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Change in land cover and use on Territorial Planning, period 2010 – 2020, in Guarainag Parish

Cambio de Cobertura y Uso de Suelo en el Ordenamiento Territorial, período 2010-2020, Parroquia Guarainag

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KEYWORDS
Rural development; planning; spatial planning; local public policy
Desarrollo rural; planificación; ordenamiento territorial; política pública local

ABSTRACT: Changes in land cover and use are caused mainly by anthropogenic factors; these can cause severe physical, territorial, and environmental damage; it is then necessary to warn and demonstrate their effects opportunely to contribute to mitigating their damages. The study was developed in the Guarainag Parish, Paute canton in the province of Azuay-Ecuador; it analyzed the changes in 17 types of land cover and use through a geographic information system from 2010 to 2020. The main results suggested an increase in areas of managed pasture, burned areas, and shrubby vegetation (Chaparro); results also included the reduction of areas of degraded pasture, plowed soil, and eroded soils, as well as, the changes of specific areas from degraded pasture to managed pasture, from plowed soil to degraded pasture and from plowed soil to managed pasture.

RESUMEN: Los cambios de cobertura y uso de suelo son ocasionados principalmente por factores antropogénicos, estos pueden causar severos daños físicos, territoriales y ambientales, siendo necesario advertir y demostrar oportunamente sus efectos para contribuir a la mitigación de sus perjuicios. El estudio se desarrolló en la parroquia Guarainag, del cantón Paute en la provincia de Azuay-Ecuador; donde se analizaron los cambios de 17 tipos de cobertura y uso de suelo mediante un sistema de información geográfica, en el período 2010 – 2020. Obteniendo como principales resultados el incremento de áreas de pasto con manejo, áreas quemadas y vegetación arbustiva (Chaparro); la reducción de áreas de pasto degradado, suelo arado y suelos erosionados, así como también, los cambios de áreas específicas de pasto degradado a pasto con manejo, de suelo arado a pasto degradado y de suelo arado a pasto con manejo.

1. Introduction

The study of land cover and land use changes is a very complex process because it requires very detailed cartographic information, satellite images, and specialized geographic information systems, which do not facilitate an exhaustive analysis and timely decision-making to reduce their adverse effects. The behavior of land cover and land use is one of the critical components for understanding the future scenario of the territory and how its changes could affect productive systems, mainly agricultural and livestock systems, population, and living conditions.

The Guarainag Parish is an area that is experiencing accelerated changes that are intensive and extensive in land cover and land use. These changes are related to the activities that have been developed in the territory and some other problems with a tendency to intensify, associated with the changes in agricultural activities during the time. Among the most relevant issues is the expansion of the agricultural frontier towards the highest zones, which should be preserved, implying the reduction of paramo ecosystems and protective forests, as well as the reduction of the environmental services provided by the ecosystems in their natural state.

In this sense, the general objective of the research is to analyze the effects of land cover and land use change in the territorial planning of the Guarainag Parish in the period 2010 – 2020. This research helped to take timely measures in order to contribute to a better quality of life and a favorable environment in the population of the Guarainag Parish.

The land cover represents the biophysical cover observed on the surface (natural and anthropic elements). In contrast, land use represents the occupation humans give to the different types of cover, resulting from the interrelation between the biophysical and cultural factors of a given geographic space [1].

[1] and [2] mention that land cover and land use change are directly related to global environmental change; therefore, it will be necessary to understand the human and environmental dynamics that give rise to land use and land cover changes regarding their type, magnitude, and location. [3] also states that terrestrial change directly impacts the biotic diversity of the world and is directly related to global environmental change and sustainability, trying to understand both human and environmental dynamics, which give rise to changes in land use and land cover not only in their type and magnitude but also in their location; coinciding with [4], [5] and [6] point out that a large anthropogenic impact currently shows changes in biodiversity and ecosystems, but the occurrence of changes was more observed during the nineteenth and twentieth centuries and with more relevance from 1950 onwards. [7] further mentions that biodiversity change trends are mainly linked to social, economic, and political factors, leading to changes in land cover and use, overexploitation of organisms, and the introduction of invasive alien species. Similarly, land cover and land use change also affect the functioning of ecological processes [6].

[8], [9], [10], and [11] state that changes in vegetation cover, mainly deforestation and changes in land use, are some of the processes that contribute to global climate change, local loss of biodiversity, and increased vulnerability to natural disasters. The causes of land cover and use changes are classified into two main groups: direct factors or proximate causes and root, indirect, or underlying causes. The proximate causes refer to activities that have a direct effect on land cover and land use, for example, expansion of livestock or the agricultural frontier, while the underlying or indirect causes correspond to forces that operate in a broader context, generally external to the study area, but that affect the decision making of local agents or organizations.

[11] indicates that studies inherent to land cover and land use change have taken great importance in environmental research since they allow evaluation of the spatial-temporal trends of deforestation

processes and affection of shrub and grassland vegetation due to the advance of the agricultural frontier caused by anthropic activities. Human activities have an impact on biotic diversity throughout the world, on global and local climate, biogeochemical cycles, soil degradation and quality, hydrology, food security, and, therefore, human well-being and quality of life; however, not everything is negative in these changes since some of them a favor or are directly related to food production and productivity, and to well-being and wealth of the people.

[8], [9] and [10] add that changes in vegetation cover, mainly deforestation and changes in land use, are some of the processes that contribute to global climate change, local biodiversity loss, and increased vulnerability to natural disasters. The causes of land cover and land use change are classified into two main groups: direct or proximate causes and root, indirect, or underlying causes. The proximate causes refer to activities that have a direct effect on land cover and land use, for example, expansion of livestock or the agricultural frontier, while the underlying or indirect causes correspond to forces that operate in a broader context, generally external to the study area, but that affect the decision making of local agents or organizations.

In this type of study, it is a priority to monitor deforestation and estimate changes in land use, as well as the estimation of the area and current distribution of natural vegetation. In some cases, the information obtained is inconsistent. This is related to the assessment methods used, such as the scale and resolution of analysis, the remote sensor used in the imaging, and the mapping methods implemented [12].

Another aspect to consider is that human activity [13] and [14] affects the streams and river banks, which act as natural traps to retain sediments, nutrients, and contaminants from the soils adjacent to the watercourses. According to [14], few works have focused on a more detailed analysis of land cover change at the watershed or micro basin level as an integral solution for strategies to have a more significant social, environmental, and economic impact.

[15] mentioned that land cover change associated with the expansion of agricultural and livestock activities, urbanization, and pollution profoundly influences hydrological processes. Hydrological modeling in small watersheds or at the regional level is widely used and has proven helpful in assessing the impact of land use change.

[16], [17] and [6] agree on the criteria that land cover and land use change are, to a greater extent, a consequence of interactions between human activities with the natural environment, influencing its management and conservation. The timely and accurate assessment of the patterns of this change makes it possible to know the impact of economic and development activities on the territory and its resources, in addition to being the clearest environmental indicator for identifying problems related to sustainability in the use of ecosystem goods and services.

[18], [19] and [6] state that agricultural expansion is one of the main drivers of land use changes in terrestrial ecosystems. These changes influence climate, water, carbon, and nitrogen cycles in the biosphere, greenhouse gas emissions, and biodiversity. Given the growing demand for agricultural products, this process seems irreversible; however, despite its possible economic benefit, the social and environmental consequences warn of the importance of planning and regulating the expansion of the cultivated area.

[20] also agrees that man is the primary responsibility over time for the occupation and transformation of the geographic space; his different and varied activities cause permanent changes in the territories he inhabits. This gives rise to the enormous concern for studying and conducting research on the dynamics and impacts that their form of expansion and growth produces in the environment they inhabit, mainly due to land use actions, both urban and rural. It implies that the expression territorial planning is

challenging to define since it is polysemic and its application depends on who uses it. However, it always revolves around human activities, the space in which they are located, and the system between them [21]. The territorial planning definition is ambiguous [19]; some approaches relate it to political, fiscal, and administrative decentralization, while other perspectives associate it with the definition of land use and its planning. Another point of view is [22], who says that territory planning involves the identification, organization and regulation of human activities. Thus, it takes relevance the land uses.

For all of the above, add the statement by [23] who states the importance of the cover and land use change models in territory planning. These models allow us to understand the territory's different dynamics, which establish biophysical, socioeconomic, and spatial patterns, explore possible scenarios, and evaluate the influences of land use policies.

According to [24], the territorial planning refers to the regulatory control that contains the effects of the contradictions intrinsic to the production of space, which determines the logic of the organization of society. At the same time, government technology is accompanied by materializing the socio-spatial order. [25] externalizes that territorial planning as a regional and subregional public policy establishes a comprehensive territorial vision implemented through territorial plans to achieve a balanced, sustainable spatial development and thus improve the quality of life. [26] indicates the importance of territorial planning management as a strategic role whose objective is to incorporate a vision of sustainable development that guarantees development while considering the conservation, survival, and sustainability of human life.

[27] cited by [28], mentions ecological, environmental, or territorial planning, which is a public and technical process as a basic level of environmental planning and management, which allows the establishment of the appropriate use of natural and human material resources based on management policies oriented to the globalization of the economy and sustainable development and thus reduce conflicts and imbalances caused by the disorderly intervention of human beings. Management is expressed in cartographic form using spatial models, which reveal flows of regional relations on the utilization, conservation, and rationality of social and natural resources, human settlements, infrastructure, and economic-productive aspects.

[29], also states that territorial planning (TP) has taken on increasing relevance in territorial decision-making, preferentially in the inequities of specific development models and economic policies, since it initially has a close relationship with territorial planning at different scales, national, regional, and local. In Latin America, since its origins in the 1970s, TP has been closely related to urban planning and the importance of incorporating the socio-environmental conflict.

