Study of Technological Surveillance in Electric River Mobility for Cargo Transport on the Atrato River, Colombia

Edinson Zapata-Campo[1], Katherine Rico-Carrillo[1], Fernando Salazar-Arrieta[1,*], Edwin Paipa-Sanabria[2] and Julian Zapata-Cortes[3]

[1]*Universidad Escuela Naval de Cadetes Almirante Padilla, Cartagena, Colombia*

[2]*Corporación de Ciencia y Tecnología para el Desarrollo de la Industria Naval Marítima y Fluvial-COTECMAR, Cartagena, Colombia*

[3]*Fundación Universitaria CEIPA, Sabaneta, Colombia*

Abstract: Electric mobility is a modality that has been implemented worldwide, however, the importance of the use of this type of environmentally friendly energy occupies a space at the top of this list that to provide solutions in this regard, the National Navy through the Corporation of science and technology for the development of the maritime and river naval industry (COTECMAR), As part of the project executor, Design of an Eco-friendly electric vessel (ECOTEA) for cargo transport on the Atrato River, Colombia, the research project was carried out, technological surveillance study to know the advances and state of development in electric river mobility for cargo transport as an applicable alternative in the Atrato River, in Colombia, as part of the Energy Transformation for Environmentally Friendly Eco Transport, carried out by institutions recognized by the Ministry of Science, Technology and Innovation, such as: the National University, Center for Research and Administrative Planning (CEIPA), Technological University of Chocó, University of Cartagena, the Institute of Environmental Research of Chocó and the Colombian Institute of Technical Standards and Certifications (ICONTEC), as co-executors of the project.

The justification for this research project is based on the UN's Sustainable Development Goals, specifically number 7, which seeks to guarantee access to safe, sustainable and modern energy, as well as the commitments acquired by Colombia through the river master plan, which has as its main objective to obtain a more competitive river system. clean, safe and beneficial for national development, with the design and construction of an ecologically friendly vessel (ECOTEA), specifically on the Atrato River, benefiting an estimated population of 370 thousand people in the energy transition program. The development of the research was descriptive with a qualitative approach because it contributed to the planning of the roadmap to be drawn.

Keywords: Sustainable, technological surveillance, electric mobility, cargo transportation, electric vessel.

INTRODUCTION

Within the framework of the macro-project for the development of the Ecological Electric Vessel (ECOTEA), which will be used for cargo transport on the Atrato River, this project was derived, which had the general objective of carrying out a technological surveillance study, which would allow to know the advances and state of development in electric river mobility for cargo transport as an applicable alternative in the Atrato River. in Colombia, for the ECOTEA project that is part of the energy transformation for eco-friendly transport, based on the identification of the progress and state of development in terms of river electric mobility for cargo transport worldwide. At the same time, a characterization of the current situation of river mobility for cargo transport on the Atrato River was carried out; the identification of advantages and disadvantages that the implementation of this type of system has generated worldwide, and, finally, the policies that have been designed at the global level by leading countries in this field were determined, in order to provide basic elements for decision-making that allow the definition of strategies and alternative solutions to the problems that are currently being experienced.

The Atrato River is located in the territory of Chocó, it rises in the Andes Mountains, in the cliffs of the Citará, in the Cerro del Plateado. Its formation is the result of the collision of three tectonic plates; that of North America, the Pacific, and South America extends to the territories of Panama, Colombia, and Ecuador. It is divided into three sections: high, medium, and low. The upper Atrato began its source in the Andes Mountains to the beginning of the alluvial plains to the west of the department of Chocó. The middle Atrato extends from the plains from the west to the center of the department of Chocó. The lower Atrato lies to the north and extends from the Atrato delta to the mouth of the Caribbean Sea, covering approximately 750 kilometers in the departments of Antioquia and Chocó. The Atrato River receives water from the main rivers of the Pacific basin, which are Bojayá, Napipi, Tengi,

*Address correspondence to this author at the Universidad Escuela Naval de Cadetes Almirante Padilla; Cartagena, Colombia;
E-mail: fsalazar.network.com@gmail.com

Riosucio, Opagado, Beté, Curvarado, Purre, Buey, Murri, Munguido, Beberama, Arquia, Bebara, Churiguido, Tenegado and Truando [1].

