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Case Report

Water retentivity and environmental impact assessment in the headwaters of the Chambira micro-watershed, San Martin region

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ABSTRACT

The study found that maximum precipitation and water retention occur in February for the Cacao sector and in October and February for the Caliza sector, with minimum values in July. The correlation between precipitation and temperature is −0.43 for both sectors, while the negative correlation between retentivity and temperature is stronger in the Caliza sector (−0.467) than in the Cacao sector (−0.096). Precipitation explains 82.07% and 89.92% of the variability in retentivity for the Cacao and Caliza sectors, respectively, according to the R^2 coefficients. The environmental impact analysis indicates a medium impact with a value of 5.6.

1. Introduction

Surface vegetation plays a key role in water retention by acting as a protective belt that controls flow velocity and reduces the kinetic energy of water near the soil surface, while plant roots reinforce the soil through the formation of root-particle interactions that reduce particle detachment [1]. Water retention and water content in green roofs are affected by structural and climatic factors and depend on soil, vegetation, and water storage layers. The amount of water retained can be influenced by rainfall and evapotranspiration [2].

Water is a critical resource and its scarcity threatens people in several regions and is increasingly perceived as a global systemic risk [3,4]. This occurs when demand exceeds its natural availability on a range of spatial and temporal scales [5]. Also, this scarcity is dynamic and complex and arises from the combined influences of climate change, basin-level water resources, and the adaptive capacities of managed systems [6]. Previous assessments have underestimated scarcity by not capturing seasonal fluctuations in consumption and reserves [3]. Factors contributing to water stress include precipitation deficit and drought, increasing water needs, population growth, urbanization, and poverty [7]. Overall, the problem underscores the need for revised water management, especially in areas with demographic change and climate vulnerability toward secure and sustainable supply [8].

Of the total freshwater, 1% is considered surface water, and of this, in soils, 20–40% is useable for plants. This is the reason why soil water is so desirable for terrestrial ecosystems. Soil is made up of mineral and organic particles of very different sizes [9].

In case water retention is required in certain soils, the measures are multifunctional because they aim to protect and manage water resources using natural means and processes [10]. Such measures are implemented by different sectors or considered in different planning processes, food risk management, biodiversity protection, climate change adaptation, or urban development [11]. Also, proper land stewardship can be an effective approach to improving water quantity regulation, however, there is a need to identify where such measures are most needed and effective [12].

Humans are causing a significant impact on the soil's capacity to retain water, and this is due to various human actions, forest degradation, water pollution from industry and other sectors, land misuse, and agriculture that negatively affect soil properties. For example, soils in the southeastern Peruvian Amazon have been affected by artisanal and small-scale gold mining due to mercury and methylmercury contamination, modifying the pH, decreasing nutrients and organic matter [13, 14].

In this sense, in the local reality, it is necessary to gather information about water retention in the soils together with an environmental impact assessment to verify if there is damage to the ecosystem. For this purpose, the Chambira stream north of Juanjuí has been selected. It

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begins at 1000 m above sea level on the Rio Blanco hill and runs from southeast to northeast. At the lower part, near the Chambira neighborhood, it joins the Juanjuicillo stream, which flows into the Huallaga River in the neighborhood of the same name south of the city. Data on the retentivity of this area and others in the Peruvian Amazon has not been found.

This research proposes a methodology that quantifies the amount of water retained by the forest's water buffer, especially during the rainiest months. The natural uptake of water in the soil helps prevent the saturation of the river, and possible losses of food species and regulates the hydrological regime. The knowledge obtained is important for conservation reforestation projects that require scientific and technical support to create a green area in the headwaters of the micro-watersheds and watersheds. Likewise, the environmental economic valuation of the water resource, which is considered a non-marketable good, can be determined indirectly with the volume of water that reaches the bed of a stream or spring to be used for irrigation of agricultural fields and fish farms.

Therefore, the objectives of the research were to evaluate water retention in the water buffer and environmental impact assessment in the headwaters of the Chambira micro-watershed, located in the district of Juanjuí in the San Martin region.

2. Materials and methods

2.1. Research design of retentivity and environmental impact assessment

For the analysis of retentivity, a completely randomized design was used, in which 2 sectors were evaluated with 3 replications for each one. Each sector consisted of 1 ha measured from the area with vegetation located on the banks of the water body.

The Leopold Matrix technique was used for the Environmental Impact Assessment, connecting the physical, biological, socioeconomic, and cultural environments as well as the effects human activity has on these habitats (Tables 4–6). The impact assessment was carried out based on an analysis of their intensity following the recommendations in Table 1.

2.2. Materials

The equipment and materials used in the investigation were: Garmin Etrex 12-channel GPS meter, 20 kg commercial scale, Jenway 3510 pH meter, INOLAB pH 730 conductivity meter, sample collection bags, tape measure, and personal protective equipment.

2.3. Description of the study areas

Chambira is located in the district of Juanjuí, which belongs to the province of Mariscal Cáceres in the department of San Martin and has an area of 335.19 km^2. The urban area covers 6.69 km^2. The population density of the district was 81 inhabitants per km^2 in 2007, and the total population at that time was 27151 inhabitants. 62.2% of the population lives in the urban area, while 37.8% lives in the rural area. The district borders the Department of Amazonas to the north, the province of Huallaga and the province of Bellavista to the east, the province of Tocache to the south, and the Department of La Libertad to the west. The district's area of influence is defined by the Marginal de la Selva highway and the Huallaga River [15].