Moreover, the right to landscape is included by [30] in a study about TP in the city of Medellín; it gives a participatory sociocultural focus to consider in the changes of land cover and land use.

2. Materials and Methods

This research is carried out from the critical and constructivist paradigm, allowing understanding, analysis, and criticism, constituting the basis for improvement proposals for the geographical and social space. This study is a mixed method research study since it is carried out using qualitative and quantitative approaches, using diverse sources of information and techniques. The scope is descriptive and analytical since it identifies the variables that characterize the use and management of land in the case of the Guarainag Parish and delves into its changes from 2010 – to 2020. From the temporal point of view, it is longitudinal research since the research variable is compared in two moments.

2.1. Study area

The Guarainag Parish is located in the northeastern part of the province of Azuay, as shown in Figure 1; it belongs to the Paute canton and is located at a distance of 20 km from the cantonal center, at coordinates 763306.76 E and 9705653.98 S. The estimated population according to data from the Development and Territorial Planning Plan - 2019, for the year 2020 is 748 inhabitants, with approximately 242 families. The Parish is made up of 8 communities, which are Las Juntas, Llamacón, Selel, Ucumarina, Bella Unión, Rambrán, Coyal, and Guarainag Centro. Its boundaries are: to the north with the Taday Parish (Azogues canton, Cañar province), to the south with the Guachapala canton, to the east with the Palmas Parish (Sevilla de Oro canton), and the west with the Tomebamba Parish (Paute canton) corresponding to the province of Azuay. Its extension is 3612.04 hectares, and the altitude ranges from 2140 to 3100 m.a.s.l., with an average temperature that ranges between 8° and 16°C and precipitation that varies between 1000 to 2500 mm. [31]

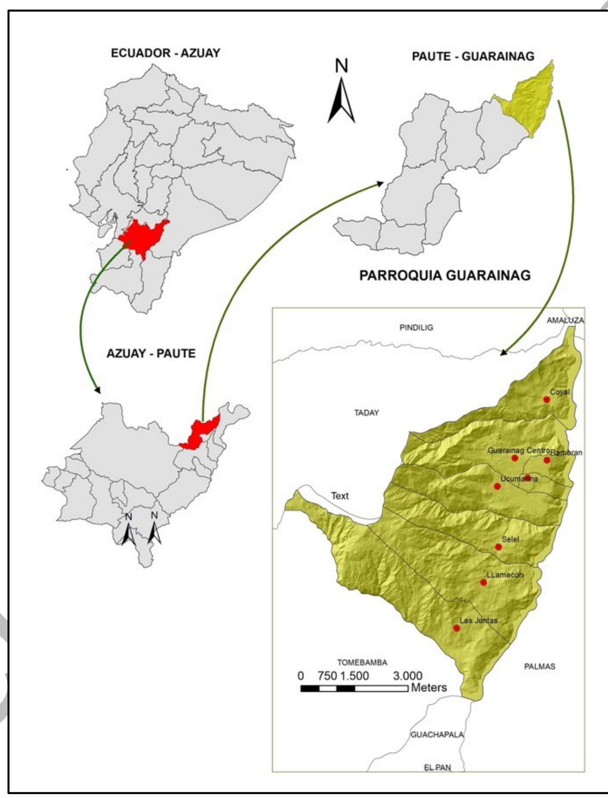


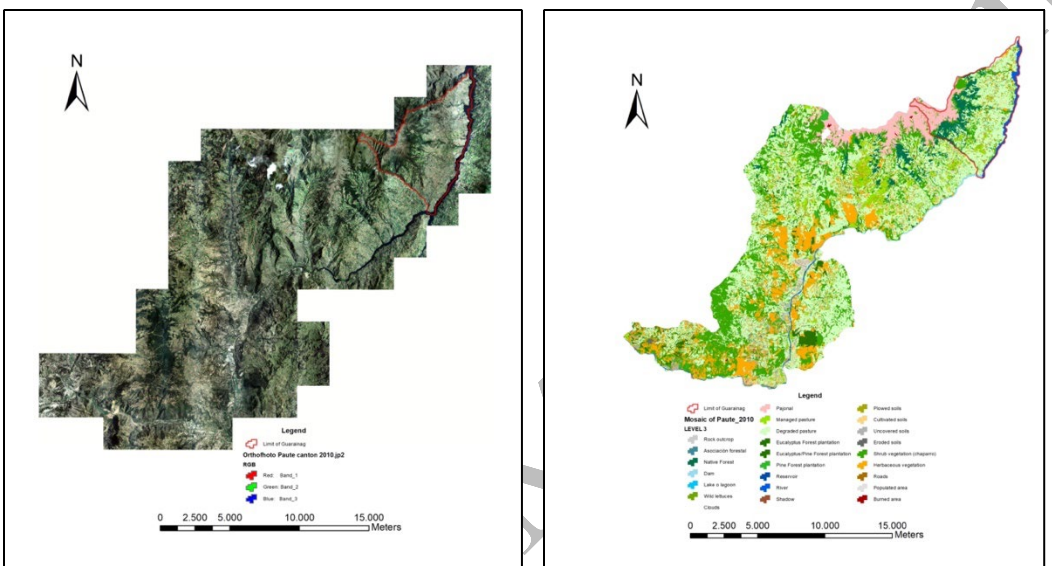
Figure 1. Location of the study area.

2.2. Methodology

For the generation of information and mapping of land cover and land use in the Guarainag Parish for the year 2020 and its comparison with that of 2010, a methodology based on the following stages was used:

2.2.1 Collection of information (orthophotographs)

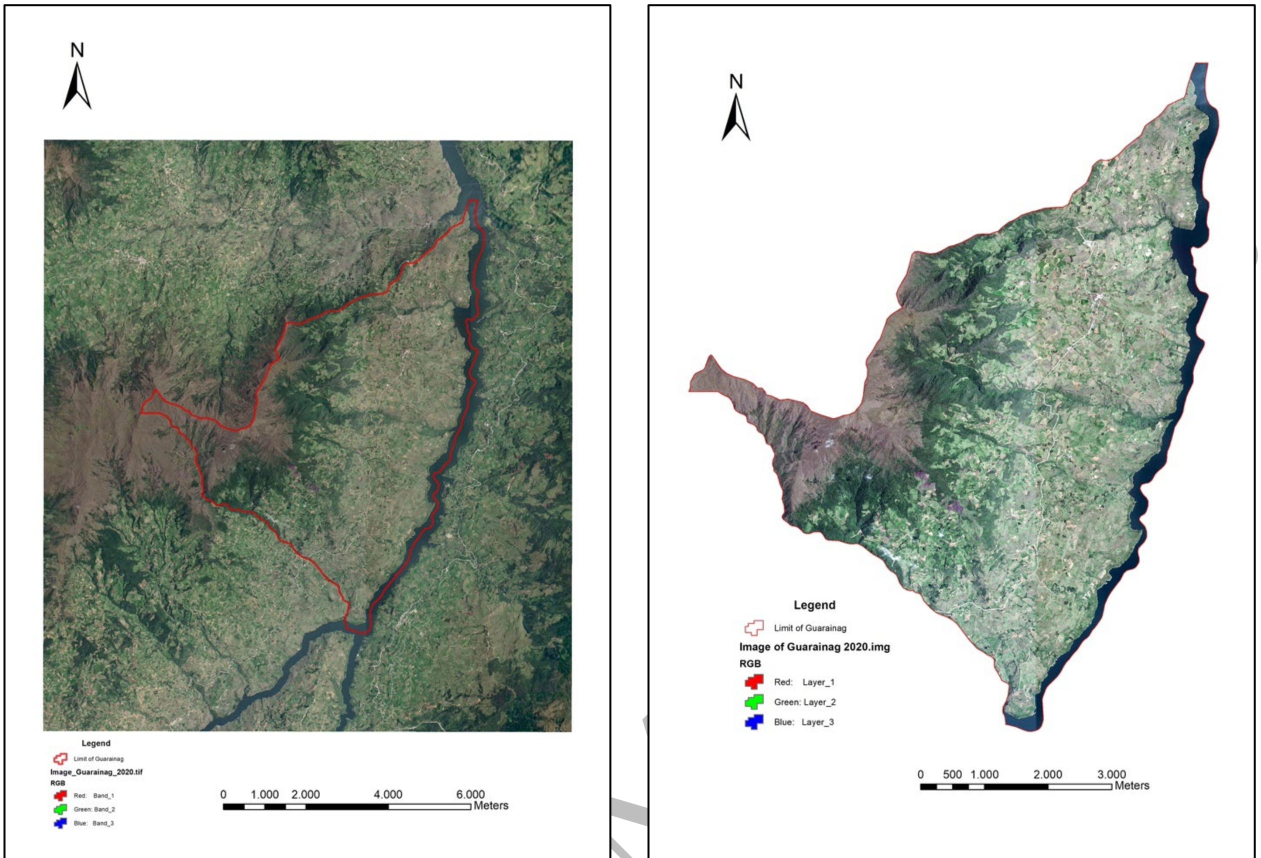
The orthophotography and base cartographic material of the Paute canton was obtained from the Instituto de Estudios de Régimen Seccional del Ecuador-IERSE of the Universidad del Azuay, through an agreement with the Provincial Government of Azuay. The orthophotography comes from the SIGTIERRAS Program of the Ministry of Agriculture and Livestock corresponding to the year 2010, has a spatial resolution of 0.3 m and has four bands (three in the visible region and one in the infrared region), which allows for generating thematic information on vegetation cover and land use at a scale of 1:5,000; as shown in Figure 2.



(a) (b)

Figure 2. (a) Orthophotography from Paute canton 2010 and (b) mosaic of Paute canton-2010

For the generation of the 2020 cartography and its comparative analysis with 2010, the image was downloaded from the SAS Planet Russian Satellite Program. This image is shown in Figure 3.