The waters of the Atrato River have the highest rainfall levels on the continent due to 12,000 mm3 falling in the region, making it the largest with an average of 4,900 m3/s. This river was declared in 2016, a subject of law for its protection, recovery of the ecosystem that sustains it for being the most polluted channel in Colombia, due to illegal mining activities and deforestation, which reach the Atrato wastewater without any type of treatment, with concentrations of chemicals such as mercury and cyanide. As well as the uncontrolled practice of felling trees that leaves the soils exposed to rainfall, generating sedimentation that reaches the river, thus altering the balance of the ecosystem [1].

In this way, the research question was answered; How is the development of river mobility in the world, using electrical energy that serves as a reference for the design, manufacture, and implementation of solutions in this area, on the Atrato River in Colombia?

MATERIALS AND METHODS

Methodology

In this way, the development of the research was descriptive and qualitative because it contributed to planning the roadmap to be implemented and focused on collecting information using documentary analysis instruments and identifying the necessary sources that helped the fulfillment of the objectives set, initiating with technological surveillance processes to the policies designed at the international and national level and, that have been implemented for the development and strengthening of river mobility in order to promote the mitigation of greenhouse gas emissions, since it is necessary to be clear that the information collected was based on the parameters that aligned with the identified problem and is directly oriented with the axes of the theoretical framework and its structure is the design of instruments for the interpretation of the information. It was a descriptive study framed in evolution and development studies that allowed to record the changes and evolution over time, using correlational studies that determined the facts, circumstances, and analysis for the characterization of the current situation.

This research is aligned with the fulfillment of the UN Sustainable Development Goals and was carried out to interpret the documents found in the process of characterization of the current situation of the Atrato River as a river corridor in the municipality of Turbo, (Antioquia). It was also sought to identify the advantages and disadvantages presented by the development for the implementation of these technologies in vessels worldwide, which allowed to achieve an approach to the design of alternative solutions for the transport of cargo with electric energy, specifically taking advantage of the navigability of the Atrato River, achieving cost optimization and connection of markets to the interior of the country. that allows you to be more efficient and competitive in logistics operations.

RESULTS

River mobility has been considered the first means of transport in the world. At first, rowboats and sailing boats were used; from the twelfth to the fourteenth century, thanks to cities located on the banks of the different rivers of Europe, the use of ships with capacities of 10 to 20 tons increased, due to the increase in the flow of trade through waterways and the development of trade. By the 16th century, navigation improved significantly due to the construction of locks on the river routes, and in the early 19th century the use of steam engines on ships was of vital importance for the development of river transport and the reduction of its cost [2].

River transport is considered the most compatible for social, human and economic support that mitigates the impact on the environment at a reasonable cost that results as other transport alternatives, carrying out a sustainable management of navigable rivers that allows the formation of an intermodal logistics system that is concurrent to the needs of the population due to local supply and demand and the limitations of the geographical location for Have access to the availability to travel distances efficiently and safely [3].

Ships, trucks, and planes that move goods around the world impact a quarter of greenhouse gas emissions, due to the flow of global trade from the transportation of wheat and corn to cement and steel. Nowadays in Vietnam, technologies are being developed that allow the production and export of "low carbon" rice with procedures that have been incorporated to improve yields and incomes, reducing water and fertilizers to reduce CO2 emissions. These projects have played a fundamental role in food security that encourages different governments to promote policies for sustainable agriculture in the

dissemination of new technologies and access to digital data that increase farmers' yields and can reduce waste [4].

In addition, it should be noted that, despite the fact that the National Government has implemented measures to mitigate the reduction of gas emissions, currently the behavior of the demand for liquid fuels has had a growth trend according to the report by the Mining-Energy Planning Unit, except for the significant reduction of 14% due to the result of the pandemic in 2020, for total gasoline consumption represented at 2.004 Million Gallons (Mgal). Gasoline demand had a growth of 31% corresponding to 2,225 Mgal for the year 2021, with a high participation in the growth in the Caribbean region with 35.97% and the Pacific region with 23.48% [5].