The Chambira stream runs through the northern part of the city of Juanjuí. It has its beginnings at an approximate height of 1000 m above sea level in the Rio Blanco hill and runs from southwest to northeast, and in the lower part at the height of the neighborhood, Chambira joins the Quebrada Juanjuicillo which flows into the Huallaga River at the height of the neighborhood of the same name in the southern part of the city. These streams run separately along some sections of their course and join on several occasions along small stretches [16].

To determine the coordinates of Chambira, the Garmin Etrex 12-channel GPS equipment was used. Chambira is located at UTM coordinates 84 305892 and 9205790 at an altitude of 360 m.a.s.l.

The Chambira geological formation is a stratigraphic unit of San Martin, characterized as a succession of mudstones and sandstones with channel structures and lithics of volcanic rocks and gypsum sheets. It was deposited in a continental floodplain environment with braided and meandering rivers, and correlates with other formations in the region. Although its age is debated, microfossils have been found that suggest a Lower Miocene age. Chambira is easily identified in satellite and radar images, and forms ridges between depressions [17].

Figs. 1 and 2, prepared for this research, show the location map of the Cacao and Caliza sectors belonging to the Chambira micro-watershed, as well as the map of land use capacity in the research area and surrounding areas. The investigation of water retentivity was focused on these areas.

2.4. Precipitation and ambient temperature

Precipitation in mm and ambient temperature in °C for the study areas were collected from the records of Corporación Peruana de Aeropuertos y Aviación Comercial S.A. (CORPAC) for July 2012–February 2013.

2.5. Soil characterization of the Chambira micro-watershed

The pH of the soils was measured with the Jenway 3510 pH meter. A mixture of soil and water was prepared in a 40:60 ratio. This mixture was also measured for electrical conductivity and total dissolved solids with the INOLAB pH 730 conductivity meter. Apparent density was determined by dividing a quantity of dry soil mass by a given volume. For the relative density or particle density, the sample is compressed to eliminate pores and air.

2.6. Determination of water retentivity

For the determination of retentivity, a block of 1 ha of pristine forest was delimited for each sector (Cacao and Caliza). Each block was divided into four quadrants and from each quadrant 1 m^2 of soil was selected from which the samples were collected. The monitoring frequency was carried out every 15 days for 8 months to determine the levels of maximum and minimum water retention in each of the two sectors considered in the study. In 1 ha of land in each sector, rectangles of 3 m by 24 m were delimited every 15 days, and in each one three points of 1 m^2 were located, following the direction of a diagonal line. The necrotic leaves per m^2 were collected to be weighed and the average value of the three subsamples extracted was reported. The drying of the sample was carried out in ambient conditions, consecutively, in the afternoon (5:00 p.m.) because at that time the exposure to solar radiation ends. This process was carried out until the sample showed no variation

Table 1
A rating scale for the Environmental Impact Assessment of the Chambira - Juanjuí stream using the Leopold Matrix.

Classification	Scalar Value	Impact
Low intensity	1	Very Positive (+)
	2	Positive (+)
	3	
Medium Intensity	4	Medium (±)
	5	
	6	
High Intensity	7	Significant negative (−)
	8	
	9	Very negative significant (−)
	10	

Source: Adapted from Ref. [19].

