

Environmental problematics associated with anthropogeomorphologic activities: the case of Chia in the savannah of Bogotá, Colombia

Problemáticas ambientales asociadas a actividades antropogeomorfológicas: el caso de Chía en la Sabana de Bogotá, Colombia

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ABSTRACT

The objective of this article was focused on the recognition of the environmental problematics related with anthropogeomorphologic actions in the territory of Chia, a geographic phenomenon of remarkable relevance and growth for this municipality in recent years. Based on concepts addressed by environmental geography and geomorphology and covering the first two decades of the XXI Century, a qualitative documentary analysis of secondary information was carried out through quotation, coding, linkage, and visualization techniques provided in the software ATLAS.ti. The results were categorized in groups of impacts, risks, and environmental conflicts, considering significant the correspondence among actors, causes, temporalities and managing decisions. Validation was carried out through photographic registers in field and the use of geospatial images. In summary, a cartographic representation was made in the software ArcGIS to condense the findings and confirm that fluvial environments of the municipal altiplano are the most critical scenarios, and they require urgent attention regarding those problematics.

KEYWORDS: anthropization; anthropogenic modelling; impact; environmental risk; environmental conflict

RESUMEN

El objetivo del artículo se centró en el conocimiento de las problemáticas ambientales relacionadas con las acciones antropogeomorfológicas en el territorio de Chía, fenómeno geográfico de notable crecimiento y relevancia para este municipio en los últimos años. Con base en conceptos tratados por la geografía y geomorfología ambiental, y abarcando las dos primeras décadas del siglo XXI, se desarrolló un análisis documental cualitativo de información secundaria mediante las técnicas de citación, codificación, vínculo y visualización dispuestas en el software *ATLAS.ti*. Los resultados se categorizaron en agrupaciones de impactos, riesgos y conflictos ambientales; considerando además significativa la correspondencia existente entre actores, causas, temporalidades y determinaciones administrativas. La validación se realizó a través de registros fotográficos en campo y el uso de imágenes geoespaciales. A modo de síntesis, se elaboró en el programa *ArcGIS* una representación cartográfica que condensa los hallazgos, y corrobora que los entornos fluviales del altiplano municipal son los escenarios más críticos y de atención prioritaria ante las problemáticas.

PALABRAS CLAVE: antropización; modelados antropogénico; impactos; riesgo ambiental; conflicto ambiental

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Introduction

The environmental consequences produced by human intervention gain more and more interest every day, due to the implications they have for the comprehensive functioning of the planet, as well as the positive and negative effects for the future of society. The concern regarding these environmental problematics encompasses a wide spectrum of approaches, among them those provided by geographic science and its subdisciplines, whose ties have been quite close in its territorial dimension (Bocco & Urquijo, 2013).

From the geomorphological view there is a generalized consensus that human capacity to influence the Earth's surface has increased remarkably (Cendrero et al., 2006) with more complex processes, a wider variety of integrated materials, and more efficient technology (Haff, 2003). Most of the activities developed by human beings have a direct relationship with all landforms (Cassetti, 1995) and such actions, with their transformations, are leaving a particular signature over landscapes, with varied influences over the natural forms, processes, and balances (Gutierrez, 2007; Tarolli et al., 2018).

For the municipality of Chia, human interventions of the geomorphologic environments have become a significant phenomenon that has meant changes and repercussions for the territories of the municipality. Thus, the research of this documents is focused on examining, identifying, and knowing the environmental consequences related with those modifications, without excluding the relevance of the actors, their causes, and the politico-administrative decisions. The general objective is to complement and provide a synthesis outlook that contributes to the territory management tasks and strengthens more sustainable and balanced decision-making towards an effective environmental justice at a local and regional level.

To achieve this objective some key concepts addressed in environmental geography and geomorphology were considered, and Castiblanco's (2022) work was used as a reference. In his article regarding actions occurred in the geomorphologic environments of the municipality of Chia they define some interventions related to agricultural and livestock, mining, industry, waste management, hydrological

management, transit, and urbanization activities. The initial hypothesis is that these activities and their resultant anthropogenic modelling are in most cases the starting point of the environmental problematics that this geographical space currently faces.

