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Cases of the application of landslide knowledge to land-use planning and risk management

Gabriel Avellaneda A, Gloria Lucia Ruiz P.

Servicio Geológico Colombiano

gavellaneda@sgc.gov.co, gruiz@sgc.gov.co

Abstract

Landslides are events that greatly affect the everyday life of Colombian citizens and can have consequences ranging from great tragedies to deaths, road closures or infrastructure damage, thereby harming the local, regional and national economy. Therefore, studies of landslides are very important; however, the conditions of instability caused by landslides are not changed by studies alone, and other processes based on landslide knowledge are necessary. This article provides examples and specific cases to demonstrate how social appropriation and application of knowledge about landslides can mitigate and reduce the threat, vulnerability and risk of landslides, reconfigure land use and human occupation and manage the territory from different perspectives. To this end, this article presents an analysis based on landslides and other types of information about the territory and society. This work is accomplished using cases of social appropriation from studies conducted in Cáqueza, Cundinamarca, Soacha, and Barranquilla (in Atlántico), which demonstrate different aspects of the application of landscape knowledge.

1 INTRODUCTION

Landslides represent an important phenomenon in the history of Colombia due to the magnitude of some tragedies, such as Quebrada Blanca along the Bogotá to Villavicencio road on June 28, 1974, which left more than 500 people dead; Armero in Tolima on November 13, 1985, which left more than 23,000 dead; Villatina in Medellín on September 27, 1987, which left more than 500 dead; Supía in the department of Caldas on December 16, 1970, which left more than 200 dead; and Guavio in the department of Cundinamarca on July 28, 1983, which left more than 200 dead. These are the most widely recognized events in collective memory and the media.

There are numerous studies of the instability issues in the municipalities mentioned as examples in this article. In the case of the municipality of Cáqueza in the department of Cundinamarca, instability due to landslides has been observed in the municipality since the 1930s, when the first warnings about the problem were issued. A technical visit associated with one of these alerts resulted in a report titled “Cracks in Cáqueza (Cundinamarca) and the danger these pose to the public,” which was written by the well-known scholar Enrique Hubach Eggers. Since then, the susceptibility of the municipality and its urban area to instability problems due to landslides has been noted. At that time, technical studies were conducted but not implemented, and by 2010 and 2011, pressure from local, regional and even national authorities led the Colombian Geological Survey, formerly INGEOMINAS, to develop a landslide hazard zoning study for the Cáqueza municipality in Cundinamarca at a scale of 1:10,000.

In that study, the landslide hazard assessment group of the Geohazards Department applied the methodology of social appropriation of geoscientific knowledge for the first time. The complete process of social appropriation was applied alongside the technical work, and then a monitoring phase was conducted after the results were delivered, which is the emphasis of this article.

The next case is that of the municipality of Soacha in the department of Cundinamarca, where there was an emergency in the Villa Esperanza neighborhood, where movement had been slow up to December 20, 1999, and then increased gradually until reaching 3 meters per day by January 6 and 7, 2000. Other areas of the city also

had major landslide problems, which generated several studies, including “Geotechnical Study in Cazucá, La Capilla sector. Agreement No. 034 of 1995, INGEOMINAS”; “Technical report on emergencies in the Villa Esperanza neighborhood of the municipality of Soacha – Cundinamarca, INGEOMINAS, 2000”; and other studies conducted by other entities, such as the National University of Colombia.

Finally, INGEOMINAS, which is currently known as the Colombian Geological Survey, carried out geomechanical and landslide hazard zoning in the municipality of Soacha, department of Cundinamarca at a 1:25,000 scale and in the municipality of Soacha in the urban area and urban expansion area of the department of Cundinamarca at a 1:5,000 scale. In this location, based on the complexities of the growing occupation of the territory and the results of these studies, the monitoring phase was carried out after the results were delivered. In the case of the municipality of Barranquilla in the department of Atlántico, there have recently been instability problems in the hillsides, which resulted in economic losses, such as those reported in the media that occurred in the neighborhoods of Ciudad Jardín, Carson Mirador and Campo Alegre. In these locations, it is estimated that approximately 2,000 families that own homes and apartments were affected. This event led to a lawsuit for various damages and impacts, in which the administrative Judge 11 of the Circuit of Barranquilla resolved a class action and ordered the District of Barranquilla and several construction firms to compensate those affected by the landslides for material and moral damage, with the payment amounting to 300,000 million pesos for each victim. Due to this instability on the slopes of Barranquilla, the Colombian Geological Survey carried out landslide hazard zoning of the western slopes of Barranquilla in the department of Atlántico at a 1:5,000 scale. With this funding, the municipal council and the inhabitants of Barranquilla had a valuable resource to manage the territory, mitigate the landslide hazard, establish a harmonious relationship between the inhabitants of Barranquilla and the territory, and build risk management processes based on geoscientific knowledge of landslides. Social appropriation performed after the delivery of the results of this process consolidated the intervention plan.