The transportation sector corresponds to 98.89% of total gasoline consumption, as can be seen in the following graph, the monthly consumption behavior increased for the first three months of 2022, with an average of 18% compared to 2021, in addition, the behavior since 2019, the great impact that the pandemic had on consumption for the months of March to August 2020 and the trend can be analyzed. growth until March 2022 [5].

The behavior of Diesel-ACPM with the effect of the pandemic was reduced by 16% with a consumption of 1,793 Mgal, while for the year 2021 a growth of 22% was reported with a consumption of 2,191 Mgal and 2.23% compared to 2019. Likewise, the consumption of ACPM was reported lower for the month of May 2021, which is why there were mobility restrictions caused by

Table 1: Gasoline Demand by Region (Million Gallon-Years) 2020-2021

Region	Total Consumption (Millions of gallons)		Annual consumption growth (%)	
	2020	2021	2020	2021
Caribe	303	412	-12,31	35,97%
Pacífica	312	385	-12,48	23,48%
Andina	98	129	-16,79	31,45%
Orinoquía	74	95	0,75	27,84%
Amazonía	43	57	0,74	32,99%
Insular	3	4	-34,76	54,95%

Note: Source [5].

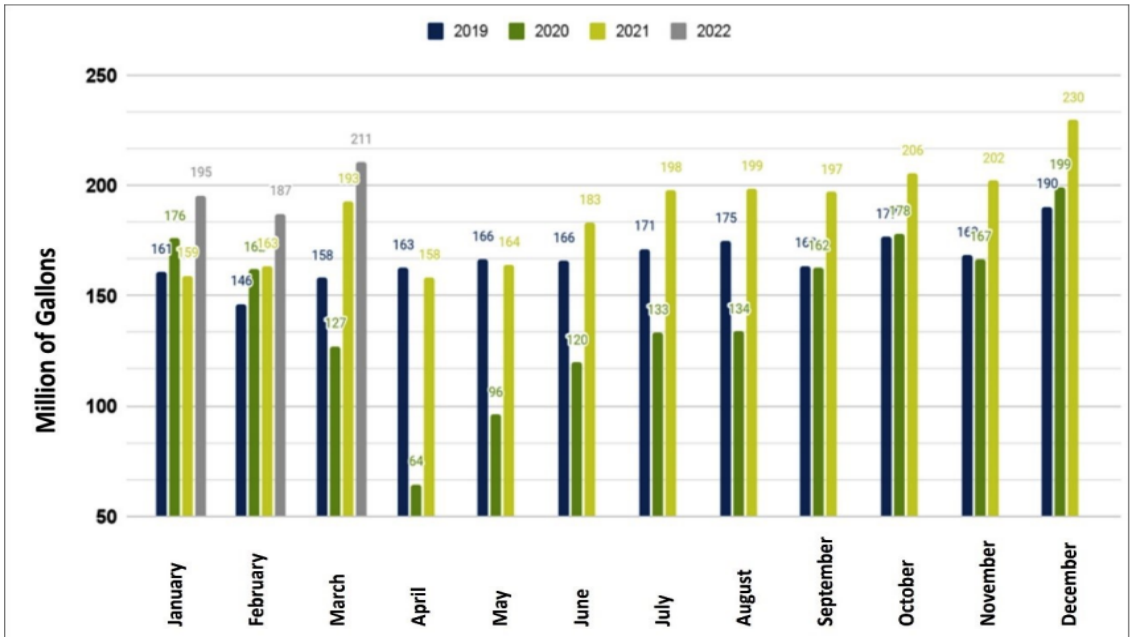

Figure 1: Gasoline Consumption in Colombia Monthly (2019, 2020, 2021 to March 2022).

Note: Source [5].

Table 2: ACPM-Diesel Demand by Region (Million Gallon-Years) 2020-2021

Region	Total Consumption (Millions of gallons)		Annual consumption growth (%)	
	2020	2021	2020	2021
Caribe	480	603	-22,94	25,69%
Pacífica	258	283	-5,96	9,58%
Andina	93	114	-14,68	22,99%
Orinoquía	94	114	-18,42	21,46%
Amazonía	24	28	-23,56	14,64%
Insular	12	15	-20,45	26,10%

Note: Source [5].

