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Generation of Geology, Geomorphology and Geological Threats for the Updating of the Development and Land Management Plan of Quilanga Canton of Loja Province, scale 1: 25 000.

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Abstract: This project refers to the generation of geology, geomorphology and geological hazards for the updating of the Development and Land Management Plan of Quilanga canton. For which 76 aerial photographs and Digital Terrain Model (DTM) at 1:25 000 scales of SIGTIERRAS of 2012 were used, in addition to the official geological maps of Gonzanamá and the plowed scale 1: 100 000 and topographic maps of Gonzanamá and the plowed at 1:50 000 scale The generated base cartography allowed obtaining the water supply, road network, and settlements through 3D vision allowed by the Arc Scene extension; The analysis of geology, geomorphology, and geological hazards was characterized based on the genesis, morphology, morphometry and identification of landslides; additionally, it should empathize that these digital tools allowed the obtaining the result. For each terrain feature, was obtained through the field validation photo interpreted data, which affect was georeferenced performed the respective corrections, there obtained to qualitative and quantitative end map for each one. Finally, with the assistance of information generated, the landslide susceptibility map was obtained through the State Matrix of Analytic Hierarchy, according to on the methodology that consists of an appraisal, normalization, and weighting of the factors.

Index Terms: Geology, Geomorfholopy, Geological, Geographic Information Systems (GIS).

I. INTRODUCTION

Ecuador since 2008 is developing projects that contribute to the improvement of the productive matrix, from a new management model, which promotes economic growth focusing directly on the human being as the center of progress. Being the main objective achieving the good living, so that it has been necessary to the systematic use of tools such as the plans for Territorial Development and Planning that are planning instruments provided by the law. Which enables the Autonomous Decentralized Governments to propose strategies and criteria, to leverage resources and recover the productive capacity of the population, giving priority to the Strengthening of the capacities and potential of dispersed areas. Within this approach, the Government Autonomous Decentralized of the Canton Quilanga is in the needing for a detailed analysis of its territory by the biophysical components, economic, socio-cultural, human settlements, mobility and political institutional,

To have a precise idea of the current situation in which located; with the objective to establish criteria for action, directed toward the strengthening of productive activities in which will get a social and economic development of urban and rural communities.

In the same way, in the specific case of natural hazards, it refers to analyze the phenomena of mass removal, due to that the canton with its relief uttered is aimed to suffer problems of landslides, which generates economic losses in infrastructure and crops annually, being the most affected the inhabitants of the area.

It is for this reason that the present project is aimed at obtaining information base, mapped with the help of the Geographic Information Systems (GIS).

For from engineering, contribute to the biophysical component, through the stereoscopic interpretation of aerial photographs and thus determine the genesis, composition, type and Characteristics of the materials and landforms that compose the relief of the Canton, which then must corroborate in the field through points of reference, facilitating the validation of the data. Likewise, this analysis allows with the help of a Digital Terrain Model (DTM), obtain specific characteristics of the relief as slope and uneven relative, which from a technical point of view.

Allows elaborating a model of susceptibility to landslides associated with these factors through the matrix of the analytic hierarchy of State, which based on the selection, prioritization, and allocation of weights, to then combine the factors and determine the unstable areas.

This information will be of great help to the GAD Municipal because it will help to implement a better population expansion, in addition to conducting a proper use and occupation of the territory the cantonal levels.

II. METHODOLOGY

The generation of geomorphological and geological units, consists in the subdivision of the territory according to each one of the forms of relief, in the portion of the landscape that constitute, like rock or deposit superficial, pending, unevenness relative, the shape of the slope, erosion processes,

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among others. [Hupb, 1989]. This analysis performed in two phases, one of cabinet and another field; which happen through the systematic development of data processing as described in Fig. 1, within these stages, is analyzed the traits that make up the crust of according to the genesis, morphology, morphometry and morfodinámica of those materials as in Fig. 2, [Lopez, 1988].

Considering that the minimum unit of mapping corresponds to 1 Ha, which gets the detail suitable for the scale of work to 1: 25 000. Also, you can generate a land use map, from the interpretation of the vegetation cover, which presents the ground, generating polygons according to the marked areas. [Centeno 1994].

The scanning process allows for the mapping of the area of base study, according to the employment of programs such as Global Mapper 12, Lewis 3.6, Erdas 11.0 and ArcGIS 10.1; being necessary a later corroborated by the field with matrices. That collects concrete data on the situation in which presented the materials in situ, so from the geological point of view, geomorphological and geological threats establish their structural characteristics, genetic, composition, among other. Also, it is essential the microscopic analysis determines the mineralogical composition of the materials they need a more detailed verification. Thus, with this process is the best data that can use for subsequent studies. [Felicísimo, 2009].