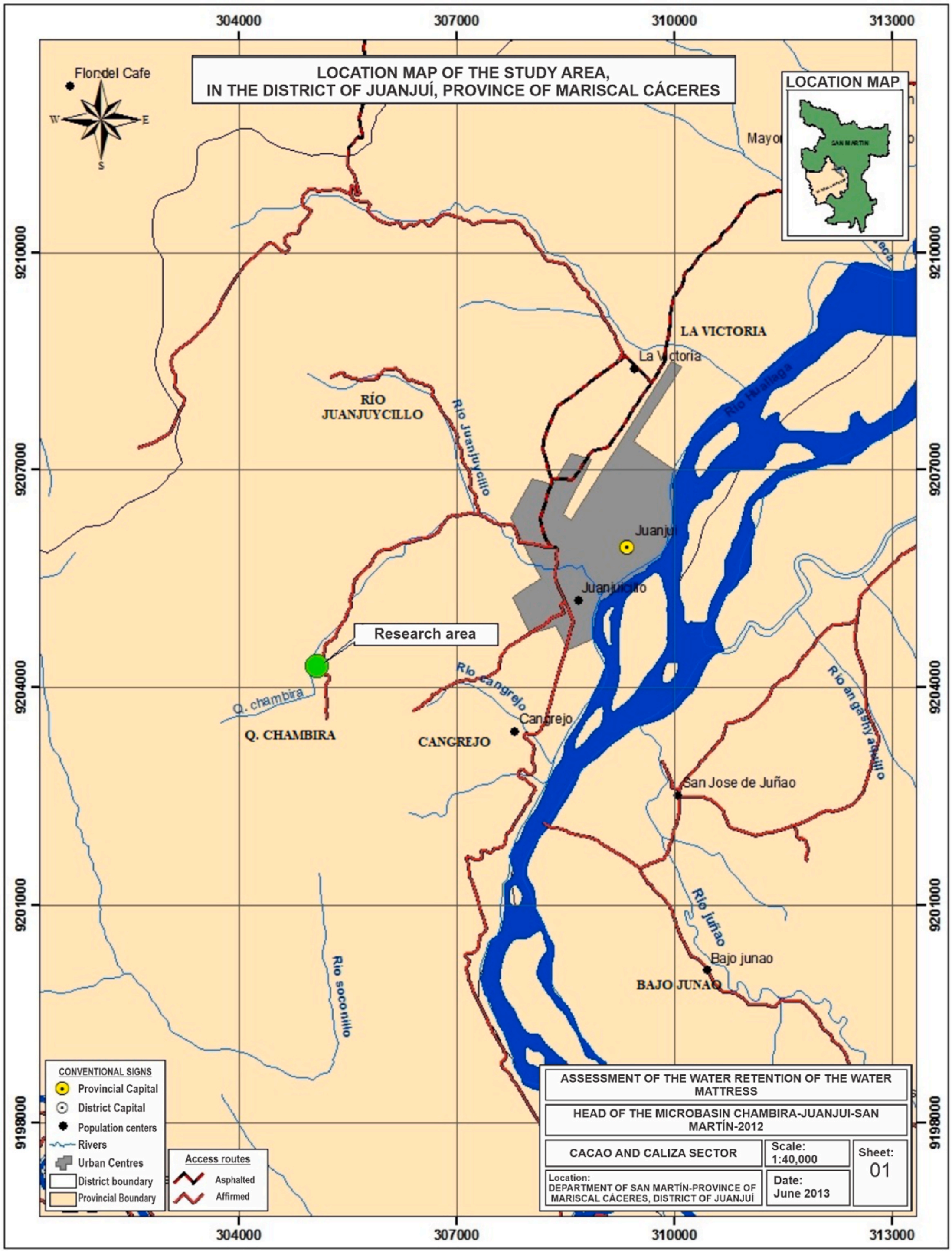

Fig. 1. Location map of the research area.

in weight during three consecutive days. The wet and dry samples are weighed on a commercial scale with a capacity of 20 kg. Water retentivity was obtained using the formula:

$$Retentivity\left(\frac{L}{m^2}\right) = (Wet\ sample - Dry\ sample\ weight)\ g \times \frac{1}{density\ \left(\frac{g}{L}\right)} \times \frac{1}{surface\ (m^2)}$$

For a better visualization of water retentivity, temperature and precipitation, 3D and contour plots were made with Minitab V19 software, and 2D plots in a spreadsheet.

2.7. Statistical analysis

Scatter plots were made between temperature, precipitation, and retentivity, for the Cacao and Caliza sectors, to visually evaluate between which variables there is a correlation. Subsequently, a linear regression between retentivity and precipitation was performed with