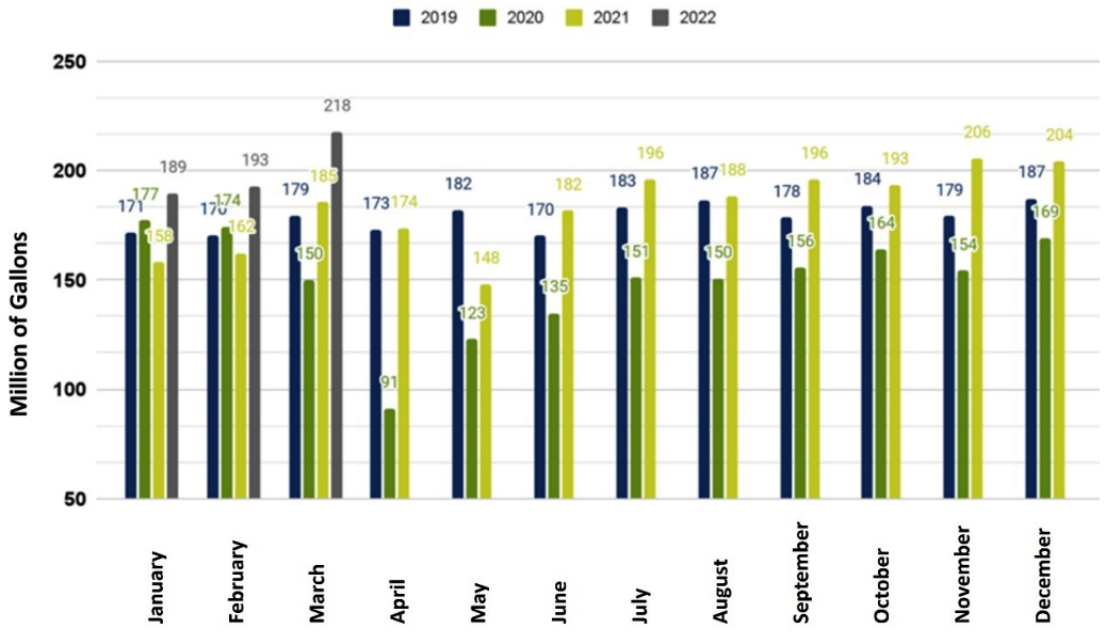

Figure 2: Monthly ACPM-Diesel consumption in Colombia (2019, 2020, 2021 to March 2022).

Note: Source [5].

the national strike, in regional terms its increase is focused on the Caribbean region with 25.69% and the Pacific region with 9.58% [5].

Consequently, the return of economic activities can be evidenced in the following graph, the levels of consumption of ACPM were higher than the reports of previous years, except for the pandemic and the national strike for the months of May 2020 and 2021 that reflect a reduction. Likewise, for the months of November and December 2021, its growth exceeds 200 Mgal and maintains consumption for the month of March 2022.

According to the National Yearbook of Transport in Figures 2021, gasoline represents approximately 99% of consumption and has maintained the growth trend in the last 10 years, while the consumption of ACPM with the last reported consumption represents 77.6% and is positioned as the highest trend within historical consumption, with a significant growth since 2012 as evidenced in the following graph.

Therefore, it can be concluded that the consumption of fossil fuels today continues to be those traditionally used and it is necessary to carry out the energy transition as alternatives that help mitigate the emissions of gases that are generating high pollution and allow compliance with the commitments that Colombia has acquired for 2030 in accordance with the Sustainable Development Goals [7].

