Ecotourism as green engineering: a case study of rural areas in Colombia based on the AHP

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ABSTRACT: The tourism value chain and green engineering are important research topics aimed at improving sustainability. This is especially the case in rural post-conflict areas in Colombia, where value networks and their components are key players in the development of the territory and in implementing green engineering. Therefore, tourism development must be characterised and planned, through a method with three phases: the first to identify stakeholders, the second to choose appropriate data collection instruments, and the last to analyse the data through the analytical hierarchy process (AHP). The main criteria are sociocultural (32%), economic (22%) and ecological (21%), with representative variables including social empowerment, local identity, the financial capacity of the demand, the level of supply prices, biophysical conditions and the supply of natural resources. The AHP indicates an assessment for each municipality: Mesetas 2.37, Lejanías 2.17 and La Uribe 2.0. In addressing critical areas for tourism development, it is critical to incorporate new instruments that support planning and management with sustainability approaches.

INTRODUCTION

The tourism sector is a powerful force for change in the economy, in which the participation of the value network is an important factor in the planning, management and impact of tourism in the territories [1], since it improves employment, infrastructure and the income of the population involved in tourist activities, and it generally belongs to the communities that make up the territories [2][3]. According to the above principles, during the last decades, the tourism sector has contributed significantly to the world GDP due to its rapid growth, evidenced in the increase of international tourist arrivals worldwide, showing a growth of 5% since 2018. For this reason, tourism is recognised as an engine of growth and economic development worldwide [4].

However, this favourable performance of the tourism sector has been detrimentally affected by the Covid-19 pandemic. Tourism is a sector with the greatest negative impact, due to widely applied travel restrictions and the ensuing decrease in international tourist arrivals. However, it has been identified that the reduction in tourism is mainly related to urban destinations focused on foreign tourism, so rural destinations create a viable alternative for national tourists with excellent natural, gastronomic and local attractions in these areas [5]. Colombian tourism is incipient; however, in the last decade growth has been significant as part of the orange economy supported by green engineering instruments resulting in the increase of foreign travellers before the pandemic [6]. Despite the growth, the results are low compared to countries that have similar economic conditions. One of the reasons is the image that the country has abroad [6], due to its complex circumstances, such as drug trafficking and the internal armed conflict that have increased poverty, displacement, dispossession of productive assets and violence that complicates the situation of those rural territories that are directly involved in these conflicts [7].

The Peace Agreement signed in 2016 sought to improve the level of security, accessibility and international image, to promote economic growth through tourism [8], since it generates social and economic development in rural areas affected by war. In accordance with the above goals, the signing of the Peace Agreement had a positive influence on the increase in international arrivals by 27%. The level of security has been improved, similar to international promotion and training initiatives of the value chain of tourist services. In those initiatives, it is important to focus on elements of sustainability that can overcome economic limitations while aiming to reduce inequalities and differences [7].

The study outlined in this article has been concerned with the department of Meta in Columbia, which is located in the central-eastern region and represents 7.5% of the country. Meta has a strategically critical geographical position, and is characterised by its water wealth (tax numbers), by having one of the best-known natural parks in the country, La Serranía de la Macarena, and the largest number of natural reserves and biodiversity.

However, the territory experienced some serious consequences of the armed conflict, such as displacements, homicides, forced disappearances, threats, kidnappings and other acts [9]. After the Peace Agreement, the department of Meta was declared a post-conflict area in order to support the reintegration process of the demobilised forces through employment and sustainable economic income [9][10]. For this reason, the public policy of the department of Meta recognises tourism as one of the most anticipated economic activities to apply the sustainable development that is carried out in the different territories and that contributes to the consolidation of peace and coexistence in all eleven regions of Columbia [11]. Of the 29 municipalities of the department of Meta, the municipalities of Mesetas, Lejanías and Uribe were selected for this study.

These municipalities are post-conflict areas with a legal framework that defines specific lines of action in the tourist spaces affected by the armed conflict [12]. With programmes, such as Tourism, Peace and Coexistence, integrating the regions into the national tourism market, or Tourism and Peace Pilot Regions defining local producers of nature tourism, regional entrepreneurship contributes to improving coexistence between communities. In those areas, eight pilot regions were articulated, comprising more than 42 municipalities [7]. Therefore, there was a need to gather information and characterise the development of tourism in the selected municipalities. In the study outlined in this article, the qualities, requirements and possible expectations were identified to reinforce or propose relevant action plans in the region.

