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Industrial perspective regarding circular economy activities in Atlántico-Colombia

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Abstract

This work seeks to diagnose the business perspective of the department of Atlántico presenting general strength and weaknesses of companies to undertake circular economy policies; for that it seeks to know the actions for the circular economy of companies in each sector, the waste generated, resources used and the management systems or methodologies implemented. The results show that minimize waste by recycling or reusing it, in addition of replan and minimize the water consumption are the main actions to implement circular activities; more than a third of companies have at least one quality, security, save or environment management system that circularized its processes a bit; but they do not achieve an economic, social and environmental positive impact. For this reason, these actions need to become in a holistic structure with systematization of practices, focusing on single innovation stages and involving their stakeholders. Besides, in addition of barriers reported by previous studies, the lack of expertise and complex administrative legal procedures are specific gaps for Atlántico Industry applying circular economy processes that should be considered in the model used to implement it.
Finally, this work serves as the basis for a future pilot project where the level of success and acceptance of various circular economy methodologies that will be implemented in previously selected companies is compared. In this way, build a relevant method to achieve the culture and capabilities of the industries

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of the department of Atlántico in order to achieve economic, social and environmental innovation by applying the concept of circular economy.

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Introduction

The industrial philosophy of the last century was primarily focused on manufacturing production. Most of the companies were based on take-make-dispose; To control the traditional economy development model that relies excessive consumption of resources and the generation of waste (Pan *et al*., 2022), governments create regulation for recycle and to make processes material and energeticaly efficiency, but it hadn't be enough due to industries are under increasing pressure from stakeholders to be clear in the impact reporting environmental (Sartal *et al*., 2020). Increasing population and affluence, and the limited capacity for the planet to provide resources and absorb waste direct thinking towards a more circular way of using materials (Ashby, 2024). Circular economy is a sustainable economic development model.

The 'circularity' concept is a way of thinking that looks not just for efficiencies but also for new ways to provide functions. The idea of deploying rather than consuming materials, of using them not once but many times has economic as well as environmental appeal (Ashby, 2024). Circular economy aims to inculcate the concepts of reduction, reuse, recycling, and recovery of the materials used, and nexus thinking aims at waste reutilization through the interconnections between water, food, and energy resources (Parsa *et al*., 2021).

The lack of understanding of readiness for the Circular Economy transition, manufacturing companies still face a number of challenges in successfully implementing Circular Economy (Pigosso & McAloone, 2021). In general, a little less than a third of the publications are categorized as case studies and a little less than a quarter correspond to reviews (Bjørnbet *et al*., 2021). Because of that It is important to develop a work that explains the way in which the local industry of the department of Atlántico understands and applies the circular economy as a strategy to save raw materials and inputs and at the same time being economically, socially and environmentally sustainable.

Some questions in recurrent works about circular economy are: What are new business model(s) proposed? What type(s) of CBM are proposed?,

Are stakeholders addressed?, How are value chain/suppliers discussed?, Is communication addressed?, What are barriers for Circular Economy?, How can barriers be categorized?, How can barriers be overcome?, What are drivers?. Others Pre-defined topics that present the researches are: What are the efforts towards circulating materials, energy, waste in the case study?, Which parts of the waste hierarchy are in focus?, How is the use stage of products and user/consumer behaviour addressed?, Is progress towards Circular Economy addressed?, Are indicators used/suggested?, What is the connection (clearly expressed/implicit/not expressed) to sustainable development?, Is social, environmental, and economic sustainability addressed? (Bjørnbet *et al.*, 2021). The above are carried out in a particular way to generate new knowledge or apply circular economy methodologies through case studies and reviews, but there is no information about the nations or communities' trends about circular economy. There is no information about the state of the Colombian national industry, the Caribbean region or the department of Atlántico in an intersectoral way that show responsible behavior with the consumption of resources, disposal of waste, Industrials ways to reuse materials, water and energy.

The low adoption of environmental activities in companies, as reported by the Colombian government's indicators, and the disregard problems related to the nature of companies in global samples, stand out the need to consider the employees' perspectives, communities, and the impact on the environment, as well as preserving resources to maintain competitiveness in the market. This is why the question arises, what are the weaknesses and strengths of the department industry to undertake actions related to the circular economy where it can make the most of its resources and achieve the effective implementation of management systems.