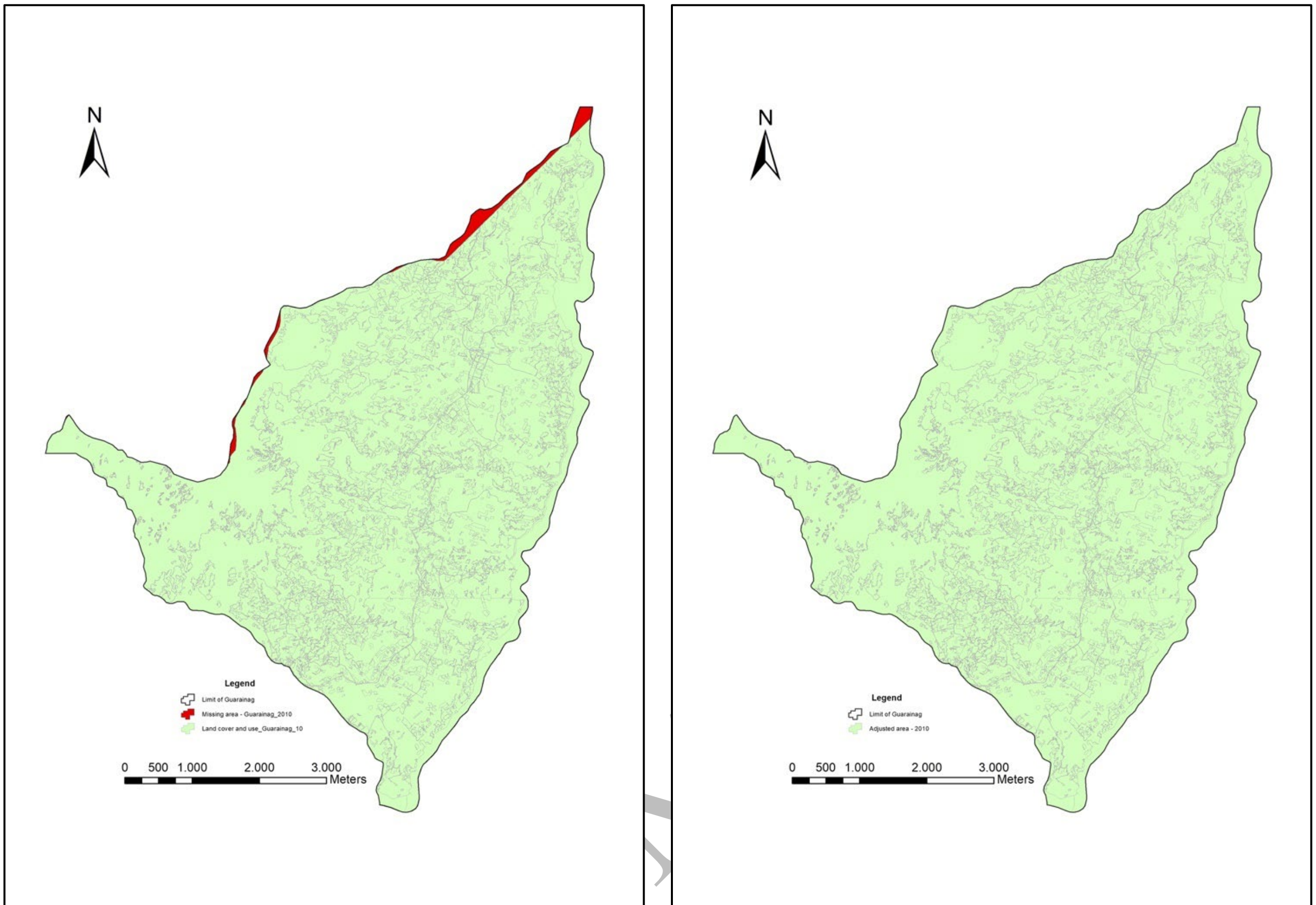


(a) (b)

Figure 3. Image from SAS Planet Russian Satellite Program-2020; (b) Image from Guarainag-2020

2.2.2 Editing and depuration of coverages

First, the orthophoto and mosaic of the Paute canton of the study area were cut according to the official boundary provided by the Decentralized Autonomous Government-DAG of Guarainag in 2020, detecting concordance failures in the total area of approximately 32.04 hectares because the boundaries of 2020 did not coincide with those of 2010, to subsequently perform the respective digitization of each classification of this missing area. We also corrected the polygons of the poorly generated land cover and land use types so that they are by the 2010 orthophotography. Figure 4 shows the previous map and the adjusted map in Figure 4.



(a) **(b)**

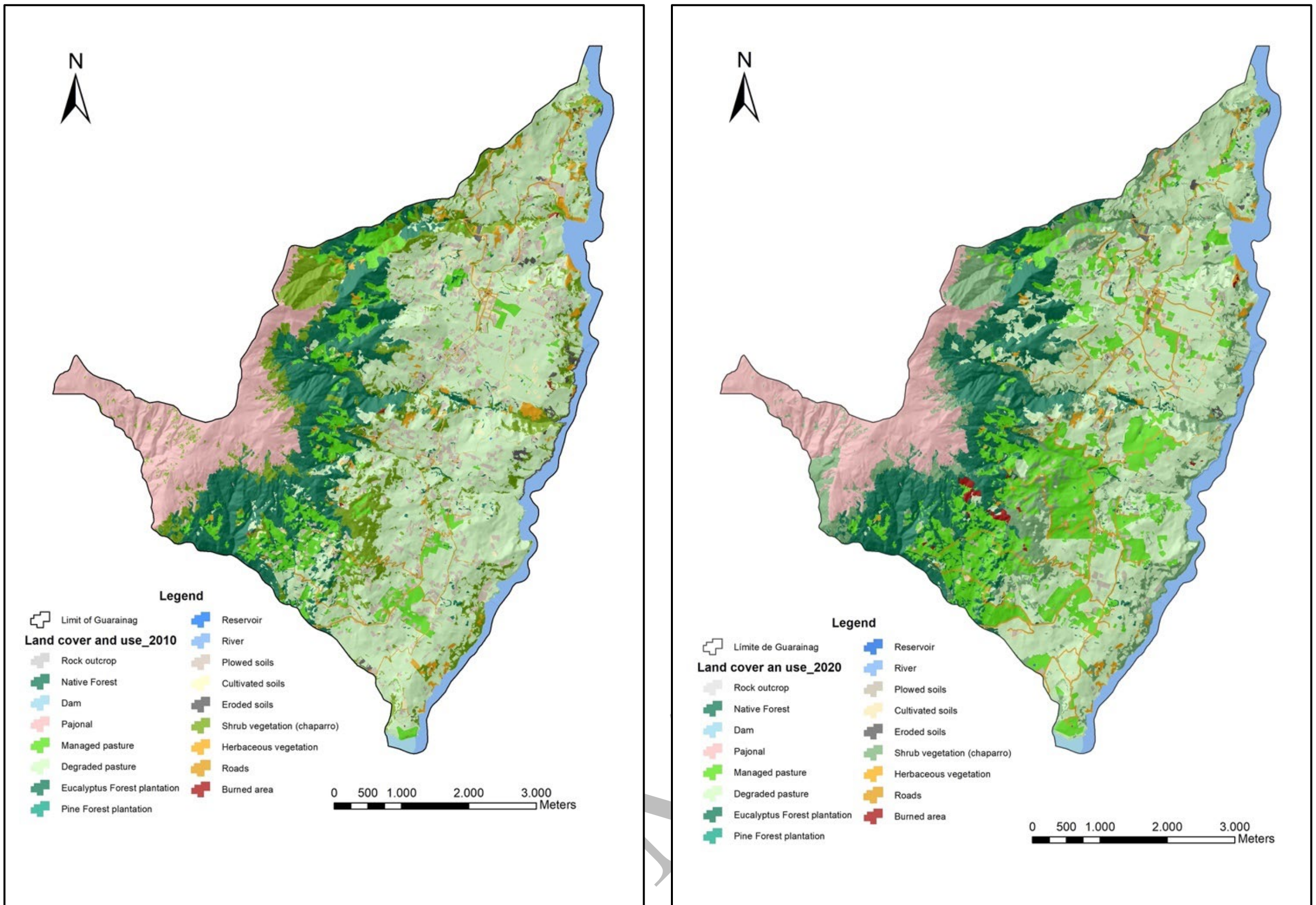
Figure 4. Missing area Guarainag-2010; (b) adjusted area Guarainag-2010

2.2.3 Spatial information processing

The products are generated with the UTM 17S coordinate system and Datum WGS84, and ArcGIS 10.8 software was used to process the spatial information. Each orthophoto was digitized, and geographic elements were drawn on the screen since using the digital classification technique does not permit the differentiation of both natural and anthropic areas. . Those polygons with closed angles were rounded, and others were edited so they did not cross each other.

2.2.4 Characterization of land cover and land use

Cartography was generated for the year 2020 at level 3, with the description of land cover and land use of 17 types: rock outcrop, burned areas, native forest, dam, managed pasture, degraded pasture, eucalyptus forest plantations, pine forest plantations, reservoir, river, plowed soil, cultivated soil, eroded soil, shrub vegetation (Chaparro), herbaceous vegetation and roads, based on the image obtained from the Russian SAS Planet Satellite Program and its subsequent comparative analysis with the year 2010. Figure 5 shows the land cover and use in 2010 and 2020.