METHODOLOGY

The information management of the ecotourism value chain and its contribution to green engineering from an integral logistics has several phases as shown in Figure 1.
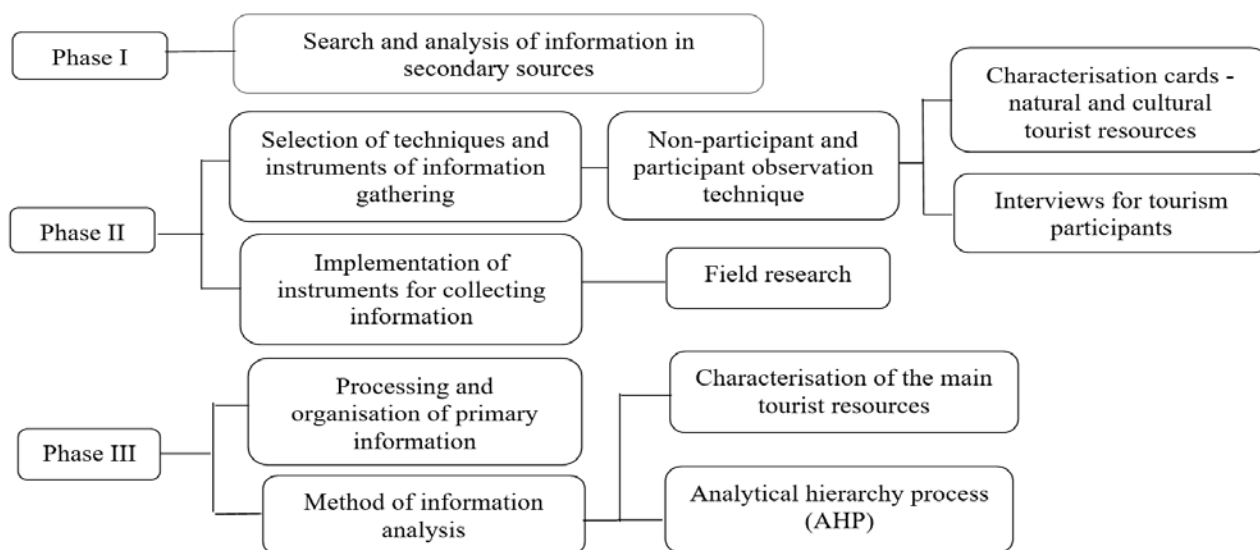

Figure 1: Stages of research development.

In Phase I information was sought out related to the development tourism in the municipalities under study. Information on government documents and laws that regulate tourism was identified; but there were very few studies and/or investigations carried out on the subject that would be useful for the current study. Phase II was about data collection techniques and instruments, in which direct observation (*in situ*) was used without the participation of the actors. For the characterisation sheets of tourist attractions, the elaboration of the tourist inventory of the Ministry of Commerce, Industry and Tourism was taken into account. Surveys were administered to the actors in the area, such as administrators of farms, hotels, restaurants and tourist attractions. Based on the collected data, the tourist territorial assessment form of each municipality was elaborated [8].

Likewise, it is important to mention that a discretionary sampling technique was used since it was not possible to have the same level of participation of the interested parties in the visits. Phase III involved data processing and consisted of data reviewing and digitising in previously determined tables and matrices. For data analysis the analytical hierarchy process (AHP) was employed. Below is demonstrated the result of the characterisation of the main tourism resources and a global analysis for each of the municipalities analysed through the AHP.

Characterisation of Tourist Resources

The characterisation was carried out with a valuation matrix, where weighting was applied according to the type of tourist resource (natural and cultural). In the natural category, geographical areas, natural resources and biodiversity were considered. Likewise, in the cultural category, real estate was considered, rural and archaeological groups, festivities and/or events and groups of special interest with the presence of indigenous communities. Table 1 lists the variables and weights in the valuation of natural tourism resources:

- State of conservation: it is the structure and ecological functioning of the natural area, its natural resources, biodiversity and/or its components, considering the level of affectation by anthropic environmental impacts and tourism.