Understanding the characteristics of companies, their strategies and programs, the resources they need to conserve, and their strengths and gaps are crucial for developing policies and strategies to reduce environmental, societal, and industrial impacts. This research aims to analyze these factors in order to provide a comprehensive understanding of the current state of the industry and identify opportunities for improvement at the departamento del Atlántico. Based on the EuroBarometer survey, the study, quantitative and descriptive approach and focuses on sub-questions related to waste management, such as the types of waste generated and used, the status of management systems within organizations, resources and inputs saved, and the limitations in implementing such systems.

1. Background

As the global population continues to rise, the consumption of natural resources has surged in order to meet the daily needs of society. Unfortunately, this has resulted in negative impacts on the environment, as indiscriminate consumption leads to degradation, scarcity, and ultimately depletion of resources. To fully grasp the research being conducted by scientists, it is essential to first define the concept of Circular Economy.

According to (Alhawari *et al.*, 2021) Circular Economy is a set of organizational planning processes that aim to create and deliver products, components, and materials at their highest utility for customers and society through effective and efficient utilization of ecosystem, economic, and product cycles by closing loops of concerning resource flows. This concept is based on an extensive review conducted by the authors that match up a set of perspectives associated with terms such as Cradle to Grave, recycling, and reuse. This study aims to examine the business perspective of the department of Atlántico in relation to circular economy practices and how they command with this holistic concept.

This definition of Circular Economy is widely accepted by the scientific community, as it references one of the leading advocates of this concept, such as Ellen Macarthur (Ellen Macarthur Foundation, 2017); states that, in contrast to the traditional linear "take-make-waste" model, a Circular Economy is designed to be regenerative and aims to gradually reduce the consumption of finite resources. This represents a significant shift from the extractive approach of the past and focuses on strategies that keep products in circulation for their useful life.

To gain a better understanding of the Circular Economy movement, the Ellen MacArthur Foundation has created the Circular Economy Systems Diagram, also known as the Circular Economy Butterfly Diagram. This diagram illustrates that a circular economy always keeps materials and components of products in use at their highest value and aims to decouple economic growth and development. It consists of two types of cycles, technical and biological, and as stated by (Camacho-Otero *et al.*, 2018). "At the center of the diagram is the consumer for the biological cycle and the user for the technical cycle. Other stakeholders involved in this definition are the service provider, the product manufacturer, and the parts manufacturer". This highlights that in technical cycles, components and materials of products remain in circulation in the economy for as long as possible, while in biological cycles, the strategy is to return nutrients to the biosphere while rebuilding natural capital.

The technical cycles, which generally apply to products made of non-biodegradable materials such as metal and plastic compounds, propose that

in order to be more effective, it is necessary to maintain and reuse products, thus preserving the value of the product and increasing its useful life, which leads to lower environmental impacts.

Regarding the biological cycle, biodegradable materials, such as food or wood-based products, can be recycled in biological cycles. These materials are naturally renewable, but greater value can be created by extending their uses through remanufacturing, thus giving them added value before reaching the end of their useful life.

From an economic, ecological, and social perspective, Ellen Macarthur's postulate incorporates other perspectives that seek to organize proposals around sustainable development (Korhonen *et al*., 2018). To adopt the circular economy successfully, organizations need to take a systems approach that maximizes the service produced from the linear nature-society-nature material and energy throughput flow, while maintaining a balance between ecosystem cycles and economic cycles and preserving natural reproduction rates by allowing nature to tolerate production flows.

Proposal such as Green Businesses start from the idea that "activities that are consciously addressing environmental/social problems/needs through implementation of entrepreneurial ideas amidst high risks and expectation of net positive impact on environment and financial sustainability" Green Project (2012, as quoted by (Muo & Azeez, 2020)). This approach encourages organizations to focus on customer satisfaction while also incorporating good environmental, social and economic practices, contributing to the conservation of the environment.

Globally, there are countries that have aligned their public policies with strategies that promote the development of circular economy activities in organizational processes in order to achieve sustainable environmental goals (de Melo *et al*., 2022). In the article "Circular Economy Public Policies: A Systematic Literature Review", the highlight that European Union countries such Finland, France, Greece, the Netherlands, Poland, and Spain have policies, action plans, and roadmaps for the implementation of Circular Economy strategies. Other countries such as Brazil, England, Russia, and Scotland address specific environmental issues such as waste management, reduction of greenhouse gases, and efficiency in the management of natural resources. However, Colombia is not unfamiliar with these trends, which is why the *National Strategic Plan for Green Markets* was created (Ministerio de Ambiente y Desarrollo Sostenible, 2014) which defines public policies, objectives, methodologies and tools for organizations to enhance their environmental competitive advantages. It proposes eight strategic lines, which are: 1. Communication, positioning and awareness to consumers and producers about Green Businesses. 2. Politics and regulations. 3. Science, technology, and innovation. 4. Economic and financial resources and