(a) **(b)**

Figure 5. Land cover and use (a) 2010; (b) 2020

2.2.5 Identification of specific land cover and land use areas

To determine the specific areas of land cover and land use that have undergone some change at the two points in time 2010 and 2020, a Multitemporal Vector Analysis was performed in ArcGIS Desktop of the two polygon layers, previously assigning a similar coding in each of their attribute tables, according to the following reference like in **Table 1**:

Table 1 Coding of the types of cover land and use

Code	Type of cover land and use
01	Rock outcrop
02	Burned area
03	Native Forest
04	Dam
05	Pajonal
06	Managed pasture
07	Degraded pasture

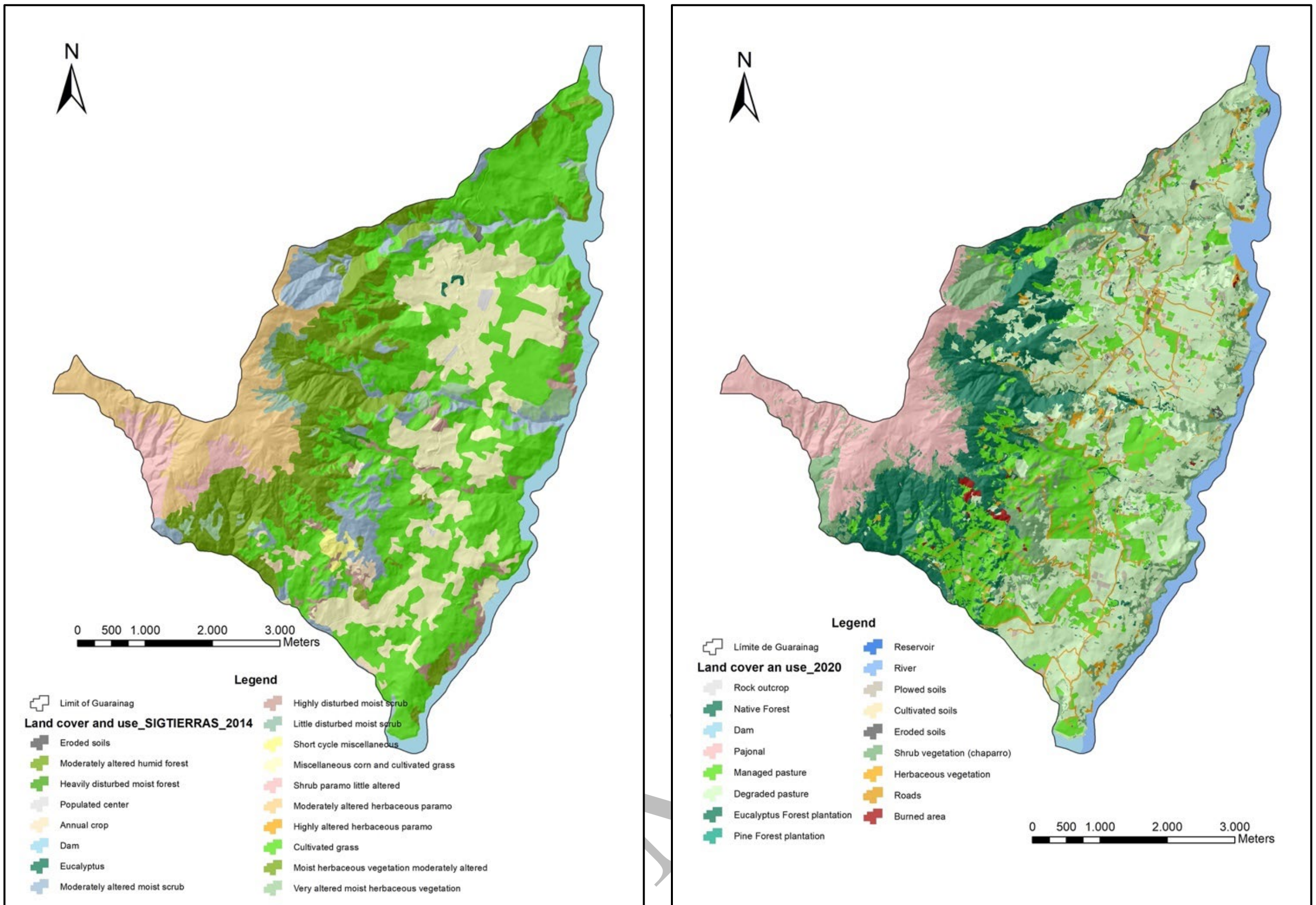
Code	**Type of cover land and use**
08	Eucalyptus Forest plantation
09	Pine Forest plantation
10	Reservoir
11	River
12	Plowed soils
13	Cultivated soils
14	Eroded soils
15	Shrub vegetation (Chaparro)
16	Herbaceous vegetation
17	Roads

Then, an intersection of these two layers from the different moments was made, updating their surface areas in hectares. Some of them changed, and others did not. It was necessary to separate these areas based on the codes initially created; finally, the areas were concatenated to determine precisely the transformations between the land cover types and land use with their respective surfaces.

2.2.5 Review and validation

To ensure a reliable outcome, the following review systems were used:

- Confrontation and correction of coverages, using information from the MAGAP-MAE-2014 Land Cover and Use Map of Ecuador and later versions at a scale of 1:25000 or higher; as shown in Figure 6.



(a) **(b)**

Figure 6. Land cover and use (a) SIGTIERRAS 2014 scale 1:25000; (b) 2020 scale 1:5000

- Visits to the territory, using samples of different land coverages and uses: the information processed for 2020 was checked and validated. Some photographs are shown in Figure 7.

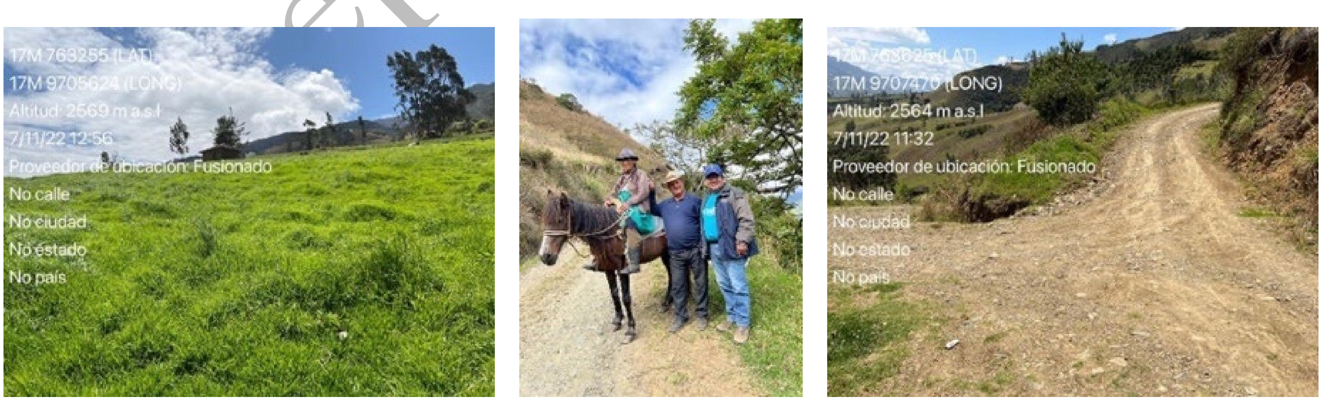


Figure 7. Territory visits to validate the information

- Working meetings with Parish leaders, community leaders, and agricultural producers to conduct a retrospective review of land cover and land use changes and the advance of the agricultural frontier, its causes, and consequences. Figure 8 shows images of these meetings.

Figure 8. Working meeting to review land cover and land use changes

3. Results

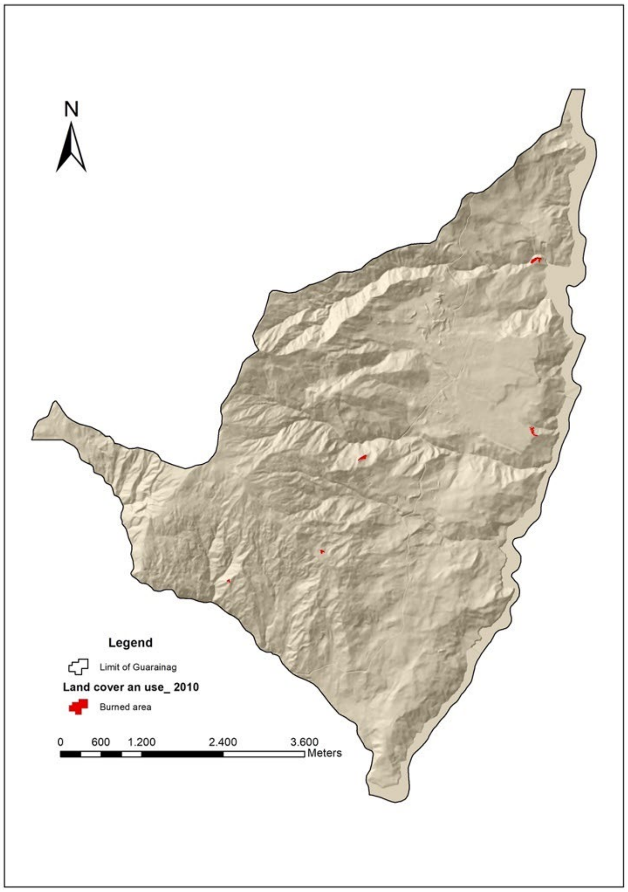
The results obtained on land cover and land use changes for the period 2010-2020 are presented in **Table 2**, showing the increase or decrease in hectares of different types during the period.

