015	-.043	-.006	-.092	-.115	.060	-.015
Have the bodies of water (rivers, lakes, lagoons,	-.005	-.086	.015	-.008	-.006	.603	.075	.024	.002	.039	-.089	-.026	-.062	.004	.034	.052	.040	-.032	-.025

Indicators	Components																		
	1				5														
estuaries, among others) in the study territory been affected by any type of contamination ?																			
Have the species been significantly affected in their natural habitat by any external problems?	-.001	-.009	.016	.090	-.068	-.036	.094	-.265	-.075	-.055	-.001	-.034	.372	.053	.144	-.027	.055	-.064	.036
Has air quality in the study territory declined in recent years?	.029	-.031	.042	.097	-.184	-.097	.137	.099	.043	-.037	-.093	.109	-.016	-.191	-.423	-.042	.143	.098	.135
There is no solid waste processing plant or project in the study territory.	-.002	-.013	-.007	.001	-.005	.044	-.001	-.026	-.061	.521	-.022	.087	.056	-.007	-.039	-.048	-.074	.040	-.080
In the territory under study there are no adequate conditions to exercise political freedom.	.001	-.021	-.006	-.046	-.042	-.036	-.062	-.021	.024	.127	-.030	.556	.086	.022	-.068	.033	-.022	-.031	-.012
Human rights are not put into practice in the territory under study.	.001	-.034	.025	.075	-.041	-.011	-.049	-.039	-.041	.157	.040	.158	.000	.115	.191	-.119	.017	-.099	.506
In the study territory there are no socioeconomic conditions for a dignified life.	-.005	.013	.041	.092	.170	-.080	.045	.116	-.093	.131	.261	.116	.362	.209	-.055	.047	.005	-.125	.073
In the territory under study there is no adequate context for the development of human capacity.	-.037	-.063	.040	-.072	.039	.160	-.041	.050	-.054	-.056	.002	.086	.070	.011	-.157	-.203	.278	.188	.102
In the territory under study there is not an	.017	-.015	.091	.082	.375	.093	.139	-.101	-.123	.023	.105	.017	-.193	-.005	.052	-.020	-.217	.211	.075

Indicators	Components																		
	1				5														
adequate average monthly income for the various needs of the families.																			
In the territory under study there are no conditions that guarantee adequate social inclusion.	-.006	.011	-.040	.049	-.065	-.036	.244	-.074	.274	.123	.101	-.063	-.085	.273	.036	.028	.247	-.003	-.117
There is no adequate link between the geographic qualities (natural, social, cultural and political conditions) and the development of the study territory.	-.006	-.042	.073	.038	-.054	-.046	.288	-.024	.147	-.079	-.187	.218	.159	.018	.268	.043	-.003	-.032	.089
There is no socio-territorial justice (equity and territorial integrity of socioeconomic development and coherence of sectoral policies) in the jurisdiction under study.	-.016	-.018	.027	-.011	.016	-.087	-.583	.076	.063	-.002	-.084	.037	.040	.090	.108	-.013	.120	-.001	.047
There is no evidence of a balance between the community and the ecosystem in terms of the rational use of its environmental resources.	-.030	.123	.230	-.093	.073	.150	.043	.120	-.011	-.017	-.102	-.092	-.067	-.081	-.097	-.001	.089	-.079	.044
In the territory under study there is significant social mobility	.025	.024	-.024	.002	-.143	.081	-.020	.295	-.018	.047	.113	-.136	-.095	-.003	-.009	-.239	.134	-.206	-.001
There are no adequate conditions for	-.013	.000	-.006	-.066	-.014	.036	-.102	-.027	.031	-.005	-.032	.010	-.077	.534	-.068	-.045	-.052	.003	.034