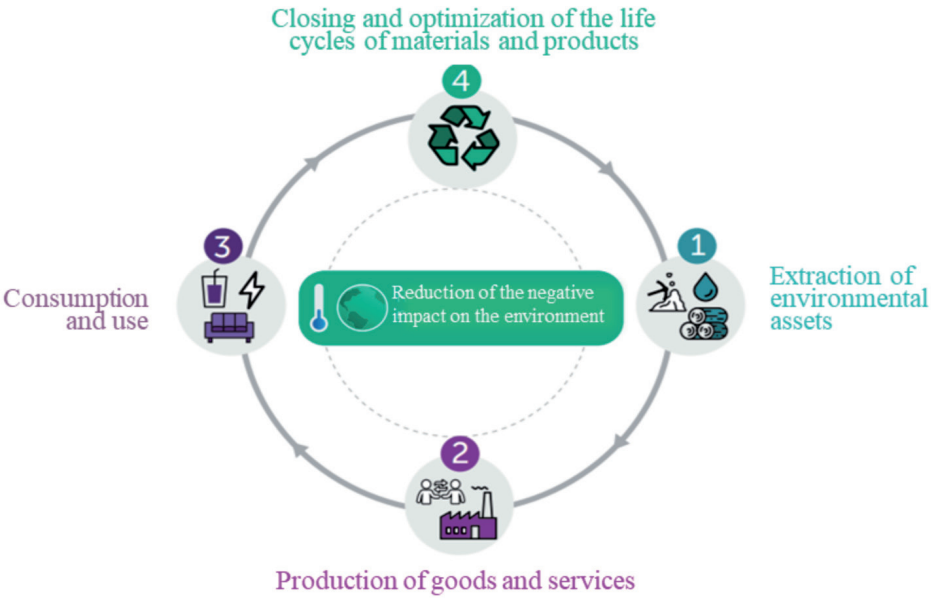
incentives. 5. Access to markets. 6. Coordination and institutional/sectoral articulation. 7. Market information system, monitoring and evaluation. 8. Development and strengthening of the offer. Based on these policies, a general classification of this type of business is established, where according to the report of (MinCiencias, 2017), three categories are contemplated: (1) Sustainable goods and services from natural resources such as bio-trade, sustainable agro systems and businesses for restoration, (2) Industrial eco-products, such as the use and recovery of waste, non-conventional sources of renewable energy, sustainable construction and other sustainable goods and services, (3) Carbon market, the regulated or voluntary market.

This is why many companies in Colombia have opted to improve their environmental components by aligning their processes with international regulations such as ISO 14001, a voluntary standard for most economic sectors, whose main objective is "to provide a framework to protect the environment and respond to changing environmental conditions in balance with socio-economic needs" (ISO 2015, as cited in (Mosgaard *et al.*, 2022)). This has led to more organizations in the country making a commitment towards environmental improvement, taking into account a life cycle approach and identifying and addressing their environmental aspects as stated in this standard. Other methods used include the Total Production Management Methodology (TPM), Environmental Protocols, Eco-efficiency Plan, and Sustainability Policy (Giraldo-Bermúdez, 2020).

Starting from this national background, the country in 2018 began to adopt the philosophy of the circular economy, which includes actions such as Discard, Reduce, Rethink, Redesign, Reuse, Repair, Renovate, Recover, Recycle (Uribe *et al.*, 2019). This was implemented as of November 14, 2018 with the launch of the strategy as part of the Development Plan 2018-2022 (Departamento Nacional de Planeación, 2019) in its sustainability chapter, which aimed to implement economic strategies and instruments so that the productive sectors are more sustainable, innovative, and reduce environmental impacts, with a circular economy approach. This led to the formulation of public policies including the National Circular Economy Strategy – ENEC (Departamento Administrativo Nacional de Estadística – DANE, 2020), which established the instruments for achieving the short and medium-term goals of the country. The goal is to reduce, reuse, and recycle waste and materials, as well as efficiently use resources, water, and energy, thus reducing negative impacts on the environment (Figure 1).