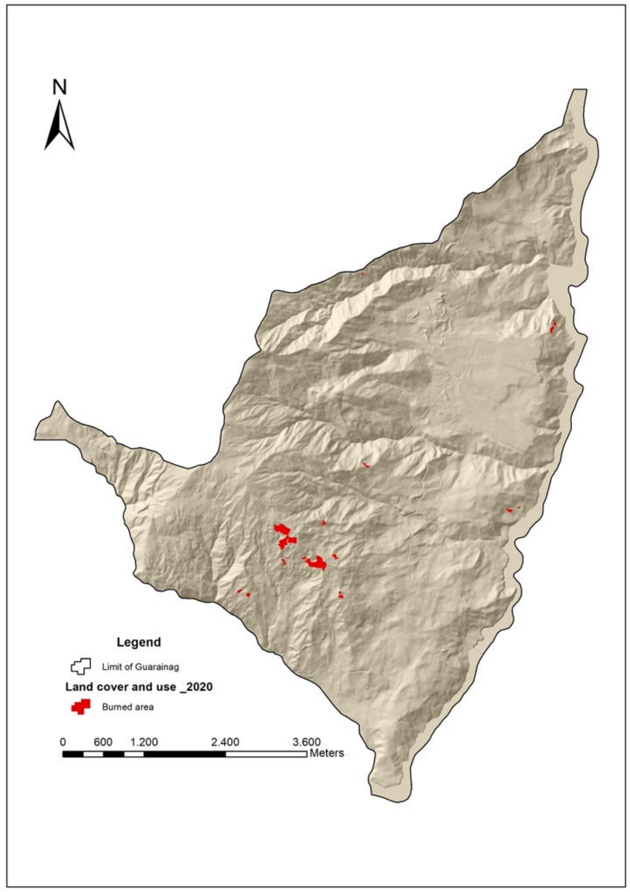
Table 2. The difference in land cover and use areas between 2010 and 2020

Types of land cover and land use	Area ha 2010	Area ha 2020	Difference ha	Percentage %
Rock outcrop	0,16	0,16	0,00	0,00%
Burned area	2,06	11,44	9,37	454,26%
Native Forest	521,49	502,03	-19,46	-3,73%
Dam	7,73	7,73	0,00	0,00%
Pajonal	377,18	350,99	-26,19	-6,94%
Managed pasture	236,22	583,73	347,51	147,11%
Degraded pasture	1483,38	1287,64	-195,74	-13,20%
Pine Forest plantation	5,78	4,85	-0,94	-16,22%
Pine Forest plantation	0,14	0,08	-0,05	-39,65%
Reservoir	0,14	0,31	0,17	117,45%
River	190,06	196,14	6,08	3,20%
Plowed soils	208,99	78,72	-130,27	-62,33%
Cultivated soils	46,40	31,71	-14,69	-31,65%
Eroded soils	35,81	18,44	-17,38	-48,52%
Shrub vegetation (Chaparro)	421,21	470,09	48,88	11,61%
Herbaceous vegetation	58,76	36,49	-22,27	-37,90%
Roads	16,52	31,47	14,96	90,55%
Total	**3612,04**	**3612,04**		

3.1. Area with increased land cover and use

- Figure 9 shows that the area burned increased by 9.37 ha, an increase of 454%.

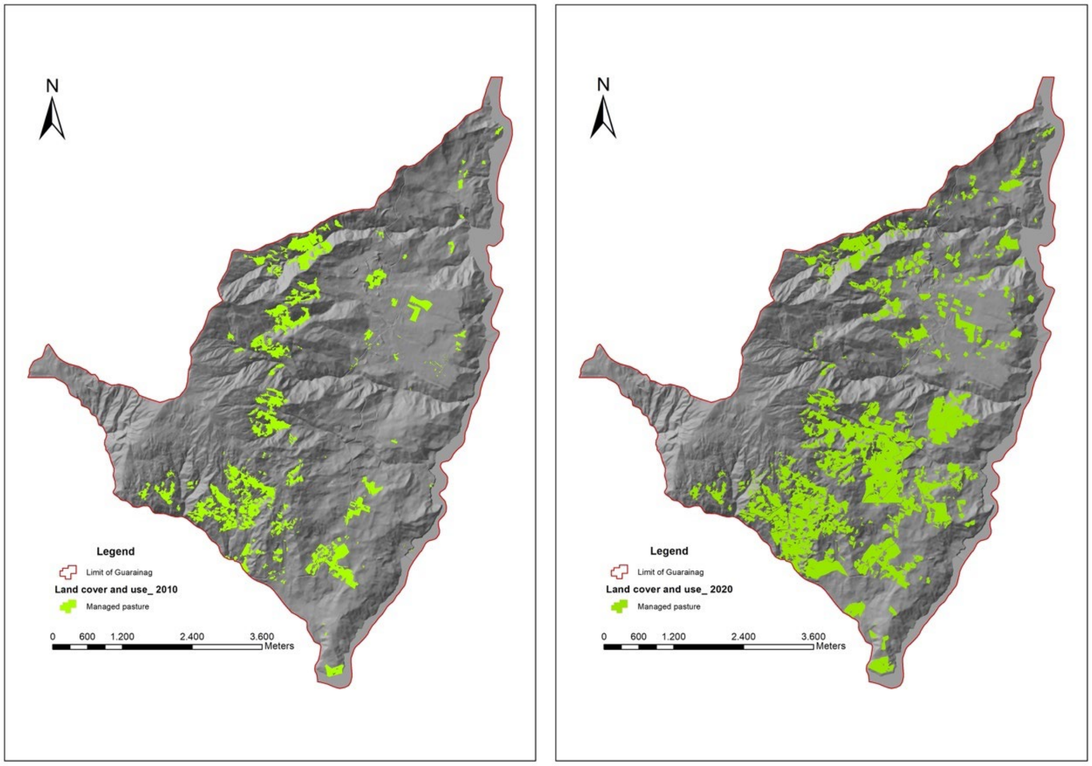




(a) **(b)**

Figure 9. The area burned (a) in 2010; (b) in 2020

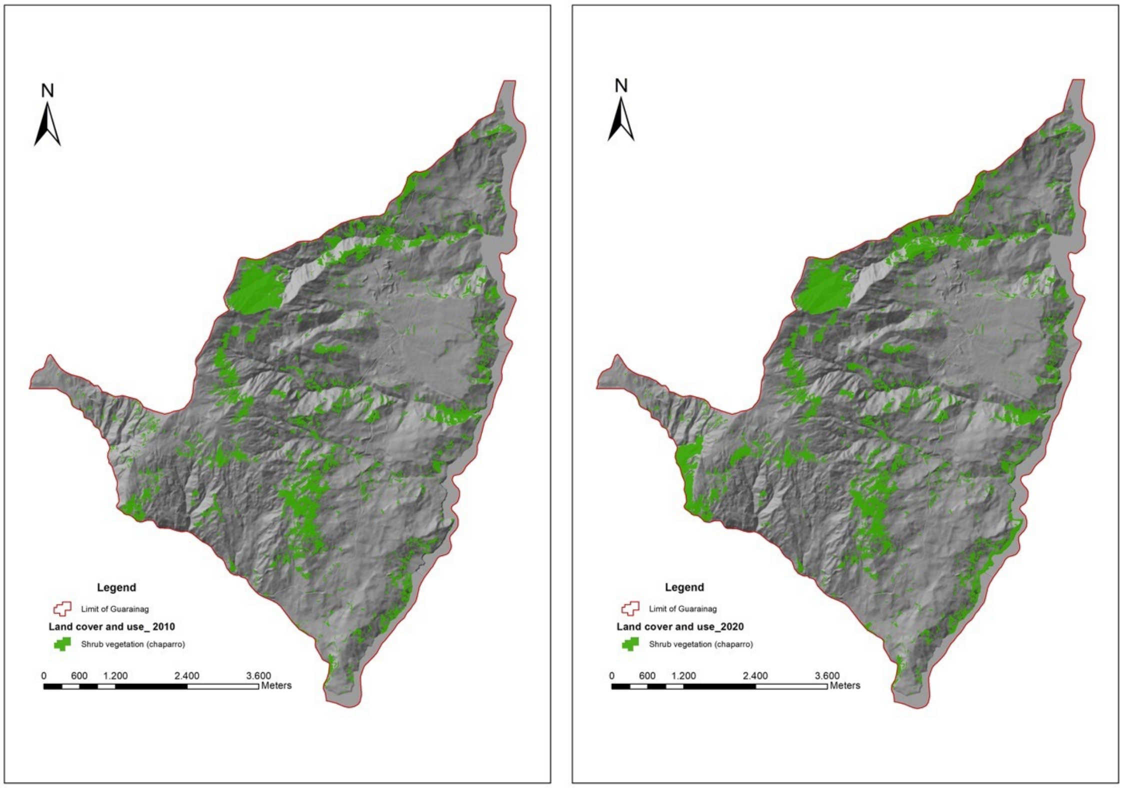
- The area of reservoirs increased by 0.17 ha, representing 117.45% growth.
- The area of managed pasture increased by 347.51 ha, representing a 147.11% increase, as shown in Figure 10.