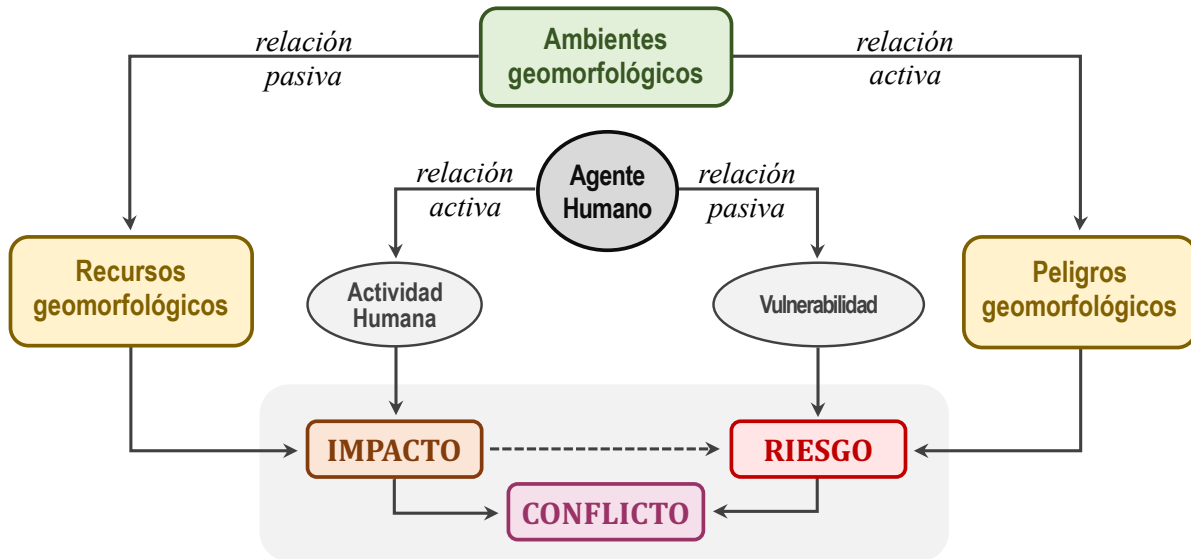
Conceptual basis

Geomorphology as a nature element is a geographic resource of interest (Cassetti, 1995), and its anthropization refers to how societies have been intervening those elements, considering human actions as an important environmental agent (Elissalde, 2005). Anthropogenic actions and the number of artificial geoforms have been increasing as never before, due specially to the urbanization dynamics and the improvement of human capacity to remodel nature at a planetary level (Li et al., 2017). Anthropogeomorphologic activities determine significant superficial changes in the territories, and the human agent not only constantly creates new geoforms (anthropogenic models), but also considerably disrupts the functioning of natural processes such as weathering, erosion, and sedimentation (Szabó et al., 2010; Goudie & Viles, 2016). The situation described unavoidably implies the increase of environmental deterioration and the development of complex problematics.

Environmental problematics are conceived as the set of circumstances that influence nature negatively, therefore, human beings (societies), alterations that human activity produces in the natural order processes (impacts), alternations of natural phenomena towards society (conditions and risks), as well as synergies produced between these two typologies (Pérez, 2015).

In the geomorphologic field, the dual examination of the relationship human-environment has permitted to distinguish and delve into these two dimensions or levels of interaction that influence environmental problems (Kondolf & Piégay, 2011). On the one hand, geomorphologic resources that can be used, modified, or destroyed by human activities depending on the economic, social, and technological circumstances; and on the other hand, geomorphologic risks that have an effect on the vulnerability and alter human conditions and elements

Figure 1. Relationships between geomorphologic environments and the human agent



Note: Source: Adapted from Panizza, 1996.

(Panizza, 1996) (Figure 1). In this social projection of geomorphology, the interest is not only focused on the direct impacts derived from human actions, but also on the aggregate influence of the anthropic perturbation on the states of danger and risk, which provoke the origin of environmental conflicts.

- a) Environmental impact: The general set of effects applied on the environment of a determined territory, they appear from the concretion of one or many interventions (Almeida & Figueiredo, 2015), which disrupt or correct the natural processes increasing or decreasing their speed of action, causing the rupture of a balance that nature tries to reconstruct (Goudie & Viles, 2016). In geomorphology, and according to Panizza (1996), the impacts would be the consequences of human activities regarding geomorphologic resources; for instance, the degradation of a mountainous landscape modified by a backhoe.
- b) Environmental risks: Probable adverse effect on human beings and their infrastructure produced by a natural phenomenon (Vieira, 2015). Risks can be induced by an anthropic variable, and in many morphologies that do not represent danger the activities may provoke a degradation or alteration of it and its dynamics (Marco et al., 2000). Interventions are in general unfavorable and represent damages or imbalances, but in

some cases, they may be beneficial as protection jobs (Lugo, 2011). In geomorphology, risks show systems' capacity to overcome thresholds, and they are in essence potential consequences of the geomorphologic dangers; for example, a landslide that causes a collapse in the highway network (Panizza, 1996).

- c) Environmental conflicts: In the geographic field, they represent the context of disagreement and struggle between (geographical) actors, in which there is an environmental component, a territorial authority, actions inherent to the means of production in which nature is manipulated, and the awareness of human use and abuse (Johnston, 2000). Environmental conflicts are produced when the historical stability obtain between communities and their habitats (territories) gets tensed, and it involves actors that decide to modify the environmental linkage affecting others' interests, or inversely, they include external agents the alter or pretend to alter the existent environmental relationships (Folchi, 2001). Environmental conflicts respond to complex problems, involve both physical and social aspects, and manifest as resistances, usually at a local level, which question the economic model developed at the expense of interactions and environmental degradation (Pérez et al., 2019).

Area of study, materials, and methods

The working location is the municipality of Chia, located in the central part of the savannah of Bogotá in the Department of Cundinamarca in Colombia (Figure 2). Chia has two physiographic landscapes: to the eastern and western sides the structural mountainous reliefs stand out, mostly of rural occupation with important protected areas; while in the central zone there is the altiplano with modelling of fluvio-lacustrine origin, where the population and their urbanization dynamics gather, specially between the fluvial valley of the rivers Bogotá and Frío (Castiblanco, 2021, 2022). As a territorial entity, Chia has a high demographic growth and urban densification (Alcaldía de Chía, 2020a), additionally, the advance of agro-industrial, mining, commercial, touristic, educative, residential, and service economies stand out (Geographic Institute Agustin Codazzi, 2007). For the temporary context of the research the two first decades of the XXI Century were examined, years in which different instruments of spatial planning and management have been generated and implemented explicit and progressively.

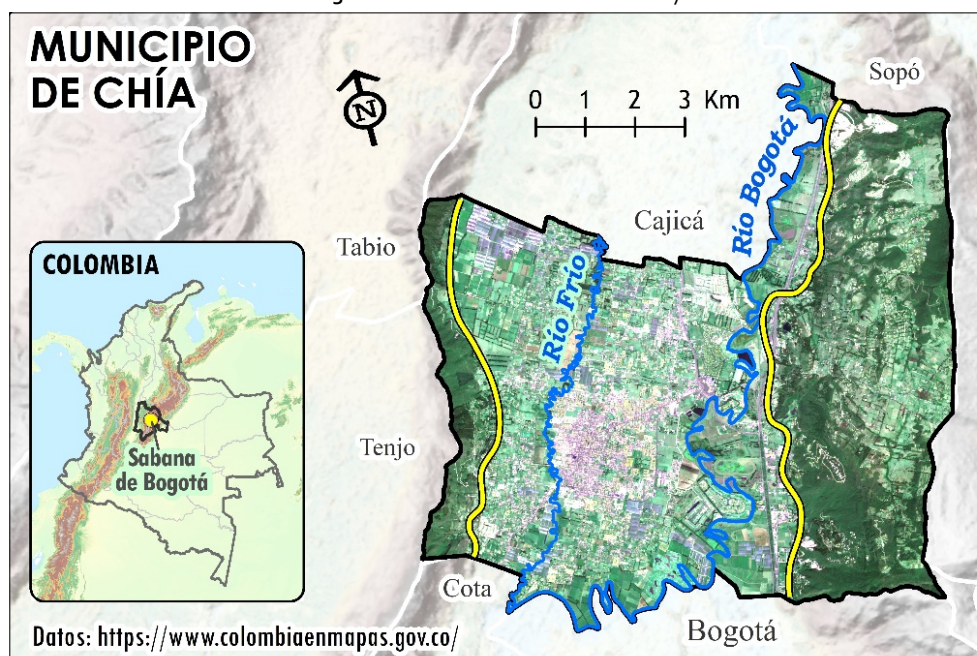
The development of the research was based on the execution of the following five research phases: data preparation, organization of the hermeneutic