With these guidelines from the Colombian state, the Circular Economy Business Guide (Colombia Productiva, 2020) was created. It teaches companies how to identify and develop strategies so that they can find benefits such as giving added value to businesses, in addition to savings by improving the use of raw materials, optimizing costs by reducing waste, and

Figure 1 - Circular Economy Approach (Departamento Administrativo Nacional de Estadística - DANE, 2020)



generating new income by seeking new business opportunities. For example, the CEMPRE organization was created, which has become a strategic ally of 14 companies nationwide to put the Circular Economy into practice and give visibility to business results in this area. Its areas of focus include steel, construction materials, electrical and electronic equipment materials, container and packaging materials, post-consumption of hazardous and special waste, optimization and use of biomass, water circulation, sources and use of energy, and consumption of materials in urban centers. All this serves as a technical reference for the transformation of materials and dynamics and activities associated with value chains, which help decision-making and implementation of the country's circular economy (Colombia Productiva, 2020).

The plastic industry represents 6.6% of Gross Domestic Product – GDP – and impacts all sectors of the economy and its use continues to increase, but only 1.4% of the potential of plastic waste is recycled, which represents environmental damage that emerges from industrial production and consumption (Mendoza *et al.*, 2020). The actions led by the construction industry towards the circular economy consist of the use of its waste for the production of biomaterials, new concrete and cement (Ramírez, 2021).

In the department of Atlántico, according to the article "Barranquilleras Companies Bet on Sustainability" (Mouthón, 2021), companies such as Ditar, Unipack, and Banapol, have as their main focus the implementation of circular economy processes while also being conscious of the environment and the interest of customers in the use of sustainable products. Additionally, the country's trends include expanding green markets in manufacturing industries, such as paper bags made with recycled materials, 100% biodegradable garbage bags, and food packaging made 100% with ecological materials such as sugarcane bagasse and palm wax as a replacement for the use of plastic and polystyrene foam.

Taking into account these trends in developing products with low impact on the environment (Valora Analitik, 2022), an economic, political, and stock market information journal, describes that the Mario Santo Domingo Foundation, along with the state-owned commercial bank Bancóldex and the Muta company, offer a credit line to support the circular economy process in Barranquilla and Cartagena cities. This helps organizations to finance their recycling fees, increasing sustainable production and consumption models.

Some academic studies had been carried out in the department of Atlántico related with circular economy action, the measure instrument of UI Green Metric World University Ranking was applied in a higher education institution. It found a sustainable trend through a proper waste management like: Luminaries, batteries, technological equipment, chemicals, plastic, glass, paper and paperbroad, but needs to improve on metal waste and leafs, is necessary to increase the use of sustainable energy and presents opportunities for improvement in water saving and there is potential for the use of rainwater (Villa-Marenco, 2021). Similarly, there are academic papers that seek to optimize drying processes with microwave energy for foods such as strawberries (Alvarado Bawab, 2017) and coal with a view to reducing transportation costs and storage risks (Alvarado-Bawab, 2012; Alvarado *et al*., 2012), control of microwave-assisted processes (Hernandez & Alvarado-Bawab, 2017), elaboration of new materials such as concrete blocks from plastic waste (Alvarado Bawab *et al*., 2018), production of bioplastics from the ñame (Alvarado Bawab *et al*., 2019), coal benefit processes with hydrocyclones (Alvarado Bawab *et al*., 2016) and storage of materials in biodegradable soft capsules (Cantillo Hernandez *et al*., 2021).

Environmental objectives might be achieved by different methodologies. In the following sections, circular economy is presented as a route most widespread and selected by many companies and government in the world that show the way to plan processes for creating and delivering products, components, and materials.

The circular economy includes the potential for economic growth and job creation, encouraging innovation, enhancing supply chain security and

building economic and environmental resilience. Beyond recognizing the evident importance of circularizing the processes in the industry and showing the success stories at the country, department and multinational level, it is necessary to investigate the aspects that limit undertaking actions in the common medium, small and micro companies. In this study, a survey was designed and applied to companies in Atlántico-Colombia with the aim of making a diagnostic and providing advice on circular economy activities.

2. Materials and methods

According to (Hernandez Sampieri, 2014) quantitative type research are those that "uses data collection to test hypotheses based on numerical measurements and statistical analysis to establish patterns of behavior and test theories". This research approach is effective in providing a comprehensive understanding of the phenomena under investigation and identifying correlations and relationships between variables. This research was framed in a quantitative of descriptive nature, which according to (Hernández Sampieri & Mendoza Torres, 2018), is defined as "descriptive studies aimed at specifying the properties, characteristics, and profiles of people, groups, communities, processes, objects, or any other phenomenon under analysis".