(a) **(b)**

Figure 10. Area of managed pasture, (a) 2010; (b) 2020

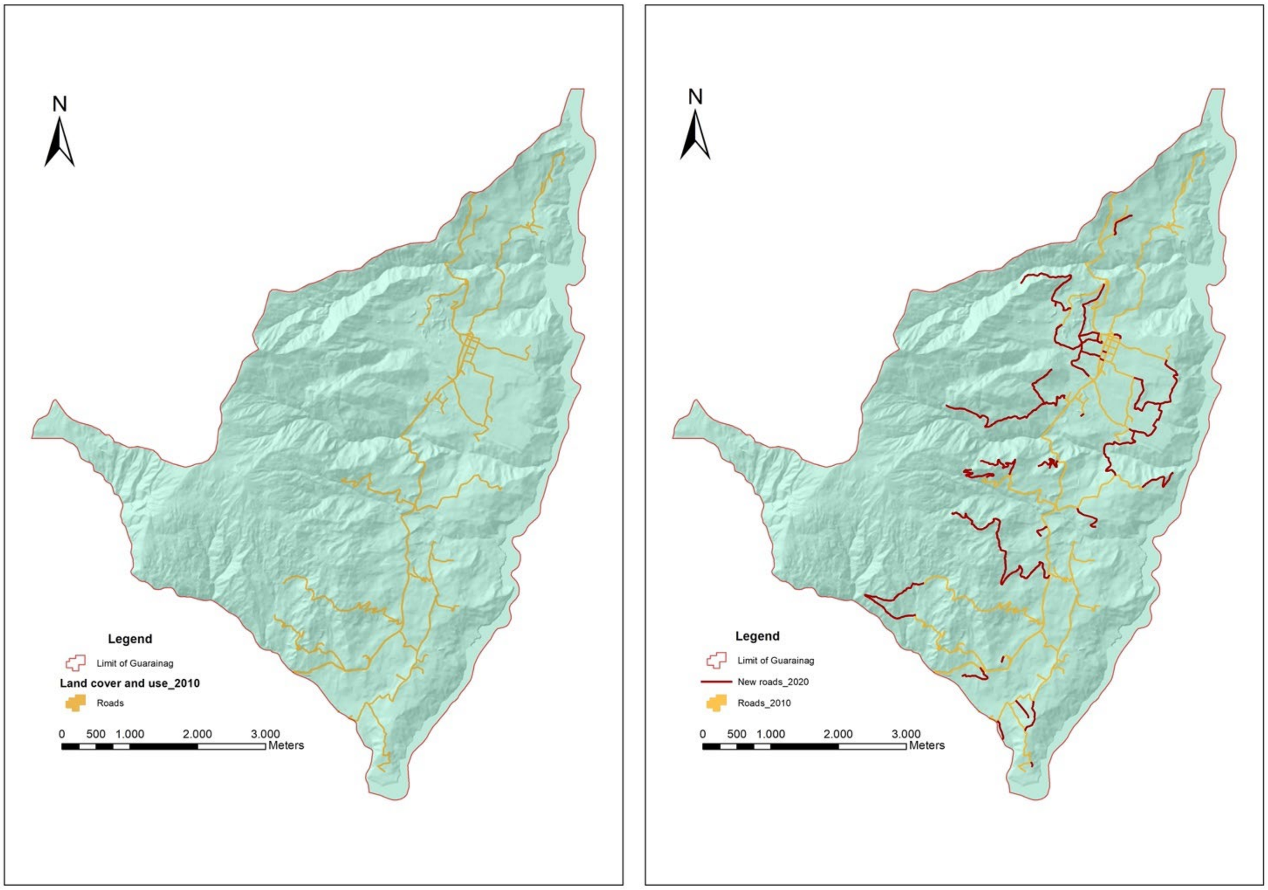
- Figure 11 shows that shrub vegetation (Chaparro) increased by 48.88 ha, representing 11.61%.



(a) **(b)**

Figure 11. Area of Shrub vegetation (Chaparro), (a) 2010; (b) 2020

- Figure 12 shows that the area of roads increased by 14.96 ha, representing an increase of 90.55%.

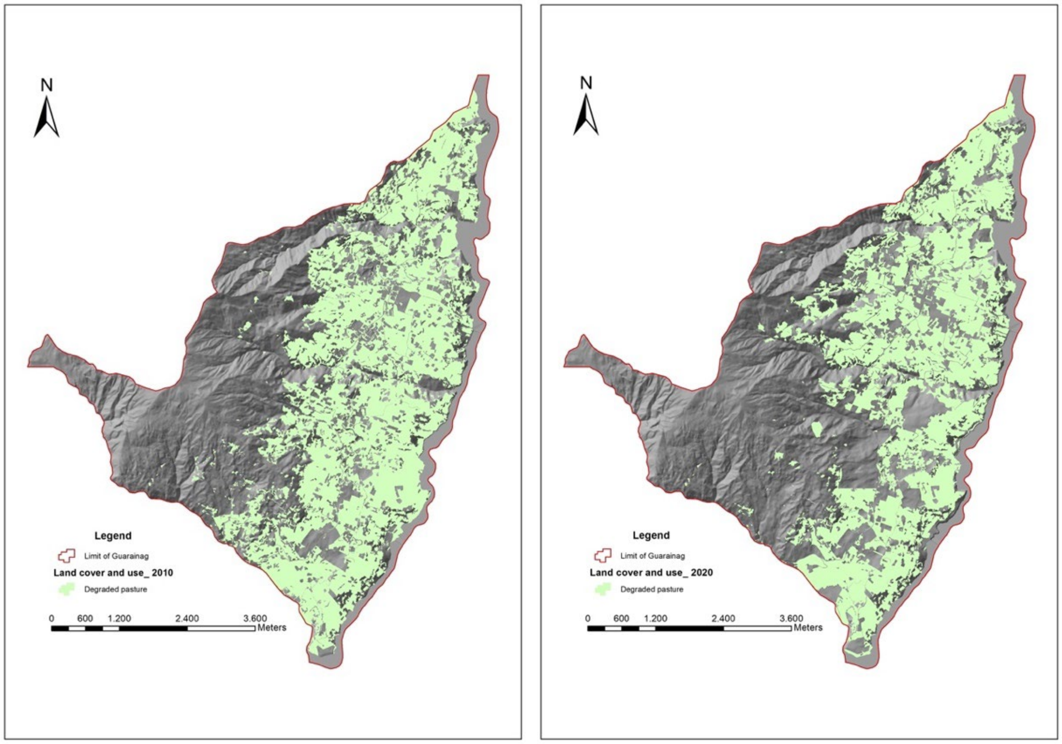


(a) **(b)**

Figure 12. Area of roads; (a) 2010; (b) 2020

3.2. Area with decreasing land cover and use

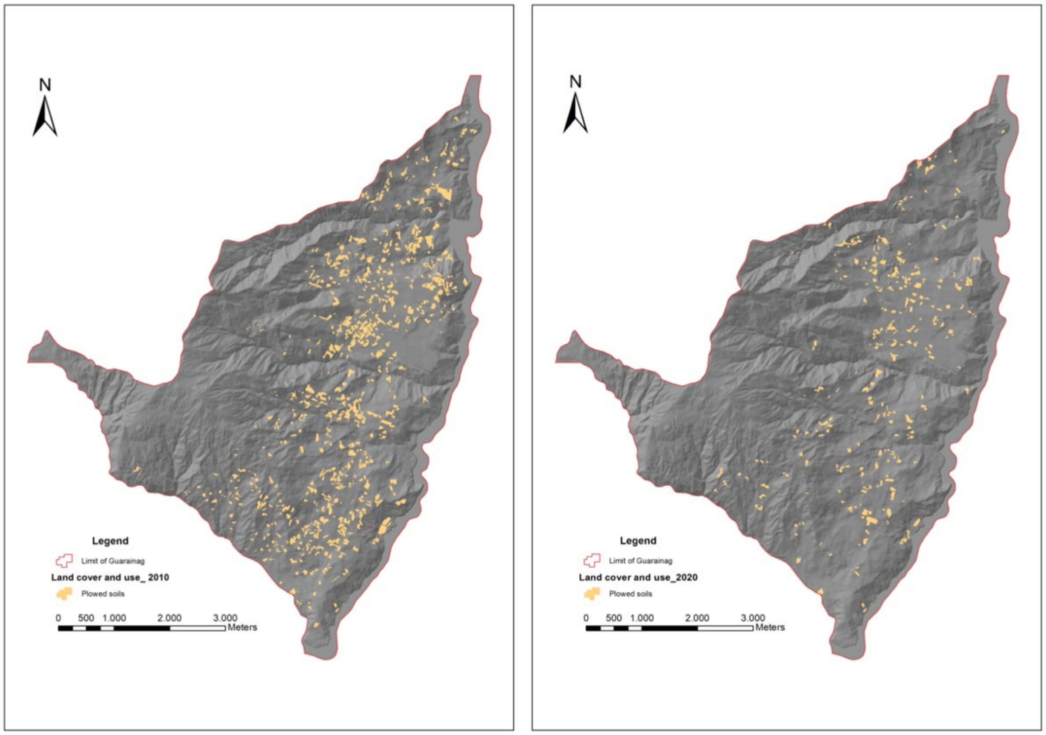
- Native Forest has decreased by -19.46 ha, representing a -3.73% decrease.
- Pajonal has decreased by -26.19 ha, representing a -6.94% decrease.
- Degraded pasture has decreased by -195.74 ha, representing a decrease of -13.20%, as shown in Figure 13.



(a) **(b)**

Figure 13. Area of degraded pasture; (a) 2010; (b) 2020

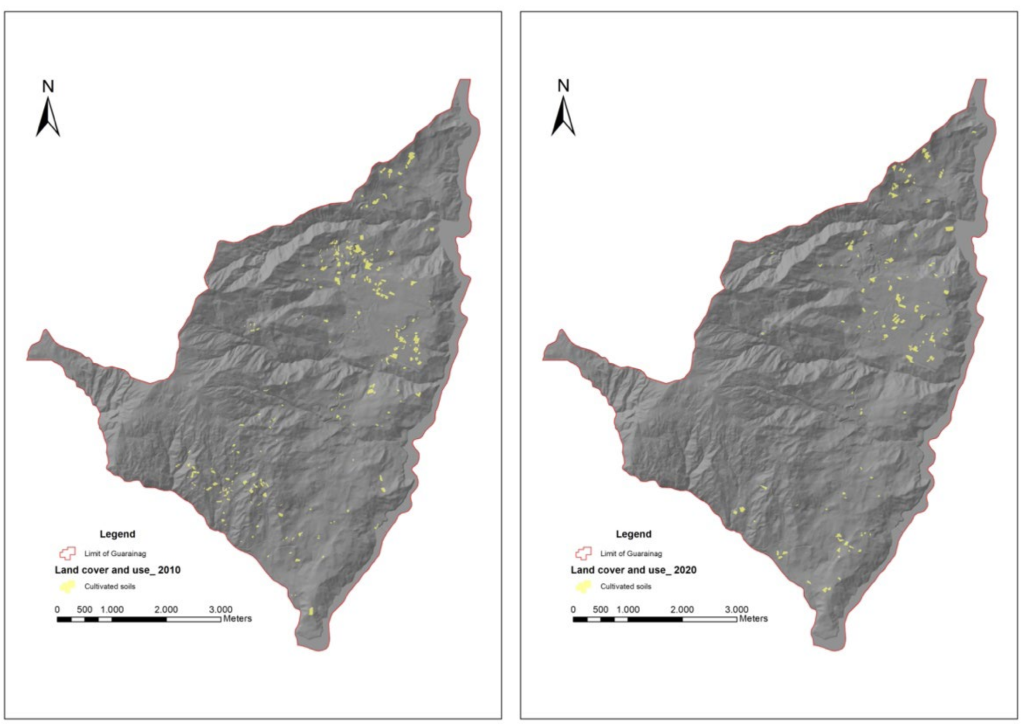
- Figure 14 shows that the plowed soil has decreased by -130.27 ha, representing a decrease of -62.33%.