2 JUSTIFICATION

Considering the history of the instability problems due to landslides of each municipality

described above, the questions that always arise are as follows: What hinders the application of landslide knowledge? What should be developed in order to apply that knowledge to land-use planning and disaster risk management? One of the explanations is the lack of understanding of the technical jargon of landslides, since it is a unique topic with technical concepts specific to earth and engineering sciences and geotechnics, which are difficult for social and administrative actors of the territory to understand. This aspect is correlated with the absence of technical actors in municipal councils and other spaces.

Landslides can affect land use or present a possible threat to inhabitants and thus represent a complex issue to undertake by the associated actors, since acknowledging the existence of instability problems caused by landslides may involve social, cultural, economic and political costs. However, from the perspective of social appropriation, the basic premise is that geoscientific knowledge of landslides represents new options for managing and adapting to the land and organizing human activities within the territory efficiently and safely.

Thus, this article shows that knowledge about landslides does not represent difficulties and restrictions but rather leads to the possibility of intelligently managing land based on the principle of prevention and management of landslide hazards. Such work is achieved via analyses using the knowledge of landslides and cross-referencing other kinds of knowledge of the territory to comprehensively study landslide hazards and their consequences and mitigate the conditions of hazard, vulnerability and risk caused by landslides.

3 THEORETICAL FRAMEWORK.

There are different reference elements in the social appropriation of geoscientific knowledge of landslides because this process is generated by a government institution, such as the Colombian Geological Survey. The social appropriation process has main 3 legal aspects. The first aspect is the mission of the Colombian Geological Survey, which is to “Comprehensively manage geoscience knowledge of the national territory and ensure its accessibility”. To fulfill this function, it should be noted that readiness against geological hazards is closely linked to the process of the communication and dissemination of geoscientific knowledge, and these elements are part of social appropriation and assist communities and actors in the

comprehension, appropriation and application of the geoscientific knowledge of landslides.

The second aspect is law 1523 of April 2012, by which “the National Disaster Risk Management Policy is created and the National Disaster Risk Management System is established”. (Ley 1523) Article 2 of this law states the following: “Risk management is the responsibility of all authorities and inhabitants of the Colombian territory”. (Ley 1523). In this regard, the Colombian Geological Survey, as part of the National Disaster Risk Management System, is a responsible actor in the generation of knowledge on geological hazards.

That same regulation cites the importance of managing and communicating disaster risk, which is related to the social appropriation of knowledge of landslides: “Communication of risk to public and private entities and to the public for the purposes of public information, perception and awareness”. This statement reaffirms the need to communicate the geoscientific knowledge of landslides to all actors, which is achieved via the social appropriation process.

The third aspect is the National Strategy for Social Appropriation of Science, Technology and Innovation, which is organized by (Departamento Administrativo de Ciencia, Tecnología e Innovación – Colciencias). This plan prioritizes the creation and consolidation of spaces to discuss solutions to social, political, cultural and economic problems using scientific knowledge, and it is where the social appropriation of geoscientific knowledge of landslides remains consistent with the needs of Colombia, since this is a phenomenon with great importance and that impacts Colombian reality.

Another reference and background for the social appropriation process is the Multinational Andean Project: Geoscience for Andean Communities, which was developed between 2002 and 2009 by the Geological Surveys of the Andean countries (Argentina, Bolivia, Chile, Colombia, Ecuador, Peru and Venezuela) and the Geological Survey of Canada. The goal of this project was “to contribute to improving the quality of life for the people of the Andes by reducing the negative impact of natural hazards” (PMA: GCA). This project demonstrated that in addition to scientific knowledge generation and collection, this knowledge had to be transferred and applied so that it could be transformed into actions to help improve the quality of life of the inhabitants. In addition, communication was identified as the appropriate tool to produce such transformation, which is reflected in the document

“Communication to transform geoscientific knowledge into action”.

Starting from a theoretical perspective of the social appropriation concept, the term appropriation, unlike comprehension, refers to “taking something for ones’ own use”, which means that people were given a more active role, as indicated by (Daza and Arboleda). This active role means that appropriation is not only understanding what is known about a phenomenon but also developing actions motivated by this knowledge in everyday life.