Taking into account those ideas, this research uses a quantitative and descriptive approach to analyze the existing business characteristics and their relationship to the circular economy and sustainability in the district of Barranquilla, located in the department of Atlántico, Colombia. The objective is to gain a comprehensive understanding of the industrial current state and identify opportunities for improvement. By collecting numerical data and conducting statistical analysis, to establish patterns of behavior and test existing theories to further advance knowledge and promote sustainable practices in the region.

The investigation aims to identify common elements, activities, and actors within this context, and the conclusions drawn from the research are intended to be generalizable. The information sources used in the research are primarily based on structured surveys with closed-ended questions. Interviewees were selected based on their company position considering their knowledge of the actions and institutional documents related to the management system that indicate the circularity of the products and services offered.

The department of Atlántico is a warm region located in northern Colombia, with an area of approximately 3,386 km^2 and a population of 2,535,517. It comprises 23 municipalities, with the city of Barranquilla as

its capital. According to the Superintendence of Residential Public Services, the department generates an average of 2,387 tons of solid waste per day (Mendoza *et al*., 2020). Energy consumption on the Caribbean coast of Colombia is approximately 15,000 GWh per year (Unidad de Planeación Minero Energética-UPME, 2022). Additionally, the city of Barranquilla and its metropolitan area produce an average of 648,000 m^3/month of water for domestic and industrial use (Camacol & Superservicios, 2022).

According to the database of the Chamber of Commerce of Barranquilla, 52,576 companies can be identified in Barranquilla (Camara de Comercio de Barranquilla, 2022). However, there is a lack of clear statistics on the practices implemented by these companies to reduce their environmental impact and optimize the use of resources, raw materials, and processes.

This project aims to conduct an analysis of the situation in the department of Atlántico, Colombia in relation to the implementation of the Circular Economy perspective, using data from the Eurobarometer survey. The goal of this analysis is to make a diagnosis of how companies in Atlántico-Colombia are evolving and adapting to a more sustainable production model. Through this research, we hope to encourage companies to transition from a linear production system to a more circular and sustainable one.

To achieve this goal, we will first attempt to identify the types of waste generated. Secondly, we will investigate the strategies, activities, documents, and records implemented by companies in accordance with the Circular Economy to optimize the use of products, processes, waste, water, and energy resources throughout their lifecycle. Finally, we will highlight the limitations faced in implementing Circular Economy activities and reducing environmental impact. The sample for this research will consist of 46 companies, including both micro and big-size enterprises, across the most important economic sectors, with a range of one to four hundred employees.

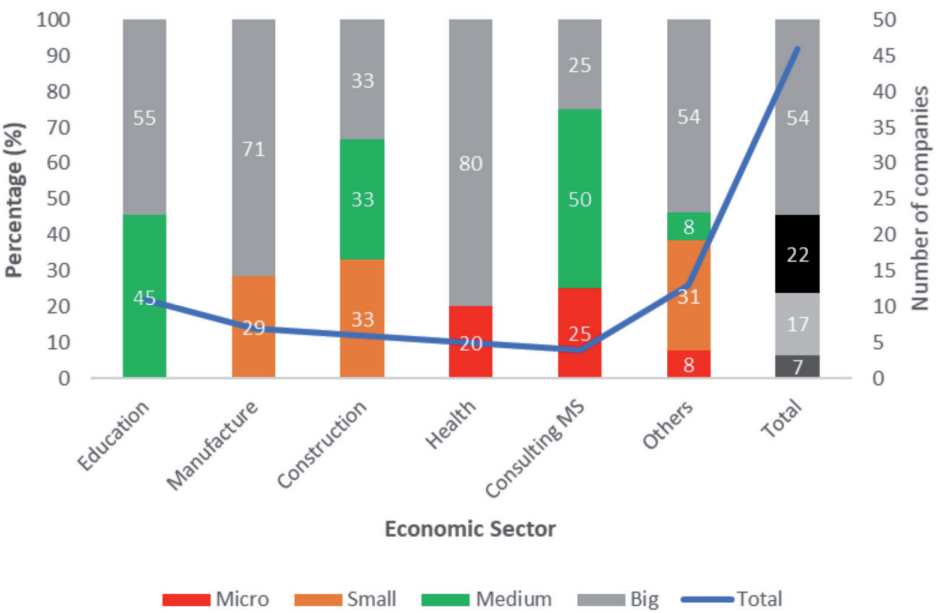
The companies were classified according to the second article of Law 590 of 2000 and Decree 2473 of 2010, which provide regulations to promote the development of micro, small, and medium-sized enterprises. The classification criteria are presented in Table 1 and are based on the number of employees and total assets measured by the legal monthly minimum salary (LMMS) (Ley 590 de 2000, 2000) (Decreto 2473 de 2010, 2010).