unit, qualitative documentary analysis, data validation, and synthesis of results (Figure 3).

The first phase consists in the search, selection, and storage of relevant documents, with the respective reliability verification. Secondary informative sources, mainly written, were acquire mostly through digital search engines, such as official state portals, university repositories, library catalogs, *Google Scholar*, press webpages, among others. After carrying out a pertinence and quality filtering, concerning the research, the input reached 213 documents, which corresponded mainly to reports, publications, and other works of institutional, academic, technical and journalistic nature, including images (maps and photographs) and some speeches both sound and video.

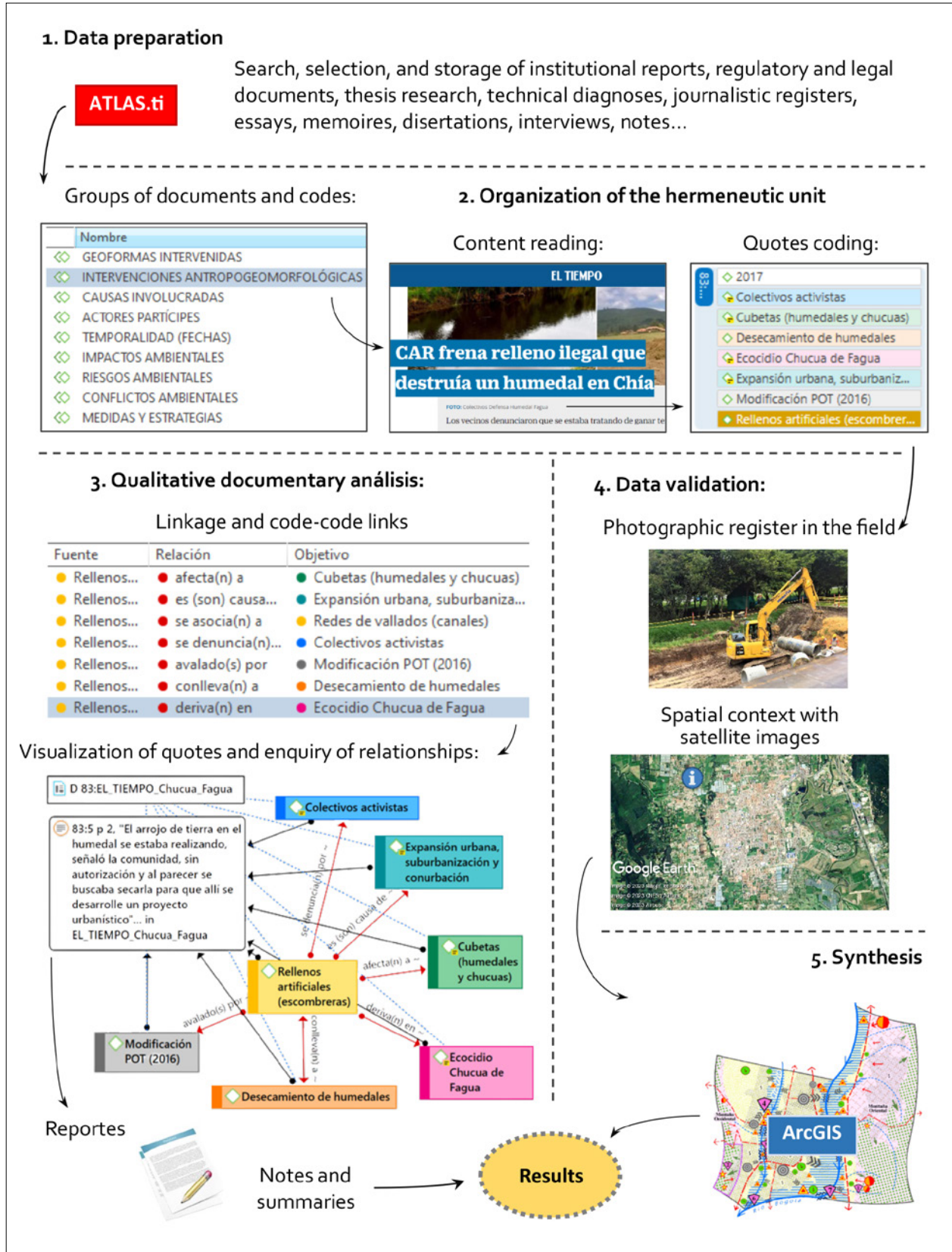
In the second phase, the work was based on the constitution and organization of the hermeneutic unit in the software ATLAS.ti (v.9). An initial procedure was to create groups of documents, as well as to define groups of codes to organize the data selection and facilitate their subsequent quotation. Together with the exhaustive and systematic reading of the contents, the quotes obtained were coded manually, classifying them in groups of intervened geoforms, types of anthropogeomorphologic

Figure 2. Location of the area of study



Note. Source: Author, based on data from: <https://www.colombiaenmapas.gov.co/>

Figure 3. Methodological flow chart



Note. Source: Author

interventions, involved causes, main actors, impacts, environmental related risks and conflicts, temporality (dates), also including the measurements and strategies included in the problematic (generally politico-administrative actions and decisions). In this phase a revision, adjustment and perfection of the coding was carried out simultaneously, at the end it reached a total of 87 registers in the coding system.