Table 3: Fuel consumption in the Transport Sector (Thousands of Barrels Per Day)

Year	Gasoline Engine		Diesel (ACPM)		AVIGAS	VNG* Vehicle Natural Gas
	Total	Transport	Total	Transport		
2010	74.593	68.551	104.004	72.491	273	70
2011	81.220	80.149	126.164	89.581	223	70
2012	83.981	82.961	133.248	91.412	223	70
2013	88.123	87.063	131.557	91.894	238	78
2014	94.108	92.930	134.054	94.285	258	81
2015	106.360	105.141	139.207	99.153	241	76
2016	117.135	116.053	135.666	98.503	238	67
2017	118.916	117.804	132.632	97.920	223	57
2018	123.432	122.246	136.302	101.512	206	53
2019	130.523	129.696	139.926	105.615	213	51
2020	118.821	110.821	117.001	93.305	165	42
2021	146.587	145.211	143.001	111.020	201	44

Note: Source [6].

To have favorable conditions for the development of road, rail, river and air transport modes, different policies and programs have been implemented to improve quality indices in terms of infrastructure and operations. Law 1242 of 2008 was enacted, establishing the National Code of Navigation and River Port Activities, with the purpose of promoting the safety of river transport and establishing measures for commercial activity. With the aim of long-term projection for the reactivation of the river mode. Similarly, in 2015, the National Planning Department and the Ministry of Transportation carried out the River Master Plan, which described the recommendations in institutional planning, transportation operation, infrastructure, and financing, including 13 projects with a 20-year projection [8].

The main objective of the River Master Plan (PMF) seeks to be the starting point for the development of the river transport system, guaranteeing a more competitive, cleaner, and safer Colombia, taking advantage of the fact that this mode of transport exists in a large part of the national territory. The implementation of this PMF seeks to integrate the recommendations proposed by the consultants, where the navigable waterways that allow a better use of navigation opportunities have been selected. That is why it is necessary to differentiate between river transport of cargo, passengers, and goods. These types of transport are dissimilar because cargo transport is oriented to large volumes, long distances, defined as the export and import of trade between regions and cities. Meanwhile, the transport of goods and passengers is encompassed as the connection between villages and isolated regions that provide this service to contribute to the improvement of living conditions [9-12].

Among the main projects, the Ministry of Transport was proposed the decision on the selection and allocation of resources, since most of the rivers are included, but only some are of greater interest to the State according to their particular purpose. Among them, a development of the intermodal corridor in incommunicado waterways was proposed, in order to create various alternatives for river cargo flows, it was called Pilot 2 that contains the improvement of the river connection with the road mode including the improvement of the docks between the Atrato River in Quibdó to the San Juan River in Istmina, with an estimated budget of $76.364 billion in the medium term, estimating a time of no more than five years [9-12].

It is important to note that, in the development of the consultancy, the Ministry of Transportation stated that the portfolio would include the rivers of San Juan, Caquetá, Oriente and Atrato. But some rivers were not included in the initial portfolio, including the Atrato River, with a justification by INVIAS based on the executive report of the Navigability Study carried out by the Institute of Environmental Research of the Pacific (IIAP) with the help of the Technological University of Chocó in February 2013, arguing that the current cargo

Table 4: Vesselsmostused in River Cargo Transport

Type of boat	Characteristics			
	Description	Capacity	Route	Cargo Type
Boat	Small size, it moves from oars, and is mainly made of wood or fiberglass. In addition, it is used for fishing activities.	Up to 50 people	Medium-range tours	Bulk Cargo Passenger Food
Boat	They are powered by an internal combustion engine that powers a propeller. As they are more powerful, the travel time is shorter than with a boat and the load can be greater.	Lower tonnage capacity	Long distances	Bulk Cargo Food
Tugs	They are large vessels that, as their name suggests, push or tow slabs with a large load capacity.	Lower or higher tonnage capacity.	Long distance	They facilitate the power of canisters and slabs.
Slabs	They transport the cargo; they are propelled by tugboats.	Higher tonnage capacity.	Long journeys.	Bulk Cargo Food Hydrocarbons Materials.

Note: Source [13, 14].