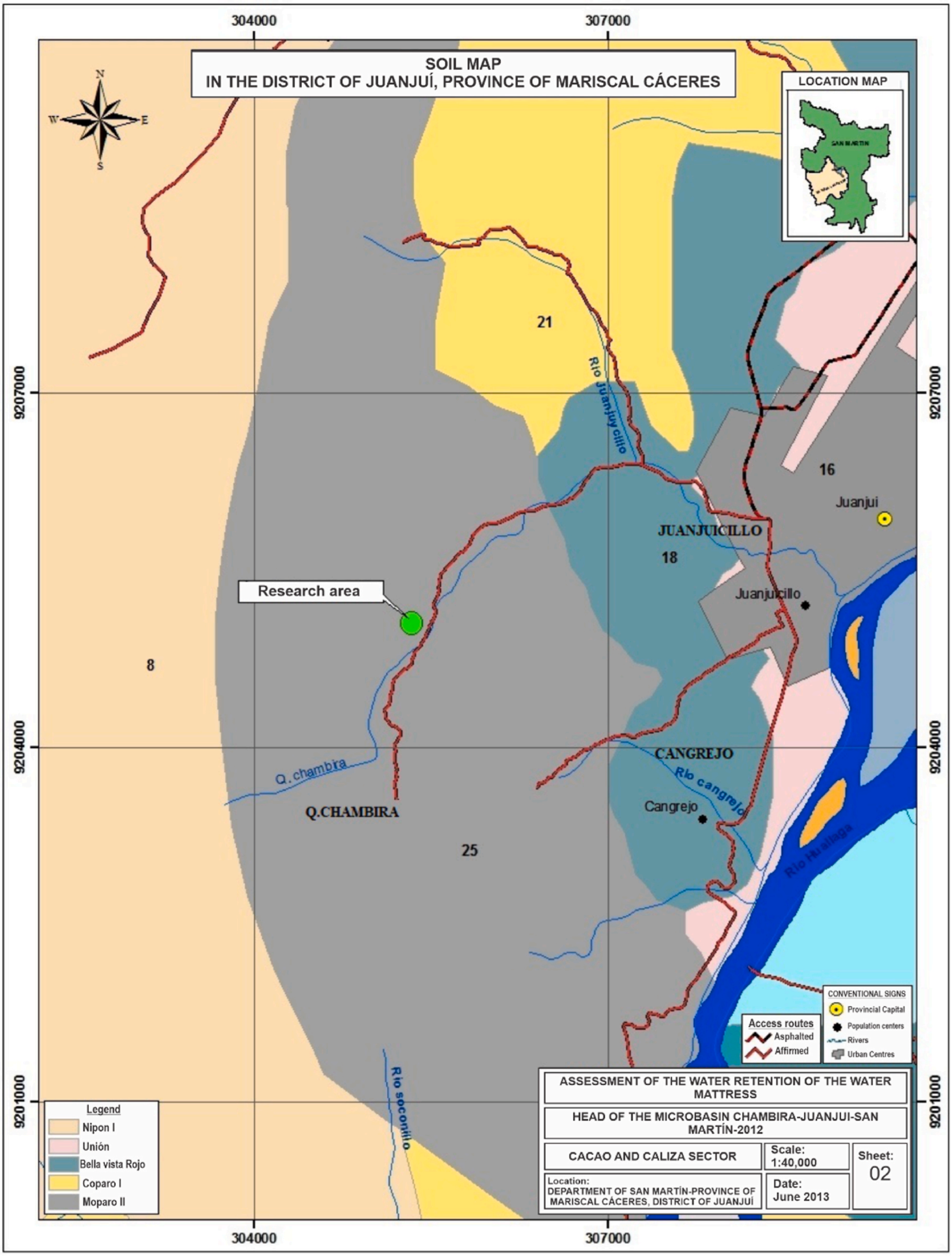

Fig. 2. Major land use capacity map.

RStudio, determining the correlation coefficient R^2. Spearman's correlation coefficient and the analysis of variance between these variables were determined with Minitab v.19.

2.8. Environmental impact assessment

The complexity of EIA methodologies varies from simple to sophisticated, and varied data formats, levels of technical competence, and explanation requirements must all be taken into account. Finding, foreseeing, and evaluating the pertinent impacts before determining how to mitigate them are all part of the EIA Analysis approach [18].

An Environmental Impact Assessment (EIA) was carried out using the Leopold matrix methodology to identify the negative and positive impacts of the activities carried out in the forest. The environmental aspects of the headwaters of the Chambira micro-watershed were identified, such as the physical, biological, and socioeconomic-cultural environment. Also, potential environmental impacts such as regime modification, land transformation and construction, renewable resources, processes, and others.

The environmental aspects of the upper part of the Chambira micro-watershed were identified as the physical, biological, and socioeconomic-cultural environment. The physical environment includes soil, water, and air; the biological environment includes flora and fauna; and the socioeconomic-cultural environment includes social (e.g., health, safety), economic (e.g., industry, commerce), and cultural (e.g., tourism) aspects.

In addition, the potential environmental impacts of various activities were identified, such as the modification of the water regime, the transformation of the soil through construction, and the use of renewable resources, among other processes. The environments are listed in rows and the activities are in columns.

The impacts on the environments were related by assigning them a score according to intensity, following the scale of values in Table 1. The criteria used to assign the scores were based on the Expert Judgment Method.

For each environmental offer related to all impacts, an average is determined. In those aspects where no impact is identified, there will be no qualification, being understood that there is no impact. Finally, all the values obtained from the impacts of the environmental offers are averaged.

3. Results and discussion

3.1. Soil characterization of the Chambira micro-watershed

Physicochemical data of soil samples from the upper part of the Chambira micro-watershed is shown in Table 2. The soil has an almost neutral pH (in water) with a slight conductivity and total dissolved solids. Soil pH is variable depending on soil composition. Some 60% of the Amazon basin is occupied by iron salts, acid acrisols, and few nutrients [20].

3.2. Historical evolution and degree of dispersion between temperature, precipitation and retentivity of the Chambira micro-watershed (Cacao and Caliza Sectors)

The historical evolution of temperature, precipitation, and retentivity from July 2012 to February 2013 for the Cacao and Caliza sectors are presented in Fig. 3.

It is observed in the surface (a), (b), contour (c), (d), and time evolution (e), (f) graphs that the maximum precipitation and retentivity for Cacao are in February and for Caliza in October and February.

From July to October, precipitation increased with more or less stable temperatures, and from November to February, temperatures decreased while precipitation had an upward parabolic behavior. The behaviors of precipitation and retentivity are similar over time in the period evaluated; no irregular or anomalous behavior on retentivity is observed, and therefore there is no evidence of soil water stress that is of consideration as presented by Chen et al. [21] in a study developed in the northern hemisphere for a wider time interval. Likewise, a comparison between the retentivity (L/m^2) of the analyzed sectors is established, in which it is observed that the retentivity in the Cacao sector is higher since the soil of the Caliza sector is stony. This data is representative and can be used for further studies after this time interval since, according to Kiedrzyńska et al. [22], biodiversity and ecosystem services are improved as a function of retentivity.

Castillo [23] conducted research on “heat events in the Peruvian Amazon” during September, October, and November from 1895 to 2015. According to his findings, at the end of the heat wave, the entry of air masses that move across the continent towards the Atlantic Ocean occurs. In the upper part of the troposphere, a cyclonic movement is formed coming from northeast Brazil. In the middle parts, a band of relative humidity greater than 70% is formed, which comes from the southeastern part of the continent, leading to the formation of cloud systems with storms that cause rainfall. These occur more frequently in warm and humid areas due to the ascent of warm air masses that, at higher altitudes, cool and fall as torrential rains. Lavado et al. [24] stated that annual rainfall in the Peruvian Amazon-Andean basin shows an interannual variant related to the sea surface temperature of the Atlantic Ocean.