Therefore, the concepts underlying the processes of communication and use of science must be determined. “Communication is understood as a two-way process, “an exercise of the recognition of the “other”” (...), an attempted encounter and relationship, which will necessarily transform the actors” (Delgado, 1990; Daza and Arboleda). This type of science communication with these characteristics is known as the democratic model of science communication, which is defined as follows: “The democratic model recognizes that the audience has knowledge and expertise, as well as values and interests, which are useful in the reflection on scientific applications to specific social contexts, and promotes two-way communication processes between science and the audience (Daza, and Arboleda).

4 STRATEGY.

The development of social appropriation is mainly based on encounters and interactions with the social actors involved in the application of knowledge of landslides. For this specific case, the main actor is the municipal council, which is the government entity responsible for land-use planning at the municipal local level.

These actors include each representative of the various administrative secretaries of the municipal council, where different topics are addressed, including education, health, environment, government, cohabitation, finance, transportation, physical infrastructure, sports, culture, agricultural technical assistance, legal representation, land-use planning and management, legal issues, risk management, communications, and other topics. Regarding the participation of all these actors, it is important to note that landslides become a key topic for the entire municipal council, since this entity is directly related to every area of the administration of the territory and its inhabitants and all the action lines of these municipal councils. Thus, knowledge of landslide hazards becomes

basic knowledge for the development of the municipality and the communities of this territory.

5 METHODS

From the premise that knowledge of landslides must be applied in the social and economic development of Colombia and its regions, social appropriation has several stages within the execution of a study of landslide hazard or risk, which consider the different moments when knowledge of landslides is generated.

The development of the methodology starts with a “before” stage, which is the moment prior to the start of the landslide study, a “during” stage, which is correlated with the execution of the study, and an “after” stage, which refers to the subsequent moment when the final products of the study are delivered (hazard map and final report). This methodology is diachronic, since it is structured with processes of interaction, communication, understanding and continuous appropriation.

One aspect of the social appropriation proposal is its flexible structure, which is important because humans and their groups are dynamic, and the dialogue among them is also dynamic. Thus, perceptions of the territory are modified, mutate and evolve in each specific sociocultural context.

In the case of this article, which is related to some examples of the implementation of zonings of landslide hazard in land-use planning through the social appropriation process, the focus is on the “after” stage, namely, after the zoning products are delivered.

5.1 After.

After the final products are delivered, a detailed interpretation of the results is initiated to understand the explanatory causes of the presence of landslide hazard or risk in each territory or area. This process allows the actors to assimilate their landslide knowledge. In this case, the actors are the territory managers, such as the municipal councils in the case of Colombia.

The next aspect is the analysis of the current scenarios of social conditions and exposed elements related to landslide hazards, where knowledge of landslides converges and overlaps with other elements, such as housing density, population, public services and structures. This analysis allows the territory to be zoned, noting that the while the technical conditions of landslide hazards may be the same, the consequences and impacts of these hazards may be different for each zone.

This process generates new map legends that include both the knowledge of the landslide hazard described by the same actors and all the exposed elements and interventions for each sector. Finally, this work generates intervention matrices for developing intervention plans, programs and projects for the prevention, reduction, mitigation and management of landslide hazard and risk.

The tools used in the “after” process include translated technical presentations, forums, participatory workshops, meeting spaces, and other tools. In this stage, knowledge appropriation occurs in the application and implementation of solutions and interventions included in tools for land-use planning and management, such as the Land-Use Planning Strategy (*Esquema de Ordenamiento Territorial – EOT*), Basic Land-Use Plan (*Plan Básico de Ordenamiento Territorial – PBOT*), Land-Use Plan (*Plan de Ordenamiento Territorial – POT*), disaster risk management plans, development plans at different scales (municipal, community), among others.

Each of these cases are presented below in order to better illustrate the activities carried out and the products obtained.

6 CÁQUEZA, CUNDINAMARCA.

Once the study was completed, workshops were conducted to understand the hazards and how they were interrelated with the different topics. Each topic was addressed, starting with the distribution of active landslides in the territory and followed by the types of surface geological units that indicated some type of trend of hazards. Subsequently, the same exercise was performed with other topics, including geomorphological elements, slopes, land use and land cover. An important aspect in the study was the presence of surface and subsurface waters, which in combination with groundwater level maps, showed a strong relationship with the presence of the hazard.