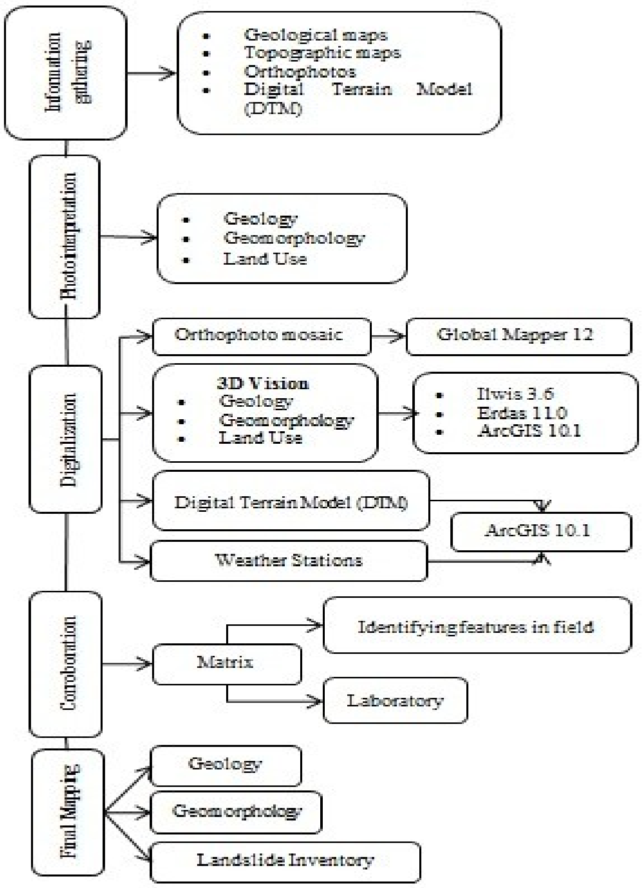

Fig 1. Process to obtain the base of the Canton Quilanga mapping

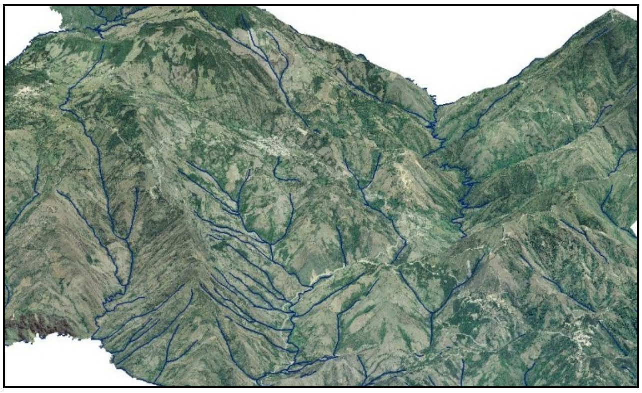

Fig 2. Photo interpretative analysis (3D) in the canton.

2.1 Susceptibility

The maps of susceptibility reflect ground units conditioned by the landslides in where there may be a lesser or greater instability, which obtained from a multivariate analysis of the factors of the terrain.

That is why, for the assessment of this phenomenon, used semi-quantitative methodology of the analysis process Hierarchical (AHP) developed by Saaty, 1980; this matrix sets a hierarchy of priorities that show the global preference for each one of the alternatives of decision. The AHP proposes the allocation of a vector of weights w = [W1, W2… WN],

To subsequently determine the eigenvector primary, which sets the weights "Wj" in an array of comparison of importance (taking them in pairs),

Obtaining values aid that it is possible to group in a square matrix of order n, the call matrix of comparisons by pairs, A = [aij], i.e. the number of criteria to ponder, as in table 1 defines rows and columns [1].

Table 1. Diagram of the Analytical Hierarchy method for the allocation of pesos (Saaty, 1980).

	Peer comparasen matrix				Main Eingenvector
Factors	**To**	**B**	**C**	**D**	
To	XAA	XAB	XAC	XAD	WA
B	XBA	XBB	XBC	XBD	WB
C	XCA	XCB	XCC	XCD	Toilet
D	XDA	XDB	XDC	XDD	WD

The procedure determines the relative importance of the criterion of each row, on the criterion of its corresponding column,

So, it is necessary to complete the entire array by entering the values in the upper right triangle, the values in the upper left triangle will be the inverse values to those of the corresponding cells. It is necessary to add each column to get a marginal value of the column to generate a new matrix using the division of each cell between the marginal of your column, and calculate the average of the weights for each line.[1]

In the work of Stay (1980 and 1994), Saaty and Vargas (2001) tested some measurement scales and exposed the following measurement scale for the estimation of the coefficients aid according to table 2.