- Diversity: is the variety of natural and/or cultural resources in the territory.
- Singularity: they are the unique attributes or level of rarity of a component or conjunction in its spatial integration, with environmental interpretation value, which achieves its differentiation. The uniqueness is associated with components of the landscape and biodiversity.
- Accessibility: is the level of ease of mobility and access to a tourist area and/or site determined by the spatial and temporal scale, type of terrain, state of the roads and means of transportation.
- Appropriation or social meaning: it is the level of knowledge and social appropriation of a tourist resource through its use in tourism. Its importance increases with its integration into the local, regional and national tourism product and its use by tourists from international and national destinations.

Table 1: Variables and weights in the valuation of natural tourism resources.

Code	Variables	Weights
VEC	Conservation status	20%
VD	Diversity	20%
VS	Singularity	15%
VA	Accessibility	10%
VPV	Promoting tourist value	5%
VAS	Appropriation or social meaning	30%

Table 2 through to Table 4 include the established rating scales for the variables listed in Table 1 above.

Table 2: Quantitative assessment scale of the variables VEC, VD, VS and VPV for natural and cultural tourism.

Criterion	Very low (VL)	Low (B)	Medium (M)	High (H)	Very high (VH)
Level	1	2	3	4	5

Table 3: Quantitative assessment scale of the VA variable for natural and cultural tourism resources.

Criterion	VL	B	M	H	VH
Level	1	2	3	4	5

VL	More than 30 km, more than 2 hours, very deteriorated road, passable road, navigable stretch and/or by foot.	H	More than 30 km, less than two hours, unblocked road in regular condition.
B	More than 30 km, more than 2 hours, very deteriorated road, passable road and/or by foot.	VH	Less than 10 km, less than one hour, paved road in good condition.
M	More than 30 km, less than 2 hours, unblocked road, passable road and by foot.		

Table 4: Quantitative assessment scale of the VAS variable for natural and cultural tourism resources.

Criterion	VL	L	M	H	VH
Level	1	2	3	4	5

VL	Minimum recognition and tourist and/or social use by tourists and/or local inhabitants, without integration into the local tourist product.	H	Recognition and tourist use by national tourists, with integration into the regional and/or national tourism product.
B	Recognition and tourist use by tourists and/or local inhabitants, with weak integration into the regional and/or local tourism product.	VH	Recognition and tourist use by international tourists, with integration to the regional and/or national tourism product.
M	Recognition and tourist use by regional tourists, with integration into the regional and/or local tourism product.		

Similarly, Table 5 through to Table 7 show the variables and weights applied in the valuation of cultural tourism resources.

Table 5: Variables and weights of tourist cultural resources - immovable property.

Variables	Weights
Conservation status	15%
Establishment of property	15%
Representativeness	25%
Accessibility	10%
Promoting tourist value	5%
Appropriation or social meaning	30%

Table 6: Variables and weights of tourism cultural resources - festivities and events.

Variables	Weights
Organisation and content	30%
Sociocultural benefits	20%
Economic benefits	20%
Social appropriation or meaning	30%

Table 7: Variables and weights of tourism cultural resources - special interest groups.

Variables	Weights
Conservation of culture, identity and ways of living	70%
Social appropriation or meaning	30%

ANALYTICAL HIERARCHY PROCESS - AHP

Tourism has complex qualitative aspects to evaluate and additionally because the available information is not sufficient, the analytical hierarchy process (AHP) was applied since it takes these conditions into account. In accordance with the method, the sub-systems and variables that make up the tourism system are identified first, that is, each sub-system is defined by a group of criteria and/or variables, which are then weighted to quantitatively determine the status of the sub-systems [13]. Then, the consistency index (CR) of the paired matrices is calculated to evaluate their consistency. Based on the foregoing, researchers and experts define the five sub-systems as: ecological, physical, sociocultural, economic and tourist along with the variables and/or criteria of each of the sub-systems (see Figure 2).

The complete application of the AHP method to the ecological sub-system is presented below [14], with the same dynamics for the others. The comparison matrix of criteria and/or variables of each sub-system is made by assigning the evaluation judgment according to the level of relative importance of one criterion over the other on a numerical assessment scale as demonstrated in Table 8:

Table 8: Numerical scale [15].