In the third phase, there was a qualitative documentary analysis, which was carried out through the application of linkage and visualization techniques included in the software package. At this point the code-code relations were defined, and these results provided the respective analytic interpretations. The use of the networks tool enabled the creation of explanatory diagrams based on the quotes and the codes, while the creation and revision of lists, tag clouds, memos, and reports of the coded data confirmed the interactions between anthropogeomorphologic interventions and their subsequent environmental problematics. The relations in the linkage module of ATLAS.ti permitted to establish connections with the different affected places, its causes, actors, dates of occurrence, and identified determinations. In this phase, and parallel to the consult and analysis of information, notes and summaries were written, based on the most representative quotes regarding the environmental problematics found.

The fourth phase represented the validation of findings. To do that, the problematics were contextualized and verified spatially by consulting and including orthographies given by the Geographic Institute Agustin Codazzi IGAC (year 2010), and satellite images recently obtained in the portals Google Earth and Bing Maps (year (2020)). In the same way, field visits were carried out between 2019 and 2021, which allowed the recognition and

confirmation of results in the mostly referred places, and which supported the photographic capture and register of the different cases.

In the fifth phase a corema map was made using the tools of the software *ArcGIS Desktop* (v. 10.8), whose purpose was the positioning and thematic categorization of the results, as well as the spatial synthesis of the problematics. To do so, a geographic base was generated in the software, using open data downloaded from the website *Colombia en mapas*, and carrying out processes of generalization, classification, symbolization, and cartographic representation. Finally, based on the notes and summaries, geospatial images, field photographs, and the synthesis map the results counted and described following were written.

Results

From the documentary analysis it was identified that in general terms prevailing social development is the structural root of the anthropogeomorphologic activities in Chia, and questionable practices such as corruption from the administration and the local territorial management stand out due to their notable influence in the transformation of biophysical means, which includes the geomorphic mean with the progressive constitution of anthropogenic modellings and their problematics. Results emphasize on one of the determining actors involved and in the particular and primary causes interrelated, which are summed up on Table 1.

Environmental problematics

Environmental impacts associated with interventions are numerous and complex; however, from the analysis, five main categories were established to group them. They are described on Table 2 and exemplified with some cases on Table 4.

Table 1. Participant actors and primary causes

Type	Actors
Victims and complainants	Farmers, indigenous communities, civilians review boards, Academic groups, collectives of activists.
Private sector	Real state, consortiums and concessions, floricultural guild, landlords and landowners.
Institutions	Chia's City Hall, Chia's Municipality Council, Regional Autonomous Corporations of Cundinamarca (CAR in Spanish), Cundinamarca's Court, Council of State, National Authorities of Environmental Licenses (ANLA in Spanish).
Causes	General description general and references
Population growth and concentration	Regional migration and demographic pressure essentially on the on the plain morphologies of the Savannah, with high quantities of inhabitants per km ² (Alcaldía de Chía, 2014, 2015a; Universidad de La Sabana, 2018).
Urban, suburban and conurban expansion	Building activity and commercial development associated with regional metropolization of disorganized tendency and high pressure in the fluvial flows, the eastern mountains and the highway networks connected to the neighboring municipalities (Alcaldía de Chía, 2020a; Regional Autonomous Corporations of Cundinamarca, 2017c, 2019; Contreras, 2017; Soler, 2018).
Irregular planning and inefficient administration	The distinctive case is represented by the Territorial Management Plan (POT in Spanish), whose modifications in in 2016 generated big abnormalities and a situation that led to its suspension and new formulation (El Espectador, 2019; El Tiempo, 2014; Rincón, 2020).
Irregular land modifications and polemical licensing	Arrangements in the planning instruments with a detrimental environmental connotation for the Main Environmental Structure (EEP in Spanish) (Dominguez and Nossa, 2019; El Espectador, 2019; Registro Urbano, 2018; Semana, 2017; Supelano, 2019).
Controversial changes in the use of land	Associated with the previously mentioned actions, the actions that give rise to many of the geomorphologic intervention processes, generally with agricultural, livestock, mining, hydraulic, industrial, and urban ends (CAR, 2017b; Castiblanco, 2022; Guerrero, 2019; Vargas and Cifuentes, 2006).

Table 2. Related impacts.

Impact	General description and references
Soil and subsoil degradation	It corresponds to the deterioration of the edaphic stratum with predominance of erosion in mountainous zones and waterproofing, compaction, and burying of soils in the lower and plain areas of the altiplano. Degradation includes the irrevocable elimination of soils due to interventions of mining, urban, and transport. (Figures 4A and 4B) (Alcaldía de Chía, 2014, 2015c; Guerrero, 2019).
Changes in the surface runoff and sedimentation	It refers specially to the destabilization of the hydric infiltration with the respective increase and concentration of the superficial local surface runoff in canals (Figure 4B). Interventions at a regional level of the high catchment areas (reservoirs and other hydraulic adequation works) contribute to the deregulation of this dynamics (Afanador, 2019; CAR, 2018a; Soler, 2018).
Drain of wetlands	Loss of bodies of water and their original ecosystems mainly due to stuffing with rubble in basins, lack of maintenance of the canals, hydraulic adequations, and road works in floodplain environments of the rivers Bogotá and Frío (Figure 4C). Many banks of the hydric currents in the mountainous zones are also affected by anthropization with stuffing. (Alcaldía de Chía, 2015c; Anecopura, 2017; Castro and Zambrano, 2019; Delgado, 2021; Semana, 2020).
Alteration of flora and fauna	It includes the generalized dismantling of vegetation derived from excavation and materials accumulation interventions, with ecosystem fragmentation, loss of biodiversity, and a high affectation specially for hydric fluvial environments (CAR, 2017a, 2017b; Cortes and Rubio, 2016; Dominguez and Nossa, 2019; Poloche, 2015).
Contamination	It considers the loss of environmental quality natural means, mainly due to removal, movement, and inadequate disposition of materials involved in the anthropogeomorphologic interventions (Figure 4D) (Alcaldía de Chía, 2020a; Aguilar, 2019; CAR, 2017c; Guerrero, 2019; Talero, 2016).