A dispersion matrix between temperature, precipitation, and retentivity for the water from July 2012 to February 2013 in the Cacao and Caliza sectors in Juanjuí is shown in Fig. 4. The data plotted are average values of two results taken every fifteen days per month. It is observed that there is a direct relationship between precipitation and retentivity, while there is no relationship between temperature and precipitation and retentivity.

3.3. Relationship between retentivity and precipitation for Cacao and Caliza

In addition to the dispersion of the data (black dots), the red trend line between the retentivity of water and precipitation, as well as the gray band corresponding to the limits of the residuals for this regression for the sectors (a) Cacao and (b) Caliza are presented in Fig. 5.

When determining the water retention of the water buffer in the headwaters of the Chambira micro-watershed, the highest retention values were obtained between October and February, and the lowest retention between July and August. This behavior is due to the direct relationship between precipitation and water retention, as shown in Fig. 5, in agreement with CORPAC’s climatological values. The organic matter of the surface soil layer (Horizon “O”) has a great capacity to retain water. In addition, the result found complies with Libohova et al. [25]. In addition, the amount of water per hectare retained by the water buffer of the evaluated forest was 2.738 m^3/ha; these values are lower than those reported by other authors; however, it is clear that this is due to geographical factors such as relief, precipitation, high stoniness in the micro-watershed sector Caliza all this causes the presence of lower tree density and thus the lower amount of leaf litter and lower amount of water retained. The high slope of the terrain and the lower density of trees influence the number of dry leaves located on the forest floor because, due to water erosion, part of the “O" horizon (litter) and particles of the A1 horizon are transported to the lower parts; favored by the high rainfall and high slopes of the terrain, generally in the high forest. This is related to the statements made by Duran [9].

3.4. Statistical analysis of the relationship between retentivity and precipitation for Cacao and Caliza

When applying the Spearman correlation between precipitation and temperature for both the Cacao and Caliza sectors, a value of −0.43 is obtained, given that precipitation is a more complex phenomenon that does not depend only on temperature; negative correlation values and weakly positive values are observed in the work of Higashino et al. [26].

Table 2
Soil characterization of the upper part of the Chambira micro-watershed, Juanjuí 2012–2013.

Apparent density	0.85 g/cm^3	
Relative or particle density	2.10 g/cm^3	
Sample 40:60	pH	7.10
	Electrical conductivity	252 μS
	Total dissolved solids	126 ppm
Sample 1:1	pH	7.17
	Electrical conductivity	325 μS
	Total dissolved solids	163 ppm