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Table 2. Saaty scale to determine the value of Xij (Saaty, 1980)

Importance Level	Definition	Description of criterion I, compared to J:
1	Equal Preference	The two criteria (I,j) contribute equally to the landslide process
2	Moderate Preference	Past experiences slightly favor the criterion (i) on the other (J)
3	Strong preference	Virtually the dominance of the Criterion (i) on the other (j) is demonstrated
4	Absolute Preference	There is evidence that determines the supremacy of criterion (i)

The AHP allows you to measure the degree of consistency between the paired views provided by the expert, defining the reason for consistency (RC), from the consistency index (CI) and the index of random consistency (ICA) equation (1):

$$RC = \frac{IC}{ICA}. \quad (1)$$

Where IC is the index of consistency of A and is calculated using the expression, equation (2):

$$IC = .\frac{n_{\max} - n}{n - 1} \quad (2)$$

$\sum_{j=1}^{n} a_{ij}\,\overline{w} = n_{\max}\,\overline{W}$, The value of $n_{\max}$ is calculated $AW = n_{\max}\ W$ noting that the equation is (3):

:

$$\sum_{j=1}^{n} a_{ij}\,\overline{W} = n_{\max}\,W \quad (3)$$

Where i= one, two, three to n given that for equation (4).

$$\sum_{i=1}^{n} \overline{W} = 1 \quad (4)$$

We get the equation (5).

$$\sum_{i=1}^{n}\left(\sum_{j=1}^{n} a_{ij}\,\overline{W_J}\right) = n_{\max} \sum_{i=1}^{n} \overline{W_1} \quad (5)$$

If IC is less than 10% the inconsistency considered as acceptable, in contrast, if the decision maker does not achieve an IC appropriate, should be reviewed their trials. In practice, this can lead to a long process of successive corrections.

III. RESULTS

Quilanga is located at 92 Km to the southwest of the Canton Loja, header cantonal province; account with an extension of the land of 236.681 Km2 and hosts to a population of 4 582 inhabitants. Politically, it is divided into three parishes, one urban (Quilanga cantonal header) and two rural (Fundochamba and San Antonio de las Arenas), and limits to the north with the Canton Gonzanamá, To the south with the Canton Espíndola, to the east with the Canton Loja and to the west with the Canton Calvas.

[1] Procedure available in the software IDRISI in module WEIGHT.

3.1 Base mapping

The photointerpretation analysis in 2D and 3D, with the subsequent corroboration in the field, allowed obtaining to detail the characteristics described in table 3.

Table 3. Characterization of the studied area referring to PDOyT Quilanga, 2015

Factor	Result	Criteria characterized
Topography	**Hills:** 1 200 - 1 400 m s.n.m. **Mountains:** 2 200 - 3 400 m s.n.m.	*Highlight*
Geology	Alluvial surface deposits, Colvin alluvial, and colluvial (clay, limolita, sandstone, gravels andesíticas sandy silt matrix, angular edges to clay matrix subangular, slimes grained sand fine to coarse). Clays, siltstones, and sandstone of the fm. Gonzanamá, Tobas andesíticas riolíticas and of the fm. Sacapalca; and, shale grafiticos Chiguinda Unit.	*Genesis, texture, structures, hue.*
Geomorphology	Low terrace and Present channel, terrace media, the surface of the cone of ejection old, old alluvial coluvión, old, relief colinado east, relief, relief colinado colinado high very high and mountainous relief.	*Morphology, morphometry, and morfodinámica*
Hydrology	Chiriyacu River, Rio Guayucu, Valdivia River, Rio Elvira, Rio Chonta, Rio Yunguilla, ravines, and slopes.	*Water Channels*
Climate	June to December: 600 to 800 mm/year January to May: 1000 to 1500 mm/year	*Precipitation*
	Lifting surfaces: 10 to 14°C Surfaces of Valley: 22 to 28 °C	*Temperature*
Land use	Agricultural, livestock, mixed agriculture, conservation and protection, conservation and protection or livestock, protection or production, forest, anthropic, unproductive lands	*Vegetative and productive activities*

3.2 Susceptibility

The qualitative analysis will be performed depending on the process of hierarchical analysis of Say, where it requires the creation of a database, through the selection and mapping of terrain factors to determine the conditions of instability, for after being scanned and updated.

The maps of factors should be normalized to obtain the final map of susceptibility through the weighted sum in ArcGIS.

Preparation of the maps

For the development of the model of susceptibility to landslides in the canton Quilanga, adapts to the data and evidence of field, to represent the largest amount of characteristics of the area that will be used are geology, geomorphology, earrings, current use of soil, relief relative and precipitation.