Figure 4. Impact scenarios **A:** Elimination of soil due to construction of road infrastructure. Sector Rincón de Samaria, town La Balsa (2021). **B:** Scoring of the surface runoff, waterproofing, and burying of soils due to road works in the North Highway. Sector Colegio Odontológico, town Fusca (2021). **C:** Drain, ecosystem alteration, and contamination of the wetland due to progressive stuffings. Sector La PTAR I, town La Balsa (2021). **D:** Contamination due to disposition of dump in mounds

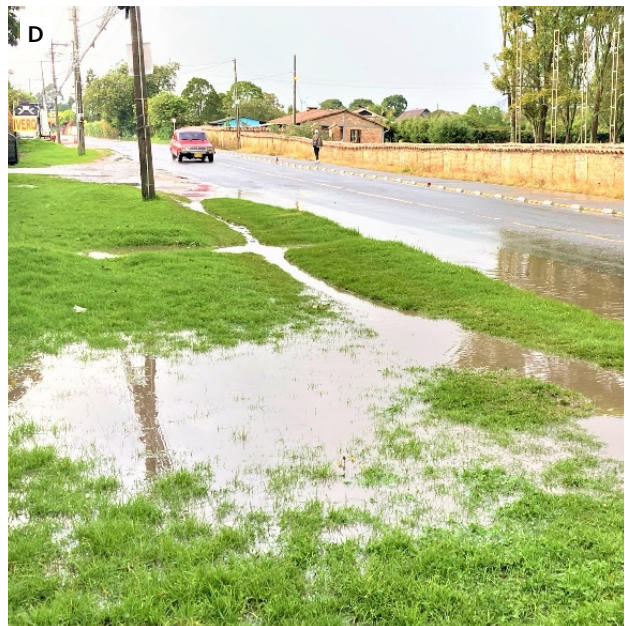


Note. Sector Vivenza, town La Balsa (2020).

Additionally, it is confirmed that the anthropic variable of geomorphologic transformation has an impact on the occurrence and control of threatening natural phenomena, whose actions cause, for the case of study, the alteration of many processes, besides the increase of exposition and vulnerability of

the population of the municipality and their goods due to the population growth and expansion. The creation, increase, or control of risk states and conditions are described on Table 3, with some photographic examples outlined in Figure 5.

Figure 5. Risk scenarios. **A:** potential risk of mass erosion and removal due to quarries and routes. North Highway, sector La Resaca, town Yerbabuena (2021). **B:** Incorporation of unstable rubble on high gradient slopes. Sector La Valvanera, town Fonquetá (2021). **C:** Changes in the dynamics of fluvial overflows due to construction of highway banks in flooding basins. Bogota river valley, sector Teletón, town Fusca (2021). **D:** Puddly floodings generated by rains in urban growth zones, sector La Virgen Source Town La Balsa (2021)



Note. Source: adapted by author

Table 3. Related risk conditions.

Risk	General description and references
Due to mass removal	Landslides, erosion, and their affectations can increase due to interventions, mainly of quarries, road cuts, and dumps disposed on the steep slopes of the mountain (Figures 5A and 5B), with changes in the natural vegetal covering that protects the hillside, intensive use of soil, deficiency in the infrastructure works, inadequate movement of materials, and increase of surface runoff during rainy periods. (Alcaldía de Chía, 2020a; Burgos and Reina, 2015; Poloche, 2015).
Due to flooding lentas	Floods, slow overflows, and prolonged waterlogging are influenced most frequently by human interventions. In Chia the inadequate disposal of materials in floodplain environments has been common, with the reduction of the buffer zones (wetlands) (Figure 5C), elimination of meanders, soil waterproofing, collapse of the sewage system (Figure 5D), and in general the improper occupation of hydric rounds (Afanador, 2019; Ávila et al., 2015; Burgos and Reina, 2015; Castro and Zambrano, 2019; Mejía and Chicué, 2014). In contrast, and as an exception of the problematic typical of overflows, hydraulic works in dams and riverbeds carried out by the environmental authority has avoided flooding events (CAR, 2018b); however, there still is uncertainty regarding their effectivity and the harmful environmental effects of these interventions (Durán and Suárez, 2013; Semana, 2020).
Others	In the mountain, both easter and western, the different activities (interventions) that alter the original morphology provoke a higher occurrence of fires on the forestry covering (Alcaldía de Chía, 2020a, 2020b; Burgos and Reina, 2015; CAR, 2018b; Cortes and Rubio, 2016), as well as concentrate possible hydric torrential flows on the main drainage network, which es modified and affected by the canals, the routes, the houses, and the local movement of materials (Alcaldía de Chía, 2015c; CAR, 2019).

The documentary analysis and results also show the origin and development of diverse environmental conflict associated with interventions, they are equally related with the impacts and risks summed up in the previous section. For the first two decades of the XXI Century, such territorial disagreements are in essence linked with inadequate and

controversial use of soil, in which transgression of planning laws mediate abnormally, and struggle, opposition and negotiation of interests are frequent among the actors involved. On Table 4 and Figure 6 there is a schematization of the outlook of the main conflicts related with anthropization of the geomorphologic environments in Chia.