The next step was to identify, in all the high hazard areas, the various exposed elements, houses, people, structural uses (commercial, residential, public, recreational), and presence of utility networks (water, electricity, telephone and gas which is a restricted service in some areas due to hazardous conditions). With all these high hazard area data, an understanding of the possible impact of landslides was obtained. With these data and the comprehension of the hazard, new descriptive legends for each sector were generated, including the possible intervention actions.

With those legends and the analyzed zones, geographically demarcated through Geographic Information System (GIS) applications, structural lines were established. These lines supported the creation of an intervention plan called the “comprehensive management for the mitigation of landslide hazard in the municipality of Cáqueza”. That plan discussed programs about education, new aqueduct and wastewater management, regulations, rural skill-training, rainwater and sewage management, which were all considered land-use planning. In each of these programs, there were several projects, such as environmental education, land purchase, treatment plant, new sewage system, recovery of water streams, drainage, stabilization works, detailed hazard studies, vulnerability and risk, building regulations, rural development regulations, inventories of water sources and water collection.

After this plan, other projects were initiated, such as a small-scale hazard, vulnerability and risk projects, and a study of critical areas that included 2 mitigation alternatives: the creation of environmental week to disseminate landslide knowledge of the municipality of Cáqueza and the generation of a new water and sewer system in which other regional and national institutions have participated. Figure 1 shows the appropriation analysis process and the results.

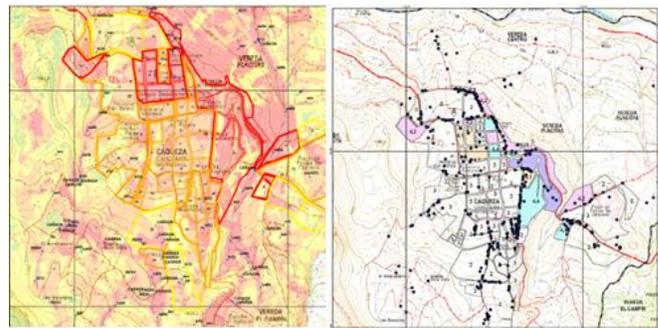


Figure 1. Comparative image of the hazard zone and the intervention scenarios.

7 SOACHA, CUNDINAMARCA.

As stated above for the case of the municipality of Soacha, studies of this municipality were already available in several zones that have experienced events. However, these studies were complemented by the geomechanical and hazard zonings of the entire municipality at a 1:25,000 scale and of the city center or urban areas at a 1:5,000 scale. These results prompted the municipal government to carry out the appropriation process.

The process began by understanding the hazard and variables involved, such as the geological conditions, water presence and slope. Subsequently, it was determined that the neighborhood was the unit of analysis, which was used to compare high hazards to the other elements of the territory. Once these elements were defined, an assessment of the land-use conditions of these neighborhoods was conducted, in which the legality of the occupied areas and the possibility of offering public services, particularly water and sewer systems, was the determining factor.

Once the zones were defined, an analysis matrix was constructed with each zone showing its area, number of parcels, type of intervention, actors involved and approximate economic costs associated with actions, such as mitigation works, family relocation, reforestation, demolitions, sewer system construction, and urban control. These analyses showed that a very important aspect was the legalization of areas in which the same communities settled and indicated that control of the area should be provided to the original area to avoid new settlements. Figure 2 shows the analysis and the intervention zones and a comparison with the landslide hazard zoning.

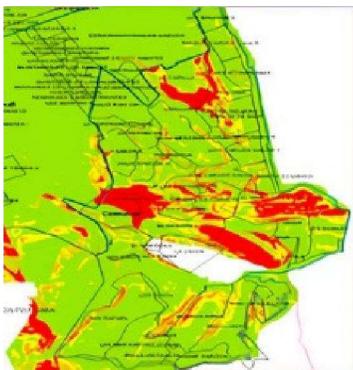


Figure 2. Image of sector of the map of threat by landslides of the municipality of Soacha, which was analyzed and reorganized by the municipal mayor's office.

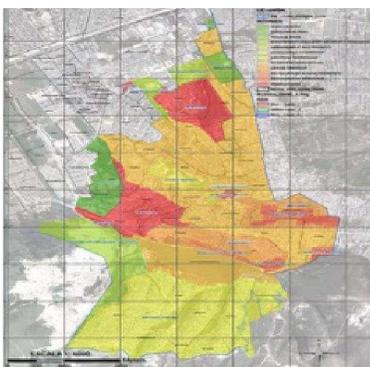


Figure 3. Image of the sectorized map for institutional interventions, generated by the municipal mayor's office.