Valuation and normalization of the maps generated

The maps generated categorized according to ranges for each feature and had different meanings and units of measure. Therefore, to be compared should be standardized values of each one to one and the same unit of measure, for which it is convenient to use a numeric scale of 0 to 1 and 0, represents the lowest potential and one the highest potential of the criterion to develop landslides. After the allocation of values to the factors: geology, geomorphology, land use, relief relative, and rainfall; the maps are normalized using the method of maximum value found. The advantage is given because allows maintaining the proportionality of the elements without making a transformation of the variable.

Subsequently, to relate the criteria of the normalized maps in a final map, assigns weights that represent the importance of each criterion in the generation of landslides. That is to say, the factors that have greater involvement in the process must contain a greater weight.

From the point of the standard maps, is the crossing of variables in pairs and then the valid criterion according to the analysis of the materials in the field, it is possible to issue a technical criterion to define the value of importance of each one of the factors in the phenomena of mass removal or landslides.

The matrix presents hierarchical factors according to the importance they have against landslides, moreover, the considerations taken for the allocation of the values of importance (1 to 4).

According to the relationship of the factors, taking into account the premise that located (array) according to the degree of greater susceptibility to present to landslides, as can see in Fig. 3, and furthermore,

It shows the relative weights that applied to the factors necessary for obtaining the map of susceptibility to the effect of the factors.

Construction of a map of susceptibility

The development comprises three basic stages, obtained the preliminary map of susceptibility of agreement to the determinants; there is the weighted sum of the map of valuation of constraints with the haste that considered as the triggering factor.

	Slope	Geology	Geomorphology	Land Use	Relief		**Relative Weight**
Slope	1	4	3	4	2	2.80	0.385
Geology	0.25	1	2	3	2	1.65	0.227
Geomorphology	0.333	0.5	1	3	1	1.17	0.161
Land Use	0.25	0.333	0.333	1	3	0.98	0.135
Relief	0.5	0.5	1	0.333	1	0.67	0.092
						7.27	1.00

Fig 3. Determination of relative weights - Array of analytic hierarchy

Finally, is reclassified the map, in some five ranges, to facilitate the interpretation and quantification of the degree of susceptibility of the area as a result of the combination of the factors registered.

In Figure 4, is summarized by a model of the construction of the process undertaken to obtain the final map of susceptibility to landslides.

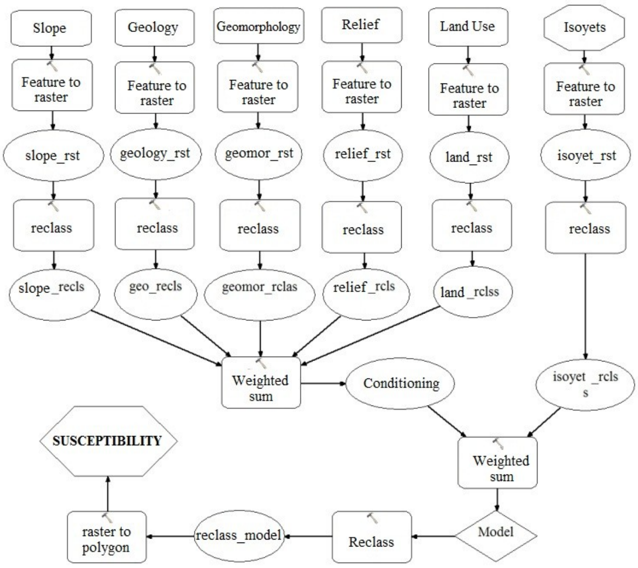

Fig 4. Flow diagram "Model Builder" to obtain the map of susceptibility to landslides

IV. CONCLUSIONS

The method used for the mapping of the geological, geomorphological and geological hazards, allows sufficient accuracy to place the survey performed in the category of semi-detailed.

The information base that generated from the photo-interpretation, as well as the final model of susceptibility, may be employed in subsequent studies of the Canton Quilanga, same that can serve as a tool to generate subsequent maps of threat and risk to landslides the analysis allowed to appreciate that the 7.68% of the area classified as very low, 26.23% is characterized by low susceptibility, the 32.73% as susceptibility average, 24.36% is characterized by the high susceptibility and the 9.00% is defined by the very high susceptibility to landslides.

Therefore, with the degree of accuracy obtained from the interrelationship of the factors, it is considered that the methodology considers a reliable susceptibility index of 80%, to the phenomena of mass removal (landslides), Due to that relates the materials with which it composed the area, the influence of relief and the influence of the erosive agents against them.

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