Indicators	Components																		
	1				5														
proper social cohesion in the study territory.																			
There are no adequate conditions for proper territorial governance (legitimacy, equity, social justice and democracy).	-.032	-.059	-.014	-.040	-.121	.098	.175	.204	.046	.176	.094	.015	.160	-.229	.137	-.097	-.086	.185	-.157
The study territory does not provide adequate conditions for the conservation of the existing cultural properties.	.000	-.016	.028	-.051	-.020	-.039	-.029	.021	.027	.068	-.019	-.033	.016	.004	-.024	-.032	.047	.616	.010
There is no development or promotion of ancestral customs in the study territory.	-.072	.241	.076	-.062	.058	-.064	.013	.038	-.012	-.001	-.013	-.038	.080	-.008	-.015	-.041	.061	-.057	.045
In the study territory, the application of ancestral practices in disaster risk issues is not common.	.047	-.005	.004	.129	-.098	-.201	.018	.261	-.036	.302	-.150	-.060	-.080	-.065	.126	.045	.004	.120	-.020
In the study territory there are no adequate conditions to form micro-enterprises, associations, networks and clusters.	-.097	.014	-.116	-.050	.130	.106	-.030	-.002	-.012	.114	-.041	-.033	-.044	-.100	.041	.009	.071	-.042	.073
There are no conditions that promote innovation in the various productive activities developed in the territory.	-.091	.041	.240	.011	-.007	-.003	.023	-.056	.064	-.010	-.091	.021	-.008	-.034	.010	-.092	-.128	.071	-.020
There are no conditions to develop the capacity and training of	-.022	.032	-.047	-.046	.059	-.057	.030	-.010	.016	-.033	.563	-.023	-.003	-.038	.014	-.066	.008	-.023	-.009

Indicators	Components																		
	1				5														
human resources in productive activities/services in the territory.																			
In the study territory there is no public/private investment for the equipment and construction of infrastructure for local development.	.008	.009	-.027	.002	-.046	.023	-.097	-.010	-.034	-.029	.006	-.002	.040	-.061	.073	.040	.528	.009	-.039
There are no mechanisms and instruments to promote local endogenous development.	.012	-.047	-.043	-.065	.002	.089	-.007	.114	-.079	-.028	-.062	.021	.006	-.017	-.032	.620	.035	-.051	-.022
There are no conditions for active citizen participation among the main territorial stakeholders and levels of government.	.001	-.002	.030	-.008	-.015	-.042	.094	.174	-.064	-.101	-.090	-.132	.093	.292	.141	.111	-.054	.233	-.038
There are no adequate conditions (transparency, integrity, legality, sound policies, participation, accountability and responsiveness) to demonstrate efficient governance in the study territory.	-.017	-.004	.021	.003	.009	-.006	-.054	.004	.034	-.072	.009	-.037	-.044	-.098	.476	-.034	.115	.021	.036
When a natural or anthropogenic hazard materialized in the study territory, there was no adequate	-.005	-.023	-.008	.030	-.026	.002	.001	.037	.424	.011	.006	.070	.040	.097	.120	.000	.009	.002	-.113

Indicators	Components																		
	1				5														
humanitarian assistance to improve the disaster situation.																			
When a natural or anthropogenic risk materialized in the territory under study, there was no adequate international cooperation to improve the disaster situation.	.044	.001	-.036	.063	-.036	.007	.002	.058	-.499	.074	.043	.065	.045	.060	.079	.087	.033	-.014	-.157
In the study territory there are no guarantees of a policy and/or strategies to minimize the context of citizen insecurity.	.018	.032	-.041	-.037	-.006	-.018	-.045	.052	.081	.025	-.039	.015	.457	-.199	-.100	.017	.027	.130	-.055
The community, within the study territory, is unaware of the evaluations, actions and strategies to be followed in relation to the IRDM.	-.003	.022	.018	-.006	.062	-.014	-.083	.522	-.002	-.073	-.025	-.005	-.021	.015	-.045	.100	-.020	.008	.053
The community, within the study territory, has different perceptions about the context of disaster risk.	.012	.027	.004	-.009	-.014	-.031	-.024	.031	.042	-.142	-.030	-.146	-.019	-.044	-.116	.072	-.025	.061	.592
Society, within the study territory, applies empirical knowledge little or not at	-.030	-.014	-.059	.017	.384	-.091	-.144	.057	.209	.040	.096	-.034	.097	-.050	.075	.130	.026	-.064	-.094

Indicators	Components																		
	1				5														
all related to IRDM.																			
The infrastructures, existing in the study territory, were not built under seismic resistance conditions.	.043	.077	-.068	.079	.070	.038	.134	.029	-.055	-.233	.046	.414	-.248	-.103	.067	.001	.047	.036	-.136
In the study territory, there are human settlements in disaster risk zones.	.081	.029	-.139	-.011	-.051	.133	.085	.065	.111	-.035	-.040	-.039	-.013	.015	-.069	-.026	-.135	-.063	-.030
In the territory under study, there are no political or territorial planning instruments directly related to IRDM.	.019	-.002	.000	-.009	.027	-.026	.085	-.089	.121	.280	.135	-.087	-.103	-.035	-.096	.249	.209	.066	.198
Extraction method: Principal component analysis. Rotation method: Varimax normalization with Kaiser.																			