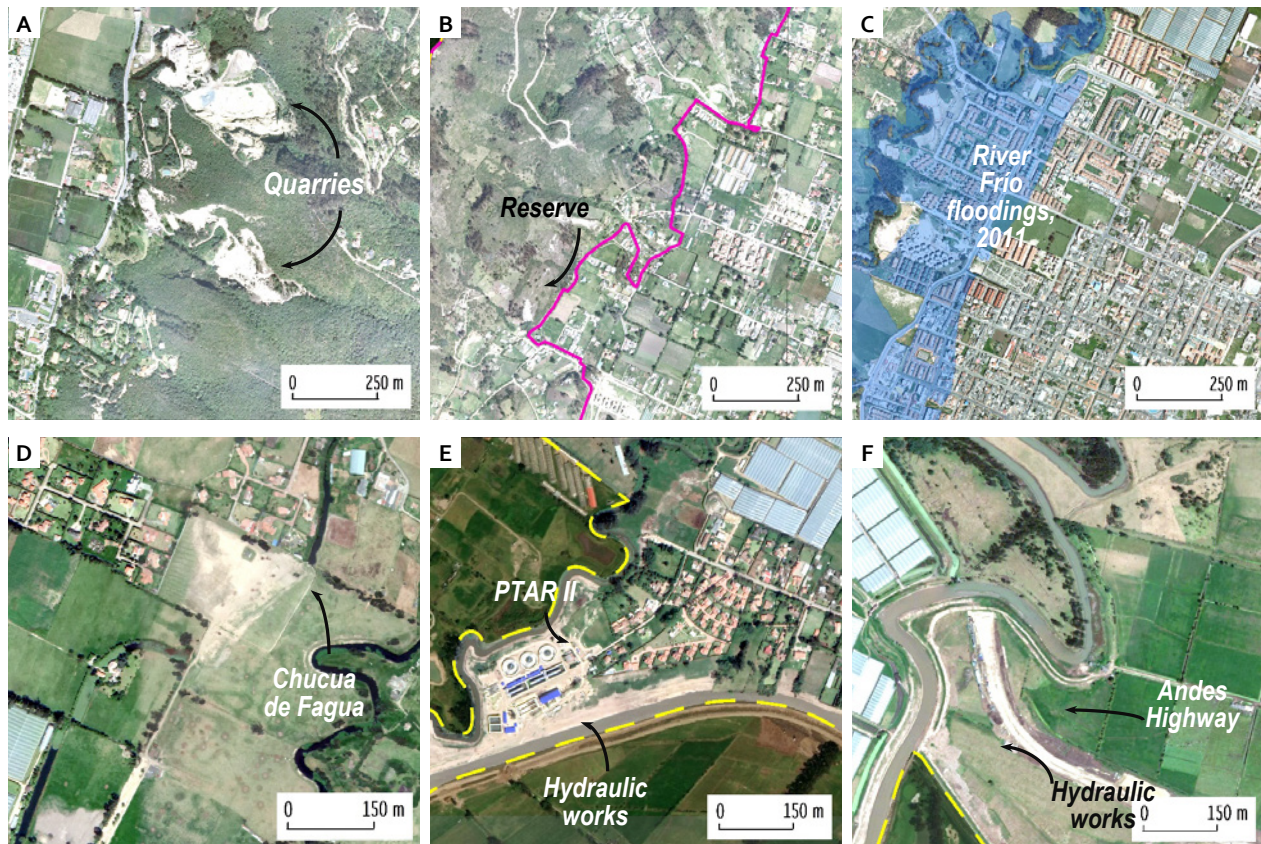
Table 4. related environmental conflicts.

Conflict	General description and references
Discontent due to mining in quarries	Altercation due to the intervention of quarries, mainly on the natural reserve, complaints regarding technical and legal deficiencies of operation, lack of control and action, and disapproval due to explosions and contamination (Figure 6A) (Castro and Zambrano, 2019; El Periódico de Chía, 2015a; Talero, 2016).
Environmental degradation of the indigenous reserve	Struggles due to illegal treasure hunting (excavations), induced fires, non-licensed felling, and the possible construction of a regional highway route (Figure 6B). Such incidents have evolved into protests carried out by the indigenous community (Alcaldía de Chía, 2020b; El Periódico de Chía, 2015b; El Tiempo, 2021; Pachón, 2014).
Crisis due to floodings	Material damage and economic loss caused by fluvial overflows mainly in 2006, 2010 and 2011 (Figure 6C), worsen by the inadequate occupation and transformation of the hydric rounds (fluvial environments), specifically in the urbanized sector denominated Río Frío. During the crisis, the conflict accelerates because of the clear deterioration in the quality of life, the overcrowding, the difficult communication, the bad smells, and the slow reaction to emergencies. Many private interventions that recently built protective barriers contiguous to the rivers have transfer the problem to other sectors of the flooding valleys, which will imply to integrate new affected actors in the future (Alcaldía de Chía, 2015c, 2020a; Ávila et al., 2015; CAR, 2018b, 2019; Durán and Suárez, 2013; El Espectador, 2011; Mejía and Chicué, 2014; Uribe, 2006).

To be continued

Conflict	General description and references
Ecocide of la Chucua de Fagua	It is the complaint of activist groups regarding the intervention of a wetland contiguous to Río Frío (Figure 6D). The conflict consists on an artificial stuffing (anthropic modelling with rubble) that degrades the ecosystem, reveals administrative irregularities, and shows the ambiguous modifications of the Territorial Management Plan (POT in Spanish) (year 2016), these aspects have provoked protests that demand the recovering of la Chucua (Alcaldía de Chía, 2020b; Anecopura, 2017; Pachón, 2014; Registro Urbano, 2018; Rojas, 2018; Supelano, 2019).
Polemic works Sewage Treatment Plants (PTAR in Spanish) I and II	It is summed up in the bad management of residues in the PTAR I (Bogota River valley), generating bad smells, loss of management capability, technological backwardness, and noncompliance of laws; which has triggered class actions due to the economic repercussions and the fruitless modernization task (Aguilar, 2019; El Periódico de Chía, 2020; Rodríguez, 2016). The construction of the PTAR II has borne the annoyance of the residents due to the intervention of the hydric rounds of the river Frío (Figure 6E), administrative, financial, and socialization irregularities. This has provoked blockades, confrontations, and recently agreements among those involved (Rincón, 2020; Soler, 2018).
Disapproval of the hydraulic adequations of the fluvial system	They are works of dredging and elevation of dams, and relocation of sediment throughout the rivers Bogotá and Frío, which mitigate the flooding risks (Figures 6E and 6F) (CAR, 2017a; El Tiempo, 2020). The adaptations generate controversy and confrontations regarding the environmental use of the wetlands, added to the "economic waste". This situation has led to protests in the region, because there is still suspicion towards the promised adequate environmental restoration by the environmental authority (El Tiempo, 2016; Semana, 2020; Gaviria 2016 quoted by Soler, 2018).
Incursion of the construction of the Andes main highway	It is a departmental traffic project, which has threatened and impacts the wetland ecosystems near the Bogota River (Figure 6F). The conflict was formalized through class actions supported by the local administration, with regards to the citizen request of preserving these spaces and the species that inhabit them (Adrenalina Informativo Regional, 2021; Delgado, 2021; Melgarejo, 2018). The case has risen and is currently being attended by ANLA.