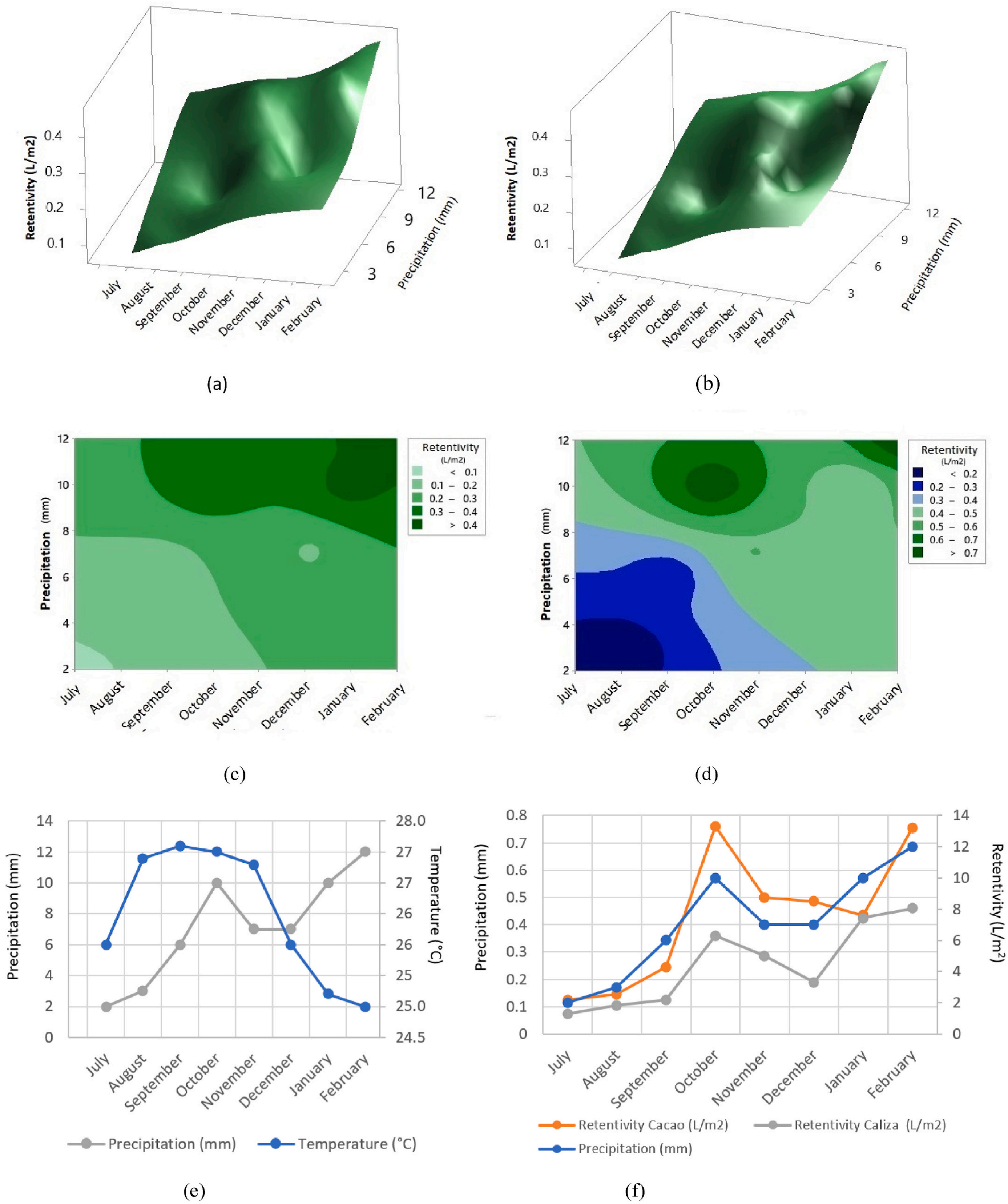

Fig. 3. (a), (b) Surface plots of monthly retentivity and precipitation Cacao and Caliza respectively (c), (d) Contour plots of monthly retentivity and precipitation Cacao and Caliza respectively (e) Precipitation (mm) and Temperature (°C) (f) Retentivity (L/m^2) and Precipitation. Evaluation period: July 2012 to February 2013.

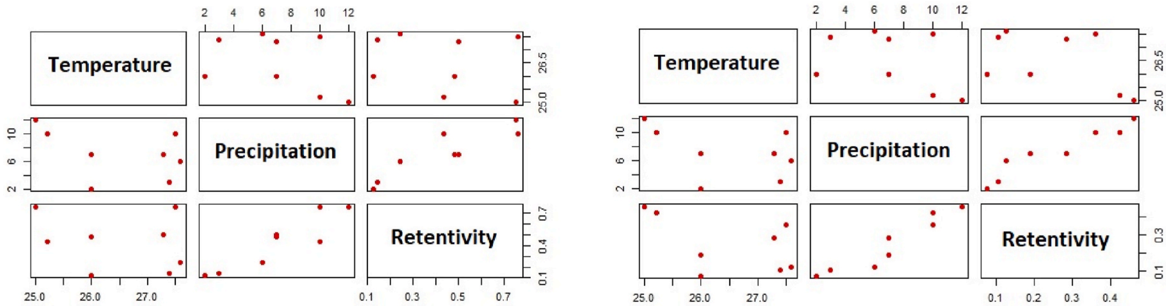

Fig. 4. Scatter matrix of Temperature (°C), Precipitation (mm), and Retentivity (L/m^2) during July 2012 to February 2013 in the following sectors: (a) Cacao and (b) Caliza.

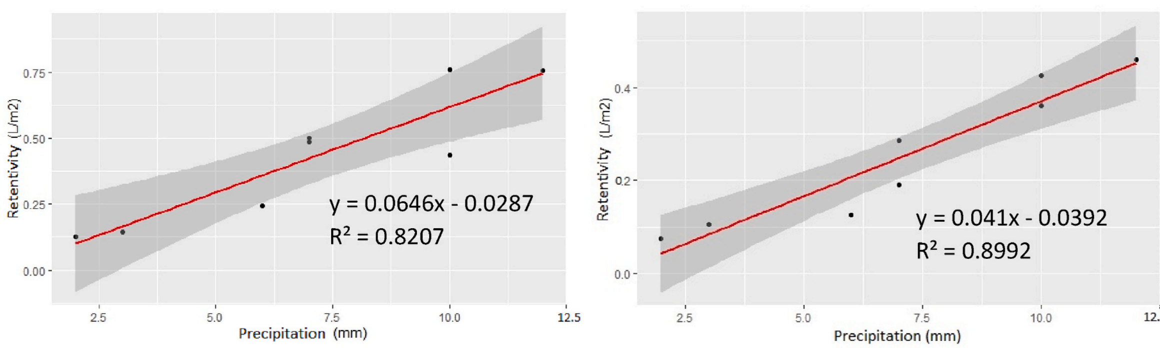

Fig. 5. Linear Regression between Retentivity (L/m^2) and Precipitation from July 2012 to February 2013 in the following sectors: (a) Cacao and (b) Caliza.

In terms of retentivity and temperature, Spearman correlations for the Cacao and Caliza sectors were −0.096 and −0.467, respectively.

The coefficients of determination R^2 obtained in the regression for Cacao and Caliza between the variables retentivity and precipitation were 0.8207 and 0.8992, respectively. This means that 82.07% and 89.92% of the variability of retentivity is due to changes in rainfall for both sectors.

The analysis of variances for the retentivity of the Cacao and Caliza sectors of the Chambira micro-watershed for the evaluation period July 2012–February 2013 is shown in Table 3.

The F-test for the Cacao Sector indicates that there would be no significant differences between the means of Retentivity in the period evaluated; however, the high coefficient of variation indicates that the variability is high concerning the mean of all months. For the Caliza Sector, the F test and the coefficient of variation show significant differences between the monthly means.

3.5. Environmental impact assessment

A Leopold matrix for the aspects of regime modification and land transformation and construction is shown in Table 4. Each component of these aspects is confronted with the physical, biological, and socio-cultural-economic environments.

A Leopold matrix for the aspects of regime modification and land transformation and construction is shown in Table 5. Each component of these aspects is confronted with the physical, biological, and socio-cultural-economic environments.