(a) **(b)**

Figure 14. Area of plowed soil; (a) 2010; (b) 2020

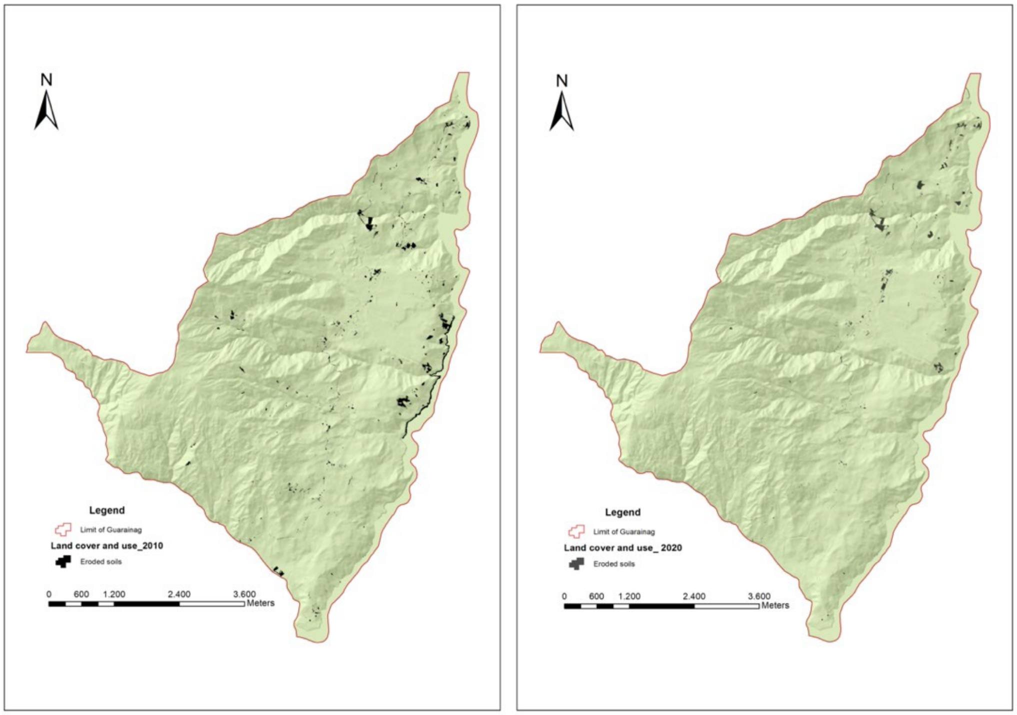
- Cultivated soil decreased by -14.69 ha, representing a -31.65% reduction, as shown in Figure 15.



(a) (b)

Figure 15. Area of cultivated soil; (a) 2010; (b) 2020

- Herbaceous vegetation decreased by -22.27% ha, representing -37.90% of the decrease.
- Figure 16 shows that eroded soils decreased by -17.38 ha, representing a decrease of -48.52%.



(a) (b)

Figure 16. Area of eroded soil; (a) 2010; (b) 2020

3.3. Specific changes between areas

- Specific changes between land cover and land use areas are present in 783.06 ha, which represents 21.68% of the total territory, and 2,828 ha (78.32%) do not undergo any change, like in **Table 3**. The most significant specific changes in land cover and land use between zones, period 2010-2020, are observed in Figure 17.

Table 3. Total areas with and without changes in land cover and use between 2010 and 2020

Area changes	Area _ha	Percentage
NO	2828,97	78,32
YES	783,06	21,68
Total	**3612,04**	**100,00**

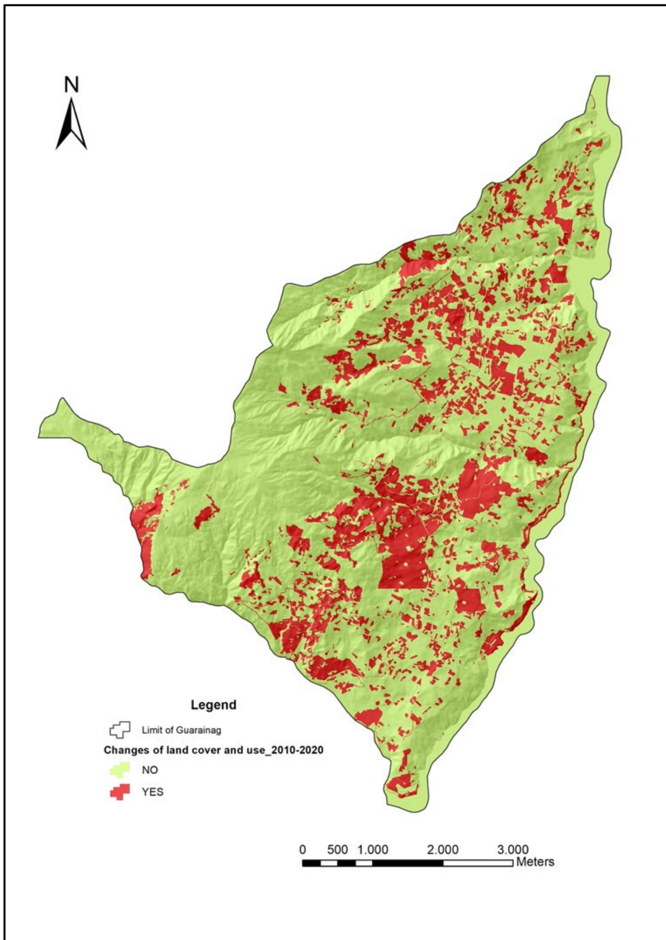


Figure 17. Most significant specific changes in land cover and use between areas, period 2010-2020

- The most remarkable changes between land cover and land use areas are from degraded pasture to managed pasture with 316.45 ha, which represents 40.80% of the total hectares that have changed, followed by plowed soil to degraded pasture with 94.94 ha (12.24%), plowed soil to managed pasture with 61.54 ha (7.93%) and managed pasture to degraded pasture with 46.15 ha (5.95%), the details are presented below, like in **Table 4**.

Table 4. Specific changes between areas, period 2010 – 2020

Specific changes between areas	Area ha	Percentage %
Degraded pasture - Managed pasture	316,45	40,41
Plowed soil - Degraded pasture	94,94	12,12
Plowed soils - Managed pasture	61,54	7,86
Managed pasture - Degraded pasture	46,15	5,89
Pajonal - Shrub vegetation (Chaparro)	28,82	3,68
Degraded pasture - Plowed soils	23,76	3,03
Degraded pasture - Shrub vegetation (Chaparro)	20,07	2,56
Cultivated soils - Degraded pasture	18,63	2,38

Specific changes between areas	Area ha	Percentage %
Herbaceous vegetation - Degraded pasture	17,20	2,20
Cultivated soils - Managed pasture	14,76	1,89
Degraded pasture - Cultivated soils	14,46	1,85
Eroded soils - Degraded pasture	13,27	1,69
Native Forest- Shrub vegetation (Chaparro)	12,41	1,58
Plowed soils - Cultivated soils	9,95	1,27
Degraded pasture - Roads	9,94	1,27
Native Forest- Burned area	7,93	1,01
Cultivated soils- Plowed soils	6,35	0,81
Eroded soils - River	6,0815	0,78
Degraded pasture - Eroded soils	4,3772	0,56
Shrub vegetation (Chaparro) - Native Forest	3,9479	0,50
Managed pasture - Plowed soils	3,9015	0,50
Shrub vegetation (Chaparro) - Managed pasture	3,4164	0,44
Shrub vegetation (Chaparro) - Plowed soils	3,3647	0,43
Herbaceous vegetation- Managed pasture	3,0843	0,39
Eroded soils - Managed pasture	3,0392	0,39
Managed pasture - Shrub vegetation (Chaparro)	3,0098	0,38
Shrub vegetation (Chaparro) - Pajonal	2,6272	0,34
Native Forest- Degraded pasture	2,6078	0,33
Shrub vegetation (Chaparro) - Burned area	1,9896	0,25
Native Forest- Managed pasture	1,8816	0,24
Shrub vegetation (Chaparro) - Degraded pasture	1,8147	0,23
Shrub vegetation (Chaparro) - Roads	1,6266	0,21
Degraded pasture - Native Forest	1,4944	0,19
Managed pasture - Cultivated soils	1,3672	0,17
Managed pasture - Roads	1,2449	0,16
Burned area - Shrub vegetation (Chaparro)	1,1307	0,14
Native Forest- Roads	0,9361	0,12
Plowed soils - Eroded soils	0,8836	0,11
Herbaceous vegetation- Shrub vegetation (Chaparro)	0,8403	0,11
Cultivated soils- Shrub vegetation (Chaparro)	0,7206	0,09
Burned area - Degraded pasture	0,7169	0,09
Plowed soils - Roads	0,6769	0,09
Plowed soils - Shrub vegetation (Chaparro)	0,6111	0,08
Degraded pasture - Burned area	0,5793	0,07
Eucalyptus Forest plantation - Degraded pasture	0,5323	0,07
Herbaceous vegetation- Burned area	0,5191	0,07
Native Forest- Plowed soils	0,5125	0,07
Managed pasture - Native Forest	0,5107	0,07
Degraded pasture - Eucalyptus Forest plantation	0,4403	0,06
Eroded soils - Shrub vegetation (Chaparro)	0,4377	0,06
Eucalyptus Forest plantation- Shrub vegetation (Chaparro)	0,4364	0,06