Numerical scale	Verbal scale	Explanation
1	Both criteria or elements are equally important.	The two criteria equally contribute to the objective.
3	Weak or moderate importance of one criterion over the other.	One criterion is moderately more important than the other.
5	Essential or strong importance of one criterion over the other.	One criterion is strongly more important than the other.
7	Proven importance of one criterion over the other.	The importance of one criterion is much stronger than that of the other which is proven.
9	Absolute importance of one criterion over the other.	Extreme importance of one criterion over the other.
2, 4, 6 and 8	Intermediate importance between two opinions.	
The allocation of an opinion as a whole number represents greater importance to the criteria of the row. The assignment of an opinion as a rational number means greater importance to the criterion of the column.		

Table 9 shows the matrix of paired comparisons of criteria and/or variables of the ecological sub-system:

Table 9: Matrix of paired comparisons of criteria and/or variables of the ecological sub-system.

Criteria	Criterion 1.1	Criterion 1.2	Criterion 1.3	Criterion 1.4	Criterion 1.5
Criterion 1.1	1.00	2.00	3.00	3.00	2.00
Criterion 1.2	0.50	1.00	1.00	0.33	5.00
Criterion 1.3	0.33	1.00	1.00	0.33	3.00
Criterion 1.4	0.33	0.33	3.00	1.00	0.33
Criterion 1.5	0.50	0.20	0.33	3.00	1.00

Criterion 1: Ecological sub-system				
FBC	NRO	BCS	TUI	EDC
Criterion 1.1	Criterion 1.2	Criterion 1.3	Criterion 1.4	Criterion 1.5

FBC: favourable biophysical conditions; NRO: natural resources offer; BCS: biodiversity conservation status; TUI: tourist use intensity; and EDC: environmental decontamination capacity.

The normalised matrix is calculated from the vertical sum of the values of each column of the previous matrix and the result is divided by the value of the total sum of its respective column (see Table 10).

Table 10: Standardised matrix of criteria and/or variables of the ecological sub-system.

Criteria	Criterion 1.1	Criterion 1.2	Criterion 1.3	Criterion 1.4	Criterion 1.5
Criterion 1.1	0.38	0.44	0.36	0.39	0.18
Criterion 1.2	0.19	0.22	0.12	0.04	0.44
Criterion 1.3	0.13	0.22	0.12	0.04	0.26
Criterion 1.4	0.13	0.07	0.36	0.13	0.03
Criterion 1.5	0.19	0.04	0.04	0.39	0.09

Each one of the rows of the normalised matrix is added to estimate the degree of participation calculated by the priority vector, resulting in the level of relative importance of each criterion and/or variables that make up the sub-system (see Table 11).

Table 11: Vector of the standardised matrix of criteria and/or variables of the ecological sub-system.

Criteria	Cr. 1.1	Cr. 1.2	Cr. 1.3	Cr. 1.4	Cr 1.5	Sum	Priority vector
Cr. 1.1	0.38	0.44	0.36	0.39	0.18	1.74	0.35
Cr. 1.2	0.19	0.22	0.12	0.04	0.44	1.01	0.20
Cr. 1.3	0.13	0.22	0.12	0.04	0.26	0.77	0.15
Cr. 1.4	0.13	0.07	0.36	0.13	0.03	0.72	0.14
Cr. 1.5	0.19	0.04	0.04	0.39	0.09	0.75	0.15
Cr. Criterion						5.00	1.00

Finally, the validation of the priorities of the criteria is developed with the calculation of the consistency index (CR) that is related in Equation (1), by measuring the dispersion of the expert group's judgments in the initial pairwise comparison matrix.

$$RC = \frac{IC}{AI} \tag{1}$$

RC: consistency ratio; IC: consistency index; and AI: random consistency index, where IC is determined by Equation (2):

$$IC = (\lambda \max - n)/(n-1) \tag{2}$$

$\lambda \max$: is the maximum eigenvalue of the initial paired matrix; and n: is the value of the matrix size.

$$IC = (\lambda \max - n)/(n-1) = \frac{5.22 - 5}{5 - 1} = 0.054$$

The AI is determined by the value of the matrix size (number of elements) that is listed in Table 12.