Table 3
Analysis of Variance for Retentivity (L/m^2) for the Cacao and Caliza sectors, Chambira micro-watershed 2012–2013.

Sector	Calculated F test Fc	Tabulated F-test Ft	Coefficient of Variation CV
Cacao	2.12	3.5	56%
Caliza	4.09	3.5	42%

A Leopold matrix for other general aspects is shown in Table 6. It also shows the scores for all aspects considered in Tables 4 and 5 for each factor, component, and environment. The final average was obtained from the averages of each environment.

The environmental impact study at the headwaters of the Chambira micro-watershed revealed, through the Leopold Matrix, an impact of 5.6, corresponding to a medium impact according to the valuation scale presented in Table 1. The physical environment is the most affected due to agricultural and forestry extraction activities. In the Socio-Economic - Cultural Environment, mainly the social component presents a greater threat to the security of the biological environment and it is observed that security has greater impact value in the entire matrix, followed by lifestyle, risks/danger, also in the economic aspect the value of land/property has importance for the urbanization of the environmental demand scenario. The lowest impact is found in the Cultural component that includes tourism - recreation, and landscape because there is no use of the Chambira micro-watershed as a source of tourism.

4. Conclusions

The information presented shows that the maximum precipitation and water retention by the water buffer occurs in February for the Cacao sector and in October and February for the Caliza sector in the 2012–2013 evaluation period. The minimum values occur in July for both zones during the same evaluation period. The Spearman correlation between precipitation and temperature for both Cacao and Caliza sectors is −0.43. In terms of retentivity and temperature, the Spearman correlations for the Cacao and Caliza sectors were −0.096 and −0.467, respectively. The F-test for the Cacao sector indicates that there would be no significant differences between the retentivity means in the period evaluated; however, the high coefficient of variation indicates that the variability is high to the mean of all months. In the case of the Caliza

Table 4
Environmental Impact Assessment through Leopold Matrix for Regime Modification and Land Transformation and Construction in the headwaters of the Chambira micro-watershed 2012–2013.

ENVIRONMENT EFFECT INVESTIGATION			"ASSESSMENT OF THE WATER RETENTION OF THE WATER MATTRESS AT THE HEAD OF THE CHAMBIRA MICRO-WATERSHED, JUANJUI - 2012"													
ENVIRONMENTAL IMPACT ASSESSMENT MATRIX			MOST SIGNIFICANT COMPONENTS OF THE HEADWATER IN THE CHAMBIRA MICRO-WATERSHED													
			REGIME MODIFICATION									LAND TRANSFORMATION AND CONSTRUCTION				
ENVIRONMENTAL OFFER		ENVIRONMENTAL DEMAND	INTRODUCTION OF EXOTIC FLORA AND FAUNA	BIOLOGICAL CONTROLS	HABITAT MODIFICATION	LAND COVER ALTERATION	ALTERATION OF HYDROLOGY	DRAINAGE ALTERATION	CONTROL OF THE STREAM AND MODIFICATION OF THE FLOW	CLIMATE MODIFICATION	FIRES	URBANIZATION	HIGHWAYS AND BRIDGES	ROADS AND ROADS	CUT AND FILL	TUNNELS AND UNDERGROUND EXCAVATIONS
PHYSICAL ENVIRONMENT	SOIL	Surface soil				5	6		8				3	8		
		Subsoil				4	5		5				2	5		
		Potential use				4	6		6				5	6		
	WATER	Superficial water					9	6	9					6		
		Underground water					8	8	9					5		
		Water quantity					9	6	9					6		
		Hydromorphic area														
	AIR	Air quality														
		Noise levels														
		Increase in combustion gases														
BIOLOGICAL ENVIRONMENT	FLORA	Herbaceous cover	1	5	6	6	9			6			5	5		
		Shrub cover	1	5	6	3	9			6						
		Tree cover	1	6	6	3	6			6						
		Protected species.'' Endemic														
	FAUNA	Aquatic fauna	1		6											
		Reptiles/Amphibians	1	6	6	6								2		
		Habitat fragmentation			8									6		
		Birds	1		6											
		Mammals	1	5	6											
		Endangered species														
SOCIO-ECONOMIC-CULTURAL ENVIRONMENT	SOCIALS	Health										7				
		Security							9							
		Lifestyles														
		Urban sprawl										6				
		Solid waste										2				
		Environmental education										2				
		Risk/Danger										8				
		Sanitation														
	ECONOMIC	Employment Level														
		Land Value/Property										7				
		Agriculture														
		livestock														
		Industry														
		Commerce														
	CULTURAL INTEREST	tourism, recreation										3				
		Landscape										3				
TOTAL PER SHARES			7	5	6	4	7	7	8	6		5	4	5		
TOTAL BY ACTIVITIES			6.00									5.00				

sector, the F test and the coefficient of variation show significant differences between the monthly means. The R^2 coefficients of the determination indicate that 82.07% and 89.92% of the variability in retentivity is due to changes in precipitation for both sectors. The analysis of the environmental impact, using the Leopold matrix, revealed a medium impact of the upper part of the Chambira micro-watershed, being the physical environment component (soil, water, air) the one with the greatest impact, followed by the biological environment component (flora and fauna) due to the scarce knowledge of the settlers regarding the impact they generate with the development of their productive activities, generating an imbalance, which is negatively affected, included in the socioeconomic and cultural environment component. The data obtained in this research are the basis for future work or projects for the conservation or prevention of possible overflows of nearby rivers.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence

Table 5
Environmental Impact Assessment using Leopold Matrix for Renewable Sources and Processes in the headwaters of the Chambira micro-watershed 2012–2013.