8 BARRANQUILLA, ATLANTICO.

This process began by motivating the municipal government to perceive the knowledge appropriation of landslide hazards as a representational aspect of managing the land, the relationship with the population and the use of the territory by the population. To accomplish this, all the departments of the municipal government and the other institutions relevant to the city worked to generate landslide interventions.

This gradual process of appropriation started by understanding the hazard maps and their legends and comprehending and appropriating the technical concepts and assimilating them with regard to the representative territory. Based on this work, an analysis of the current scenarios was generated, namely, cross referencing the hazard maps with cadastral information, population density, public services, such as water supply, sewage and electricity networks, neighborhood legalization processes and statuses, projects to be developed, and other types of administrative, social, cultural, economic and political information.

As a result of these participatory encounters, different forms of intervention were proposed in each zone based on the various plans, programs and projects that the municipal council had in its plan of government and development. This led to the construction of a large matrix of interventions from different perspectives that specifies the objective, scope and goal of each intervention, the population involved and the costs of the various forms of structural and nonstructural intervention.

This process yielded several results. Among the top results is the appropriation of geoscientific knowledge by the actors involved who could now view their territory differently and the incorporation of an expanded perspective that takes into account and assimilates various elements, such as geology, land cover and use and landslide hazard. This work allowed for the organization of the information of the territory.

Another result of the appropriation was the Comprehensive Management Plan for the Slopes of Barranquilla, which became an important part of decree 0212 of 2014 “by which the new Industrial Land-use Plan for the Special Industrial and Port District of Barranquilla 2012 – 2032 was adopted” and subsequently in decree 0959 of 2015 “by which the Comprehensive management Plan for the slopes of Barranquilla is adopted and other regulations are issued”. These elements represent forms of social appropriation of geoscientific

knowledge of landslide hazards established as public policy in terms of risk management, land-use planning, and municipal development and the generation of new forms of relationship between territory and society. Additionally, the slopes plan is established as the roadmap for the implementation of the administrative activities of the territory and human actions, and the current administration of the city of Barranquilla has continued short-, medium- and long-term work on this plan. Figure 3 compares the results of the analysis with the results of the landslide hazard assessment.

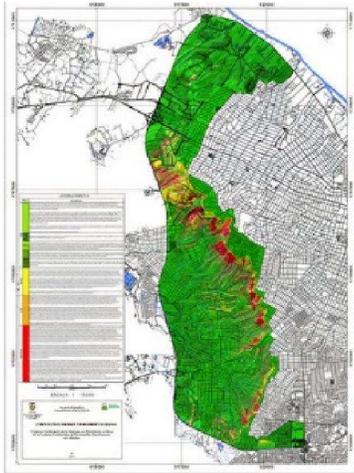


Figure 4. Image of landslides map of the city of Barranquilla, Atlántico.

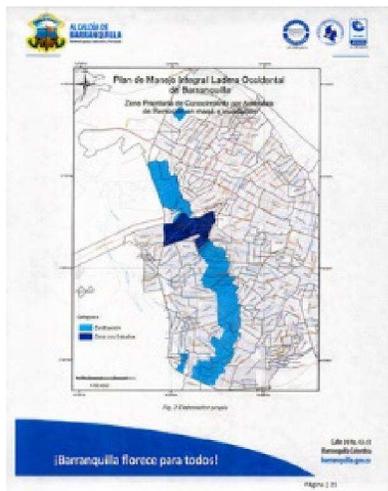


Figure 5. Image of the cover of the comprehensive management plan for the western slopes of Barranquilla, where a redefinition in blue of the areas to be intervened by the threat from landslides can be seen.

9 CONCLUSIONS

Municipal councils and officials adopted a new vision of the territory from the perspective of landslide hazards, which analyzes this geoscientific

knowledge not as a restriction but as an opportunity to organize the territory and its development.

Geoscientific knowledge and its appropriation can lead to regulatory decisions on land.

The appropriation of geoscientific knowledge allows for the analysis of the territory and the generation of interventions that extend beyond technical aspects and involve other social and administrative factors.

The municipal councils strengthened their technical teams to analyze each request of the community regarding land use.

Better relationships were established between state institutions and communities, since the understanding of landslides by the municipal councils was in turn communicated to the citizens.

Social appropriation of the knowledge of landslides allowed for the generation of multiperspective intervention plans with specific actions, which led to detailed studies, legalization of neighborhoods, and regulations on land use and their incorporation into land-use management and planning.

The process of the social appropriation of the knowledge of landslides legitimized studies on landslides, since the outlook of the studies was negative due to their economic cost and because the conclusions of the studies established restrictions on municipal development.

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