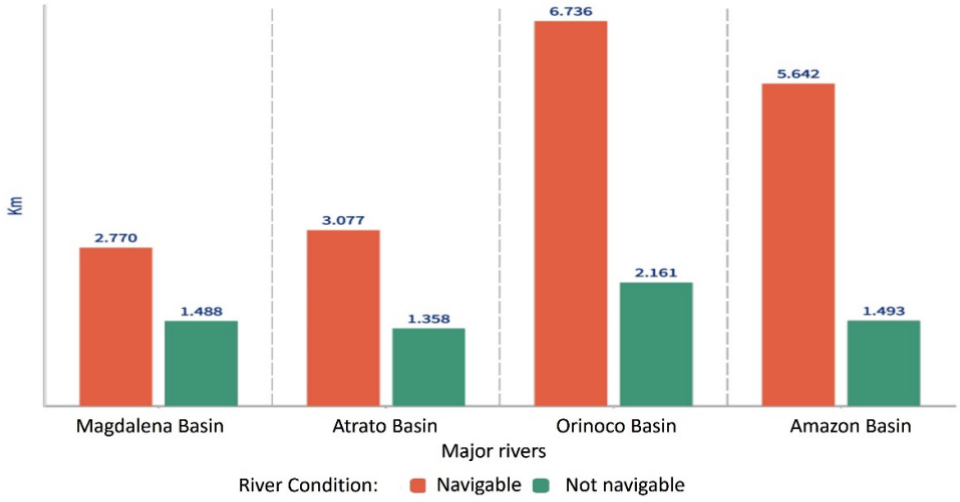

Figure 3: Kilometers of navigable and non-navigable network of the main basins of the country.

Note: Source [6].

moving through the Atrato River focuses on coal and food in Quibdó. dirty river wood to the municipality of Turbo (Antioquia) and fuel in Turbo. The above, replying that these volumes that move do not indicate that they include improvements to the river, nor to the ports or to the river fleet [9-12].

In addition, according to the study, the greatest justification for investment to improve navigability and transportation on the Atrato River should focus on the possibility of attracting container export cargo from the Port of Cartagena, making investment in port infrastructure, river fleet and road connections. But according to the criteria of ARCADIS-YESYCA, he said that it is not easy to capture 10% of the containers that move in Cartagena, the port has many intercontinental transshipment containers that cannot use any other means of transport and in its growth, it is developing a river terminal on the Magdalena River in the Andalusia terminal in Gamarra (Cesar). to have an intermodal connection with the loads in the center of the country. These projects presented in the PMF are considered very ambitious and it is hoped that they can be included in a long-term future phase, beyond 20 years [9-12].

It is of great importance to promote the strengthening of infrastructure that benefits the integration of the modes of transport that depend on the Government's Development Plans that in the future will be able to support, strengthen and restore the waterways that can meet the needs of river transport, taking advantage of the fact that there are basins of great importance for cargo transport. passengers and

goods but they are not fully usable due to the lack of infrastructure that presents problems when using them. It is estimated that the total extension of the most important river system in Colombia is 24,725 km, 7,063 km, and 18,225 km part of the year. The Atrato account transports cargo of food, agricultural products, wood, paper, minerals, timber, cement, among others, and has a length of 4,435 km of the country's river network [13, 14].

Currently, the National Government is developing strategies that allow control and surveillance in the authorization of river companies, with the purpose of guaranteeing the provision of a legal, formal service that complies with safety standards and current regulations. According to the consolidated report of the River Passport for Colombia 2021 program, the first version was carried out in 16 areas of operation by the Superintendence of Transport through the Directorate of Promotion and Prevention of the delegation of ports in its charge, it is accompanying this strategy designed to promote compliance with the conditions of authorization, safety and registration for river transport companies for compliance with infrastructure and transport regulations. For the year 2022, this strategy was developed in 34 river operation areas, where 200 river transport companies were identified, 161 operate small vessels, 35 operate larger vessels and 04 operate large and minor vessels. Concluding a significant increase going from one (01) company that achieved compliance in 2021 to twenty-two (22) companies in 2022, achieving 79% compliance with river operation permits, obtaining positive variations in the implementation of the Manual of Small Vessels, Major Vessels in 11 departments [15, 16].