Figure 6. Environmental conflict scenarios



Note. Source: Adapted by author

A: Quarries activity. Town Fusca. Source: orthophoto, IGAC, 2010. B: Anthropization of the indigenous reserve, town Cerca de Piedra. Source: orthophoto, IGAC, 2010. C: Occupation and transformation of flooding areas of the river Frío, Urban Centre. Source: orthophoto, IGAC, 2010; Alcaldía de Chía, 2011. D: Stuffs in la Chucua de Fagua, town Tiquiza. Source: Google Earth, 2020. E: Works of the PTAR II and modifications of the fluvial banks, town La Balsa. Source: Google Earth, 2020. F: Hydraulic adequations of banks of the Bogota River, and construction of a traffic embankment Andes Highway, town Fusca. Source: Bing Maps, 2020.

Discussion and synthesis

The results confirm that in most of the cases anthropogeomorphologic interventions and their resulting modellings are the starting point of the most emblematic environmental problematics in the municipality. The impacts, risks, and conflicts detailed are reiterative and require attention, mainly in fluvial environments typical of the altiplano (Rivers Bogotá and Fríos), with implications that involve in every case action of alteration and degradation of the geomorphologic resources, as well as the edaphic, hydric, and biologic resources. The cartographic representation of Figure 7 shows the key elements and the most significant situations of the environmental problematics during the studied period.

In the diagram it is observed that there is still a wide covering of the natural reserve RFPP for the southeastern mountain (town Fusca), with marginal pressure due to suburban interventions, specially to the northeast (town Yerbabuena), in which there are induced risk sectors product of erosion, mass removal and wildfires. To the north and south ends of the eastern mountain there are tensions generated by the extraction of materials in quarries, with degradations in geofoms, soils, water, and vegetation, and population's unease in their surrounding areas. For the western mountain there is an important covering of the nature reserve, subjected to the suburban pressure in the intermediate and lower zones. The outstanding aspect, specially for the southwestern end (sector La Valvanera), is the increase of environmental degradation and the development of conflicts in the perimeter and inside the indigenous reserve (towns Fonquetá and Cerca de Piedra), which include deforestation, illegal excavations, and the latent manifestation of erosion, mass movements and wildfires, the later usually induced.

On the altiplano, the problematics associated with anthropogeomorphologic interventions have been more active, difficult, and complex. There is a high occupation with urban centralities and road systems, from which pressure deploys mainly in the two fluvial environments Bogotá and Frío. For the physiographic framework of the altiplano there is a defined central sector (Urban center and towns Bojacá and La Balsa), where the problematics are more related with leveling, covering, and

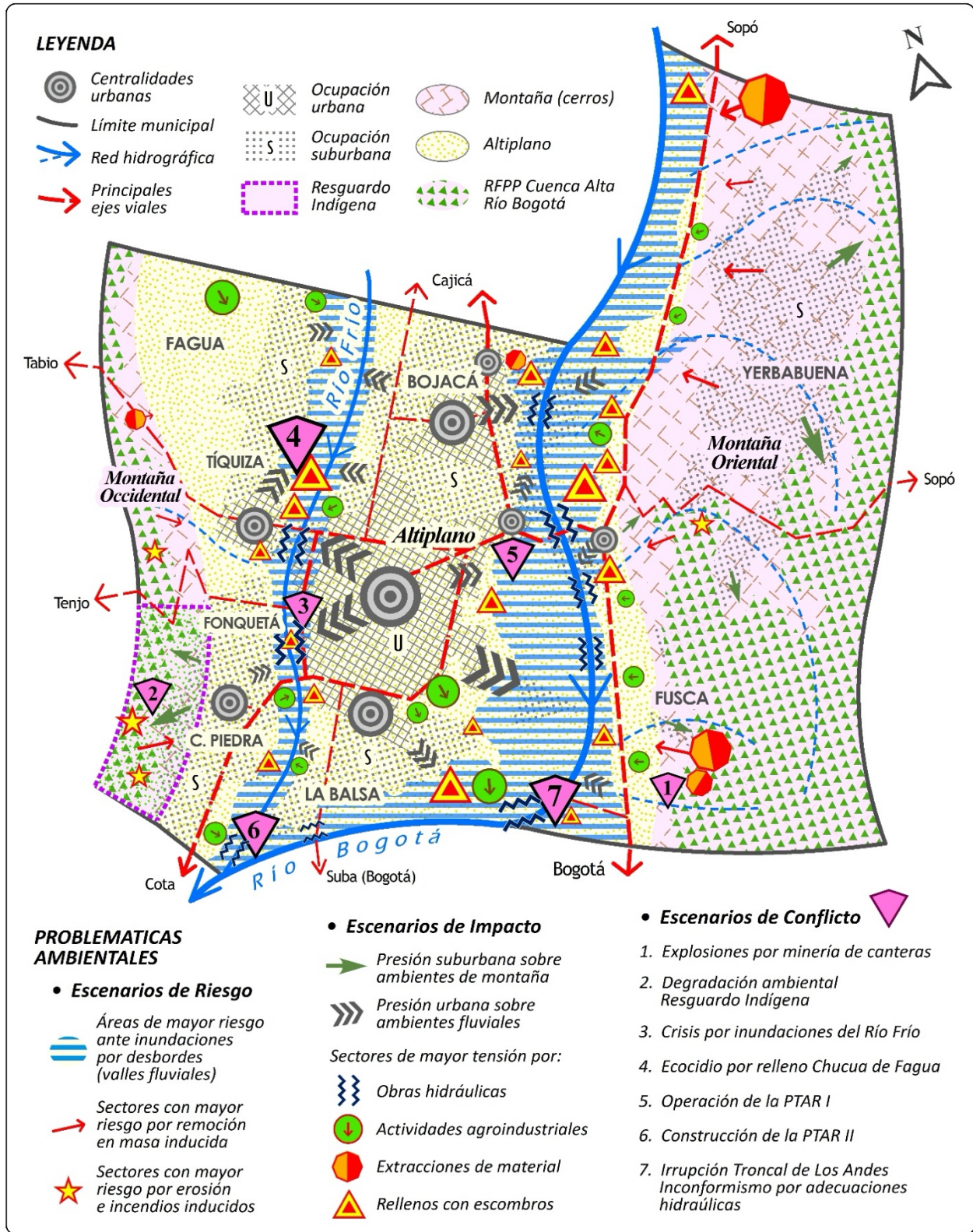
waterproofing of soils (small stuffings), and the dense urbanization that in many cases generates big excavations. To the western side of the altiplano (towns Fragua, Tíquiza, Fonquetá and Cerca de Piedra) the affectations arise from agro-industrial and suburban actions that deforest, bury, or eliminate soils and compete with agricultural and livestock activities. In the eastern flank of the altiplano (towns Yerbabuena and Fusca) anthropogeomorphologic activities are profoundly related with stuffings in embankments and dumps associated with the intertwined road system and industries.