Specific changes between areas	Area ha	Percentage %
Herbaceous vegetation- Plowed soils	0,4258	0,05
Shrub vegetation (Chaparro) - Eroded soils	0,4206	0,05
Managed pasture - Burned area	0,3789	0,05
Cultivated soils- Roads	0,3460	0,04
Herbaceous vegetation- Cultivated soils	0,3450	0,04
Eucalyptus Forest plantation- Native Forest	0,3256	0,04
Eucalyptus Forest plantation - Managed pasture	0,3111	0,04
Herbaceous vegetation- Native Forest	0,3068	0,04
Shrub vegetation (Chaparro) - Herbaceous vegetation	0,2460	0,03
Managed pasture - Eroded soils	0,2337	0,03
Managed pasture - Herbaceous vegetation	0,1845	0,02
Shrub vegetation (Chaparro) - Cultivated soils	0,1637	0,02
Eroded soils - Roads	0,1556	0,02
Eroded soils - Plowed soils	0,1412	0,02
Burned area - Native Forest	0,1382	0,02
Degraded pasture - Reservoir	0,1304	0,02
Cultivated soils- Eucalyptus Forest plantation	0,1252	0,02
Eroded soils - Native Forest	0,0891	0,01
Managed pasture - Eucalyptus Forest plantation	0,0727	0,01
Burned area - Managed pasture	0,0709	0,01
Eroded soils - Reservoir	0,0624	0,01
Plowed soils - Eucalyptus Forest plantation	0,0569	0,01
Cultivated soils- Native Forest	0,0550	0,01
Pine forest plantation - Degraded pasture	0,0544	0,01
Plowed soils - Herbaceous vegetation	0,0514	0,01
Eucalyptus forest plantation- Roads	0,0284	0,00
Eroded soils - Burned area	0,0245	0,00
Herbaceous vegetation- Eroded soils	0,0236	0,00
Reservoir - Degraded pasture	0,0231	0,00
Eroded soils - Cultivated soils	0,0160	0,00
Herbaceous vegetation- Roads	0,0156	0,00
Roads - Shrub vegetation (Chaparro)	0,0151	0,00
Plowed soils - Burned area	0,0094	0,00
Burned area - Plowed soils	0,0058	0,00
Degraded pasture - Herbaceous vegetation	0,0053	0,00
Roads - Managed pasture	0,0035	0,00
Cultivated soils- Burned area	0,0026	0,00
Roads - Degraded pasture	0,0012	0,00
Burned area - Roads	0,0011	0,00
Cultivated soils- Eroded soils	0,0010	0,00
Shrub vegetation (Chaparro) Eucalyptus Forest plantation	0,0005	0,00
Degraded pasture - River	0,0004	0,00
Total	**783,064**	**100,000**

4. Discussion

Land use is the term used to describe the different forms of the utilizing of the soil and its vegetation cover. Certain surfaces are modified when used for agricultural purposes or as human settlements, while others remain relatively unaltered by human activities [32]. This statement coincides with the main changes in land cover and land use found in this research and that are shown in the agricultural activity, mainly in livestock activity, with the change of degraded pasture areas to managed pasture areas, which is said by the local population.

Unregulated land use changes are also caused by the local population. It said by [13] and [33]. The studies demonstrate that the excessive consequences of anthropogenic activities, especially in sensitive areas such as native forests, water sources, and paramo areas, can help to prevent the advance of the agricultural frontier. This result coincides with the studies found in the case of Lake Tota in Boyaca-Colombia [6] and [34] Santa Marta, Colombia.

In recent decades, Ecuador has experienced significant changes in its land cover and land use, mainly due to the advance of the agricultural frontier, an uncontrolled and accelerated growth of urban areas, causing the destruction of land with agricultural potential and the displacement of crop and livestock areas to a hillside or mountainous regions, i.e., areas with lower fertility, losing the social and environmental function of the soil [23] and [35]. With this research, it has been possible to demonstrate how improved crops and pastures are implemented in native forests, either out of necessity or limited knowledge of the severe damage caused by the destruction of these sensitive areas. Among these reductions is that of native forests, a phenomenon that also occurs in the Cinco Mil micro-watershed in Santander-Colombia as found by [36], as well as in the upper part of the sub-watershed of the Palace River - Colombia [37] and in the Colombian Amazonia [38], as well as the increase of fire areas to promote livestock activity with the planting of pastures which has affected sensitive areas similar to what happens in the Los Nevados National Natural Park in Colombia [39]. In recent years, this type of research has become relevant in the environmental field and is part of the methodology used in land use plans.

Land use change studies have become a complex visualization due to the absence of cartographic expression about the different change processes (causes, effects, probable scenarios) and the associated phenomena, not only ecological but also economic and social. However, satellite images have displaced orthophotos due to several advantages, such as the capacity of ground monitoring that allows deforestation and land use change studies [33]. Based on satellite images to be repeated much more quickly than with the daily and costly method of photointerpretation and based on the use of these satellite images and aerial photographs used in this research, the updated cartography is made available at a scale of 1: 5000, to have input in the field of land cover and land use to facilitate the process of updating these territorial planning plans and that this methodology can also serve as a model for other Parishes to implement it.

5. Conclusions

- The cartography generated is updated to 2020 at a scale of 1:5000, in the UTM 17S coordinate system and WGS84 Datum, accompanied by its attributes (dbf table) and metadata.
- Predominant land cover and land use zones were identified; their changes are related to the increase in hectares of improved pastures, shrub vegetation (Chaparro), roads, burned areas, reservoir areas, and river areas.

- The decrease is in areas such as degraded pastures, native forests, pajonal, pine forest plantations, eucalyptus forest plantations, plowed soil, cultivated soil, and eroded soil.
- The areas that have not changed are rock outcrops and dams.
- Percentage-wise, the most significant increases are in burned areas, managed pasture, reservoirs, and roads, and decreases in plowed, eroded, and cultivated soil.
- With the multitemporal analysis for the period 2010-2020, the most representative changes are from degraded pasture to improved pasture, from plowed soil to degraded pasture, from plowed soil to managed pasture, and from managed pasture to degraded pasture, among others.
- With the cartography generated and updated to the year 2020, it will facilitate the analysis of land cover and land use in the preparation of future Development and Territorial Planning Plans of the Guarainag Parish, becoming a reference for other Parishes, also generate cartography at this scale, as currently, the official cartography is at a scale of 1:25,000.
- The increase of burned hectares is worrying, especially in sensitive areas (native forests, shrub vegetation (Chaparro). It is necessary to continue the training process undertaken by the GAD of Guarainag on environmental issues and demand that the competent authorities carry out better control and apply the respective sanctions to those who violate environmental laws.
- The most significant number of hectares that have changed are those of managed pasture and, among specific areas, those of degraded pasture to managed pasture, which coincides with the feelings of the inhabitants who state that the Parish has suffered a notorious change from agricultural activity to livestock, due to the decrease in labor for agricultural work, the greater risk that agricultural production represents due to climate changes (droughts, too much rain, Etc.), the daily income generated by agricultural production, and the fact that the population of the Parish is getting older. It is becoming more difficult for them to work in planting and harvesting crops.), the daily income generated by the dairy cattle raising activity and the fact that the population of the Parish is getting older and it is more difficult for them to work in planting and harvesting crops, but not the work of tending two or three dairy cows; for all the above mentioned, it is recommended to improve the management and technology for the cultivation of pastures, which will increase the production and productivity of milk and therefore contribute to the improvement of the economic income of the population.
- Cultivation and plowing areas have been reduced, which is also a concern and does not guarantee food sovereignty for the population of Guarainag; it is recommended to continue farming in their home gardens, but with specialized technical assistance and advice, to improve production yields.
- There has been an increase in the area of the roads in the Parish, which, in the perception of the directors, has favored the marketing of agricultural production; however, it also represents a risk in the highlands that the agricultural frontier will continue to advance, and it is recommended that producers be made aware of the need to reduce this practice in sensitive areas.
- Although the area of water reservoirs has increased due to the lack of irrigation in the area, it is necessary to continue with the development of the activity and the respective management before the competent governments for the implementation of irrigation projects, which will be very helpful for agricultural production and productivity.

6. Declaration of competing interest

We declare that we have no significant competing interests including financial or non-financial, professional, or personal interests interfering with the full and objective presentation of the work described in this manuscript.

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9. Author contributions

Conceptualization, W.P., M.A., and Y.C.; methodology, W.P., and M.A.; software and cartography, W.P.; data collection, W.P.; formal analysis, Y.C., and M.A.; investigation, WP.; data curation, W.P.; original draft preparation, W.P., Y.C., and M.A.; writing, W.P., F.C., and Y.C.; Data analysis with ArcGIS software, F.C. The authors confirm that the data supporting the findings of this study are available within the article. All authors have read and agreed to the published version of the manuscript.

10. Data available statement

The authors confirm that the data supporting the findings of this study are available within the article [and/or] its supplementary materials.

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