Colombia has 26 navigable rivers, Cartagena was the epicenter of the development of river transport with the construction carried out by indigenous and Spanish in the creation of the dike canal, generating a boost to the economy with the transport of goods where two vessels were put into operation that were named "Santander" and "Gran Bolívar". Over the years, these machines were progressively replaced by others that had the diesel engine system, achieving loads of two million tons per year. From the 20th century onwards it lost strength because efforts were focused on the development of air and land transport, but it continued to be used for the transport of heavy loads and the transport of goods to places where access to the road network was difficult due to climatic conditions. This system made it possible to boost trade through rivers with adequate depths, having the following river transport routes in the country as well; In the northwest of the country is the Atrato River, in the central area the Magdalena River, the Orinoco River and the Meta River belong to the eastern system, and in the south, we find the Amazonas, Putumayo and Caquetá Rivers [13, 14].

The waterways are the responsibility of the National Institute of Roads, except for Cormagdalena, which oversees the Magdalena River. According to the needs, there are three modes of transport: river transport of cargo, passengers, and tourism. For cargo transport, they are classified into three types of vessels that carry out the transport of food, construction materials, and hydrocarbons and are divided into major and minor. The highest capacity is 300 tons, the average capacity is between 101 and 300 tons, and the lowest load is between 25 and 100 tons. The most common vessels for passengers and cargo are motorboats, boats, pangas, canoes, tugboats, and slabs [13, 14].

In Colombia, the river network has a total length of 24,725 km and 74% (18,225 km) are navigable and 26% (6,500 km) are not navigable. The entire navigable network can be transited by smaller vessels, 62% (11,273 km) can be navigable by larger vessels with a total length of 7,063 km permanently and 4,210 km temporarily. The main basins are the Magdalena River, the Atrato River, the Orinoco River, and the Amazon River. They have the longest navigable lengths; they are the accounts of the Orinoco River and the Amazon River. On the other hand, the Magdalena River account is under the conservation and care of the Cormagdalena Corporation and the Atrato River account has a navigable length for large vessels of 1,075 km permanently and temporarily of 242 km. For smaller vessels, it is 1,760 km long and has a non-navigable length of 4,435 km [6].

CONCLUSIONS

After carrying out an analysis on the different frameworks developed in the project, verifying the current situation of river electromobility, it was possible to obtain the characterization of the current situation of the Atrato River in terms of river mobility, with this it was possible to identify that it has an absence of infrastructure that allows the development of river electromobility projects to guarantee growth and development on the path of energy transformation.

Likewise, through the identification of the pros and cons that the adoption of electromobility has represented in various places, it was possible to

determine that from the long-term economic point of view, the alternative is quite productive, although at the beginning of this type of project it is necessary to invest a large amount of financial resources. technical and human. When the break-even point is reached, significant savings are achieved, as far as the purchase and use of fossil fuels is concerned; and reduces the costs of transporting fuels to remote places that are difficult to access, becoming a viable and environmentally friendly alternative with zero polluting emissions, thus contributing to the achievement of the commitment to the goals of the Sustainable Development Goals (SDGs) for 2030.

In this way, with the information obtained throughout the research, it was found that one of the main problems faced by the implementation of the macroproject is the current infrastructure of points used as docks along the Atrato River, these do not have the necessary technical requirements for ecological vessels to dock, On the other hand, another major impediment is the high level of informality on the part of river freight transport service providers.

The importance of strengthening public programs for general tariff and economic incentives in the country was also observed, due to the fact that they are very few or non-existent compared to leading countries in the field of electromobility.

Finally, regarding the start-up of the ecological and environmentally friendly vessel and its operating systems, alternatives other than the use of lithium batteries were found, implemented in leading countries in this matter, which today have been implementing it with hydrogen and electric batteries, due to overheating and some other characteristics in the use of these elements such as a limited economic life and problems in the environment. Recycling for reverse logistics practices with a high investment cost that they present.

RECOMENDATIONS

- It is necessary that, through government policies, regulations are designed and proposed that encourage both public and private investment aimed at providing the necessary infrastructure, which allows the optimal development of river electromobility, involving digital transformation and new technologies.

- Direct efforts to the formalization of the river cargo transport sector, which is being carried out on the Atrato River, to mitigate the development of irregular practices, unsustainable with the environment, carried out by informal service providers.

- Contemplate the need to make relocation adaptations to the different points used as docks along the Atrato River, to ensure that they have the necessary technical requirements so that eco-friendly vessels can dock there.