The analyzed relationships become more complex and diverse in the fluvial environments of the territory, whose common characteristic is the cyclic occurrence of floods (both by fluvial overflows and rains) and the increase of removal and accumulation of dump with an anthropogenic origin. The different works of hydraulic adequation (extension of riverbeds, dredging, and elevation of dams) are mitigating overflows accurately, but they result in tensions by generating dissatisfaction due to the ecosystem degradation they imply, and because they are not a guaranteed solution to control extreme flooding events.

On the fluvial valley of river Frío, recent actions with big impact include mainly urbanization, accompanied by accumulation of dumps as it occurs with the case of La Chucua de Fagua, whereas to the south interventions of the PTAR II aim, with good intentions, to control hydric contamination, continuing being a polemic geomorphologic intervention. For the fluvial valley of river Bogotá activities and relationships are quite similar, tensions stress and include hydraulic modifications and a slow ecosystem recovery that generates more discomfort, a suburban occupation and constructions with irregularities in the treatment of hydric contamination (PTAR I), road infrastructure and urban residences with plenty of stuffing, and an environmental conflict active and unfinished that continues posing the dilemma between preserving the few relicts of wetlands, or carrying out road projects that satisfy the high demand for transportation at regional and local levels.

These consequences derived from anthropogenic actions are currently critical for Chia, and territorial

Figure 7. Synthesis of the environmental problematics associated with anthropogeomorphologic activities in Chia



Note. Source: Adapted by author

decisions ruled by planning instruments during the last 20 years have gravitated visibly towards environmental protection and preservation, but with numerous contradictions in their fulfillment. This reality contradicts itself, because it has become a clear regulation that forbids urbanization in flooding zones (Concejo Municipal de Chía, 2000), that highlights the adequate use of soils (Alcaldía de Chía, 2014), that categorizes mountains and strategic ecosystems under observation (Alcaldía de Chía, 2015b), and that demarcates buffer zones, nature reserves, water sources, wetlands, preservation rounds, and other environmental preservation areas (Alcaldía de Chía, 2016b, 2020b).

The municipal development plans have established several territorial and environmental commitments such as recovering hydric zones (Concejo Municipal de Chía, 2008), preserving the mountains (Concejo Municipal de Chía, 2012), implementing corrective measures regarding anthropic impacts (Concejo Municipal de Chía, 2016a), and in general developing a sustainable and controllable management facing ecologic structure loss (Concejo Municipal de Chía, 2020). However, there have been many moments in which municipal administrations have not followed and fulfilled the projected guidelines and in most of the cases their actions are questioned.

Conclusions

The qualitative documentary analysis and its methodological development permitted to know and specify the main environmental problematics related with anthropization of geomorphologic environments in Chia. The different methods of quotation, coding, linkage, and graphic display facilitated the identification and relation between affected morphologies (environment), anthropogeomorphologic interventions (activities), causes, actors, environmental consequences, and territorial decisions, whereas the field verification, the use of geospatial inputs, and the cartographic synthesis permitted to confirm the findings.

Regarding the results, it can be concluded that the structural cause of the interventions is the *modus operandi* of the economic development model

instituted, which historically has generated population concentration and urban expansion, privileged the transformation of nature, and in the territorial management context, has promoted inappropriate administrative practices that result in polemic changes regarding soil use. Urbanization dynamics are, in that sense, an outstanding agent for geomorphologic anthropization that continues threatening the eastern mountain, competes with ecologic preservation zones of the municipality, exercises pressure over the special preservation territoriality of the indigenous reserve, and concentrates the higher number of tensions in the altiplano and its two fluvial axes. By a national regulation, these two hydric environments in Chia, which are rivers Bogotá and Frío's valleys, must be protected and subjected to environmental recovery actions, which include geomorphologic restoration.

As for the environmental problematics, it can be concluded that the posed hypothesis is validated. Anthropogeomorphologic interventions are in most cases the origin of impacts, with aggravation of risk conditions and the manifestation of the most significant environmental conflicts in Chia in this Century. It is expected that the results of this research provide valuable and favorable knowledge for the decision-making process, and its use is advisable, even more in the current territorial reordering stage in which the new POT is established with better alternatives of environmental management.

Conflicts of interest:

There are no conflicts of interest associated with this article.

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