Table 12: Random consistency index (RCI).

n	1	2	3	4	5	6	7	8	9	10
IA	0	0	0.58	0.89	1.11	1.24	1.32	1.4	1.45	1.49

According to the above with a size n = 5, the IA corresponds to 1.11. Giving an RC value of:

$$RC = \frac{IC}{AI} = \frac{0.054}{1.11} = 0.049$$

RC values that exceed 0.10 indicate that the opinions are inconsistent, that is why it can be said that the RC (0.049) of the ecological sub-system has a reasonable level of consistency in the paired comparisons. In Figure 2, the weighting scheme of the sub-systems and variables of complete analysis of the study system are presented [16].

RESULTS AND DISCUSSION

It is identified that the use of tourism resources has a high level of conservation, diversity and uniqueness in ecosystems, biodiversity and characteristic landscapes of the foothills of the Llanos and Serranía de la Macarena. Likewise, a high value is recognised in the social appropriation of cultural tourism resources associated with the identity and way of life of the peasant farmer. On the other hand, it is recognised that the structure of tourism is low mainly due to the lack of planning and organisation of the value chain that provides the tourist service, which in turn adds to the lack of integration and co-operation between the actors and the deficient tourist plant. The municipality of Lejanías is characterised by its landscape of rivers and mountains, which make up tourist attractions, highlighting the Güejar Canyon with rafting and natural pools of the Güejar River. Likewise, it presents an archaeological zone with eight sites (La Piedra Gorda with its mysterious petroglyphs, Puente de la Reconciliación, El Cable). In addition to the Llano Fruit and Coffee Festival, it annually attracts a large flow of tourists.

Similarly, the results of the analysis are presented in Table 13, in which the weights of the sub-systems and of the variables (criteria) are related, and the qualifications of the variables are also observed, on a scale of 1 to 3; where 1 is the low value and 3 is the high value. This information is presented by each municipality. The sub-systems that have the highest value are sociocultural (32%), economic (22%) and ecological (21%); approaches of great importance in an economy where the quality of life prevails over economic interests. A description of the sub-systems is presented below.

Table 13: Analysis of tourism development in the municipalities.

System	Weights	Variables and/or criteria	Weights	Municipality		
				Lejanías	Mesetas	La Uribe
Ecological sub-system	21%	Favourable biophysical conditions	35%	3	3	2
		Natural resources offer	20%	3	3	3
		Biodiversity conservation status	15%	3	3	3
		Tourist use intensity	15%	1	1	1
		Assimilation capacity	15%	1	1	1
		Subtotal	100%	2.41	2.41	2.06
Physical and built sub-system	14%	Infrastructure offer and conditions	45%	1	1	1
		Public equipment offer and conditions	25%	1	2	1
		Access and mobility	19%	3	2	2
		Safety	11%	3	3	3
		Subtotal	100%	1.60	1.66	1.42
Sociocultural sub-system	32%	Territorial governance	18%	2	2	2
		Social empowerment	38%	3	3	3
		Social and economic reintegration post-conflict	14%	1	2	1
		Local culture and identity	30%	2	3	2
		Subtotal	100%	2.24	2.68	2.24
Economic sub-system	22%	Financial capacity of the demand	39%	2	2	2
		Offer price level	27%	3	3	2
		Generation of employment	20%	2	2	2
		Integration of productive activities to tourism	14%	2	2	1
		Subtotal	100%	2.27	2.27	1.86
Tourist sub-system	11%	Resources and/or tourist attractions	29%	3	3	3
		Promotion of tourist area	16%	1	2	1
		Tourist plant (equipment and facilities)	21%	1	2	1
		Tourist quality	10%	3	3	3
		Management of sustainability	10%	2	2	2
		Tourist offer	14%	2	3	2
		Subtotal	100%	2.01	2.53	2.01
Total				2.17	2.37	2.0

Ecological sub-system: the municipalities of Mesetas and La Uribe are established in the transition zone of the mountainous physiographic region of the department of Meta, Columbia, in the foothills or transition zone between the mountain range, the plain and the Serranía de la Macarena. While the municipality of Lejanías is located in the southern zone, between the moors and slopes of the eastern mountain range to the warm plains and plains of the Ariari and Guaviare rivers.