ENVIRONMENT EFFECT INVESTIGATION / ENVIRONMENTAL IMPACT ASSESSMENT MATRIX / ENVIRONMENTAL OFFER		ENVIRONMENTAL DEMAND	"ASSESSMENT OF THE WATER RETENTION OF THE WATER MATTRESS AT THE HEAD OF THE CHAMBIRA MICRO-WATERSHED, JUANJUI - 2012"									
			MOST SIGNIFICANT COMPONENTS OF THE HEADWATER IN THE CHAMBIRA MICRO- WATERSHED									
			RENEWABLE RESOURCES					PROCESSES				
			FOREST REPLACEMENT	MANAGEMENT OF AND CONTROL OF NATURAL LIFE	RECHARGE OF SUBTERRANEAN AQUIFERS	USE OF FERTILIZERS	WASTE RECYCLING	FARMING	LIVESTOCK AND GRAZING	FEEDING	SMITHS (WOOD EXPLOITATION)	PRODUCT STORAGE
PHYSICAL ENVIRONMENT	SOIL	Surface soil				2		8	6			
		Subsoil				2		7				
		Potential use				3		8	6			
	WATER	Superficial water						8	5			
		Underground water		6				8	6			
		Water quantity		6				8	5			
		Hydromorphic area										
	AIR	Air quality										
		Noise levels										
		Increase in combustion gases										
BIOLOGICAL ENVIRONMENT	FLORA	Herbaceous cover	9					6		2	2	
		Shrub cover	9					6		6		
		Tree cover						7		7		
		Protected species.''										
		Endemic										
	FAUNA	Aquatic fauna						2		2	6	
		Reptiles/Amphibians						2		2		
		Habitat fragmentation						8				
		Birds								6		
		Mammals						6	6	6		
		Endangered species										
SOCIO-ECONOMIC-CULTURAL ENVIRONMENT	SOCIALS	Health		8					7	8		
		Security										
		Lifestyles	8	8								
		Urban sprawl										
		Solid waste										
		Environmental education										
		Risk/Danger								8		
		Sanitation										
	ECONOMIC	Employment Level										
		Land Value/Property										
		Agriculture livestock								6		
		Industry										
		Commerce								6		
	CULTURAL INTEREST	tourism, recreation										
		Landscape										
TOTAL PER SHARES			7	7		2		6	6	5	4	
TOTAL BY ACTIVITIES			5.00					5.00				

Table 6
Environmental Impact Assessment using the Leopold Matrix for general aspects and total scores at the head of the Chambira micro-watershed 2012–2013.

ENVIRONMENT EFFECT INVESTIGATION		ENVIRONMENTAL DEMAND	"ASSESSMENT OF THE WATER RETENTION OF THE WATER MATTRESS AT THE HEAD OF THE CHAMBIRA MICRO-WATERSHED, JUANJUI - 2012"										
ENVIRONMENTAL IMPACT ASSESSMENT MATRIX			MOST SIGNIFICANT COMPONENTS OF THE HEADWATER IN THE CHAMBIRA MICRO- WATERSHED							SUBTOTALS Tables 4 and 5 Y 6		TOTAL	FINAL AVERAGE
			OTHERS										
ENVIRONMENTAL OFFER			BULK AND PARTICLE DENSITY	EFFECTIVE DEPTH	pH (7.20 y 7.17)	ORGANIC MATERIAL	N–P–K; Ca, Mg	RELIEF OR TOPOGRAPHY	STONENESS	FACTORS	COMPONENTS	MEDIO	
PHYSICAL ENVIRONMENT	SOIL	Surface soil	6		6	8	6	9	6	6.2	5.6	6.5	5.6
		Subsoil	7		6	8	6			5.2			
		Potential use								5.5			
	WATER	Superficial water							9	7.4	7.3		
		Underground water								7.1			
		Water quantity							9	7.3			
		Hydromorphic area											
	AIR	Air quality											
		Noise levels											
		Increase in combustion gases											
BIOLOGICAL ENVIRONMENT	FLORA	Herbaceous cover								5.2	5.4	5.05	
		Shrub cover								5.7			
		Tree cover								5.3			
		Protected species.''											
		Endemic											
	FAUNA	Aquatic fauna								3.4	4.7		
		Reptiles/Amphibians								3.6			
		Habitat fragmentation								7.3			
		Birds								4.3			
		Mammals								5			
		Endangered species											
SOCIO-ECONOMIC-CULTURAL ENVIRONMENT	SOCIALS	Health								7.5	6.1	5.1	
		Security								9			
		Lifestyles								8			
		Urban sprawl								6			
		Solid waste								2			
		Environmental education								2			
		Risk/Danger								8			
		Sanitation											
	ECONOMIC	Employment Level									6.3		
		Land Value/Property								7			
		Agriculture								6			
		livestock											
		Industry											
		Commerce								6			
	CULTURAL INTEREST	tourism, recreation								3	3		
		Landscape								3			
TOTAL PER SHARES			6		6	8	6	9	8				
TOTAL BY ACTIVITIES			7.00							TRUE			5.6

the work reported in this paper.

Data availability

No data was used for the research described in the article.

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