- Advance legislative initiatives aimed at incorporating tariff and fiscal regulations into the country's legal system that gradually discourage the use of fossil fuel-powered ships, and thus promote the use of propulsion technologies that respect the environment and ecosystems, for which zero-emission policies can be taken as a reference, promulgated by the European Union; or those enacted individually by Germany and Norway.

- Although batteries are currently the main option to be used within the eco-friendly system, it has been possible to identify through research that, in the short term, they present overheating, limited useful and economic life and, additionally, problems in recycling with a high investment cost for final disposal with reverse logistics practices; In this regard, it is recommended to study the advisability of adopting alternative models within this segment, such as hydrogen batteries and electric batteries.

REFERENCES

[1] Lifeder. Atrato River: history, characteristics, route, tributaries, flora, fauna 2021. Retrieved from: https://www.lifeder.com/rio-atrato/. Retrieved from Atrato River: history, characteristics, route, tributaries, flora, fauna.: https://www.lifeder.com/rio-atrato/

[2] Herrera VA, Betancourt Mora MP. Identification of opportunities for the use of electro-mobility. Bogotá D.C - Colombia 2019: Retrieved from https://ciencia.lasalle.edu.co /ing_civil/539.

[3] USI Infrastructure Services Unit, C. Cepal.org/transporte 2013. Retrieved from https://repositorio.cepal.org/bitstream/ handle/11362/36081/1/FAL_327_es.pdf

[4] Pangestu ME. World Bank 2023. Retrieved from https://blogs.worldbank.org/es/voices/ecologizar-el-comercio-para-el-desarrollo

[5] Mining-Energetic Ud. Demand Projection Report for Electricity, Natural Gas and Liquid Fuels 2022; 2022-2036. Retrieved from https://www1.upme.gov.co/DemandayEficiencia/Documents/Informe_proyeccion_demanda_energeticos.pdf

[6] Transportation Md. Transport in figures 2021. Retrieved from www.mintransporte.gov.co: https://www.mintransporte.gov.co/publicaciones/9443/transporte-en-cifras/

[7] Sustainable Reporting. Sustainable Reporting. Obtained from Sustainable Report 2020. https://www. reportesostenible.cl/ blog/flota-de-buses-electricos-en-chile-es-la-mayor-de-latinoamerica-y-la-segunda-a-nivel-mundial/#:~:text=Flota%20de%20buses%20el%C3%A9ctricos%20en%20Chile%20es%20la,la%20segunda%20a%20nivel%20mundial%20despu%C3%A9s%20de%

[8] CONPES 3. plc.mintransporte.gov.co 2020. Retrieved from https://plc.mintransporte.gov.co/Portals/0/Documentos/3982.pdf

[9] Government of Colombia. (Colombia River Master Plan). Colombia River Master Plan. Bogotá D.C – Colombia 2015.

[10] Government of Colombia. National Development Plan 2022-2026. Bogota D.C. 2023.

[11] Government C. Colombia's River Master Plan. Bogota 2015.

[12] Government of Colombia. River Master Plan 2015.Bogotá D.C – Colombia 2015.

[13] Quintero González JR. River transport in Colombia: operation, infrastructure, environment, regulations and development potential. Journal of Cities, States and Politics 2020; 49-68.

[14] Colombia UN, Quintero González JR, Ramírez Sosa YA, Cortázar Ávila AM. Cities, States and Politics Magazine 2020. https://doi.org/10.15446/cep.v7n1.72778

[15] Superintendence of Transportation. Characterization of Infrastructure, Port Operation and River Transport in Colombia.Bogotá D.C.: Delegatura de Puertos Dirección de Promoción y Prevención (Directorate of Promotion and Prevention) 2022.

[16] Supertransport. Superintendence of Transport, Delegation of Ports.Retrieved from Delegatura de Puertos 2022: https://www.supertransporte.gov.co/documentos/2022/Diciembre/Puertos_15/Informe-Pasaporte-Fluvial-2022.pdf

Received on 15-01-2024 Accepted on 31-01-2024 Published on 06-02-2024

https://doi.org/10.6000/1929-6002.2024.13.01