Physical and built sub-system: access is facilitated by the good condition of the road, a linear route on flat terrain and a relatively short distance from Villavicencio to the municipalities of Mesetas, La Uribe and Lejanías, limited mobility in rural areas due to the deterioration of secondary and tertiary roads. It also identifies the need to increase infrastructure capacity in roads, communications and basic sanitation, as well as the provision of tourist facilities. Finally, it is recognised that the main tourist attractions have promotional tourist value in the national market.

Sociocultural sub-system: there is territorial integration of the municipalities of Lejanías and San Juan de Arama through El Güejar River, a structuring element of tourism, as well as social empowerment with a productive chain of community tourism. Another factor is the component of training and certification in labour competency standards and the operation of specialised services in adventure tourism according to the technical standards of the Colombian sector (NTS AV 010. Rafting Activities), which increase the quality of the tourist experience. In the municipality of Mesetas, one of the three (3) territorial spaces for training and reincorporation (ETCR) of the department of Meta is located, where the productive empowerment of the population, who are former members of the FARC-EP in the region, in addition to technical support and Commercial accompaniment, is carried out in the management of its agricultural and ecotourism production units in the Buenavista district and the Mesetas area of influence.

In accordance with the above, the tourism production unit called Sanep Sasan is identified, with an ecotourism approach, which is positioned in a specialised market segment at an international level for its differentiated tourist offer, in which it adds valuable components in the historical, cultural and environmental development in the post-conflict framework.
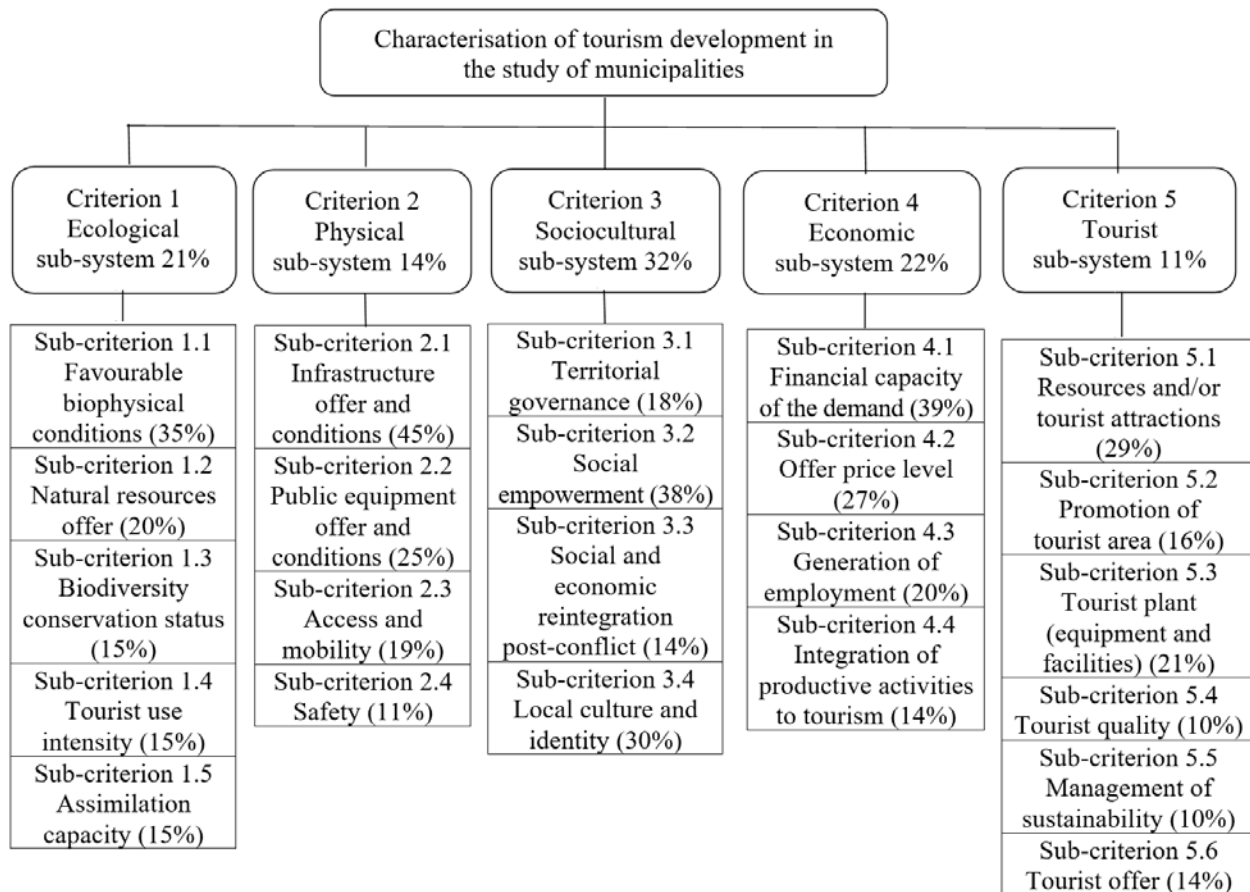
Figure 2: Weights of the sub-systems - criteria or variables for the characterisation of tourism development.

Tourist sub-system: the tourism offer is concentrated in the biophysical elements of the main ecological structure, associated with the Sierra de la Macarena National Natural Park, the Güejar River and its main tributaries, Cañón Lajon (canyon) and La Cristalina in Lejanías, Río Ariari, and its tributary, Río Guape (river) in Uribe, Río Duda (river), and cordillera, shoal, mountain range and canyon. Likewise, a tourist offer has been consolidated based on the contemplation of the piedmont and lowland landscape, typical local gastronomy and the purchase of local fruits within the framework of the Villavicencio-Mesetas-La Uribe and Villavicencio-San Juan de Arama-Lejanias Road axes.

According to the results of the tourism development analysis (see Table 13), it is identified that the sociocultural and ecological sub-systems have the highest scores, the weighted average score corresponding to 2.39 and 2.30, respectively. Therefore, changes in the dynamics of the territories can be noted since the economic sub-system is in the third position of the mentioned score (2.14). The physical sub-system has the lowest score with a value of 1.56. It is necessary to improve the tourist infrastructure, which is related to access, mobility, security and equipment at the sites.

All five sub-systems are determined that allow characterising tourism in the municipalities. A indicated earlier, the sociocultural (32%), economic (22%) and ecological (21%) sub-systems are identified with the highest value or weighting. The last two criteria are very similar, in that the development of economic activities does not ignore this important factor due to the negative effects on the quality of life of the populations that inhabit the territories. Finally, it is identified that the total assessment of tourism development has scores higher than 2 (the assessment scale goes from 1 to 3, with 2 being an average score), with Mesetas being the best valued with a value of 2.37, followed by Lejanias with 2.17 and La Uribe with 2.0.

Impact on Engineering and Technology Education

The results presented in this research generate the need to strengthen engineering education in the aspects of the triple bottom line (environmental, economic and social impacts) given that when carrying out an engineering project, it is necessary to have the participation of the different communities and stakeholders that may affect the project.

The ecological sub-system is of greater importance, followed by the sociocultural and economic sub-systems, respectively. There is little scientific literature regarding professional competencies and the AHP [17]. However, an adjustment in the competencies in the curriculum of technology and engineering programmes is required to strengthen the learning outcomes to develop skills focused on mitigating environmental and ecological impacts, as well as the economic impact to consider these elements within the decision-making process in the development of sustainable projects.

CONCLUSIONS

Municipalities with *first generation* territorial planning schemes in projection of sustainable development recognise the need to incorporate new instruments that support planning and management with sustainability approaches.

One of the weaknesses of tourism in the study area is poor connectivity (digital management of information) and irregular land transport, which affect the arrival of tourists to the region. Therefore, it is essential to improve, expand and design roads, and continue working on security strategies, which continue to be key components for the development of tourism.

The tourist offer of the study area is supported by the tourist resources that require enhancement in the components of tourist service facilities (trails, viewpoints, stopping stations and sanitary units), access assurance, tourist signage, and tourist orientation, which would increase the quality of the overall tourist experience.

Tourism development requires the implementation of management measures, mainly in the control of vehicular and pedestrian load capacity in tourist areas and busiest roads, and awareness of the use of sustainable tourism practices.

The improvement of the processes of the tourist system from infrastructure changes with green engineering impacts education in engineering and technology from the point of view of providing future professionals with tools for both professional performance and the application of instruments to measure and make decisions in fields of engineering outside the traditional and with support for sustainability.

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