The 54% enterprises size participating were big, 22% medium, 17% small and 7% micro. The Figure 2 shows the companies size by each economic sector interviewed and the percentage of each sector participating in the study. In the other sectors category, Maintenance and Cleaning Services, Electricity, gas and water supply, Transportation, storage and communications, Sales, Agriculture, castle raising, hunting, forestry, fishing, Community, social and personal services, Food, Hotels and restaurants, Technology.

Table 1 - Criteria to classified enterprises

Enterprise size	Workers number	Total Assets (CLMMS)
Medium	51-200	5001-15000
Small	11-50	501-5001
Micro	1-10	0-501

Figure 2 - Companies size by each economic sector interviewed



Interviews were conducted with key decision-makers of companies via direct meeting and the methodology used is based on Eurobarometer surveys published in 2016 (European Commission, 2016).

The survey discussed earlier, focused on understanding the activities associated with the circular economy that are carried out by companies in the European Union, the types of actions they undertake, their financing processes related to this issue, government support and achievements obtained through the implementation of these initiatives. Similarly, this project's survey aims to investigate the documentation associated with environmental and organizational processes and resources that are saved in organizations.

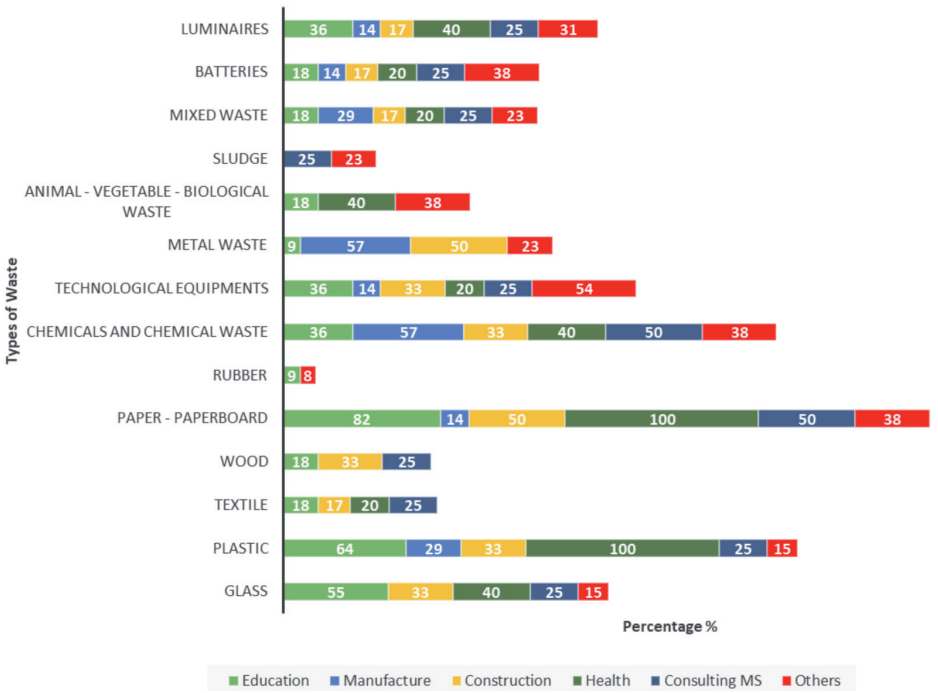
3. Results and discussion

In this section we present a diagnosis of the types of waste generated by economic sectors, this with the objective of knowing the business behavior with the generated waste, the type of savings that the management systems and registers related to the circular economy that supports the actions undertaken by companies around the circular economy. Finally, diagnose the situations that limit companies when undertaking circular economy activities.

This work seeks to diagnose the business perspective of the department of Atlántico regarding circular economy activities. It seeks to know the actions for the circular economy of companies in each sector, the waste generated, resources used and the management systems or methodologies implemented.

The key findings show that paper, paperboard, plastic, chemicals and chemical waste, technological equipment, glass and luminaries were the most residual material generating by companies. All of the health companies generate plastic and paper waste. 82% of education companies generate paper and 64% plastic and 55% glass waste. The main waste by manufacture industry were metal and chemicals around 57%. The Figure 3 show in details all the waste type generated by each economy sector companies.

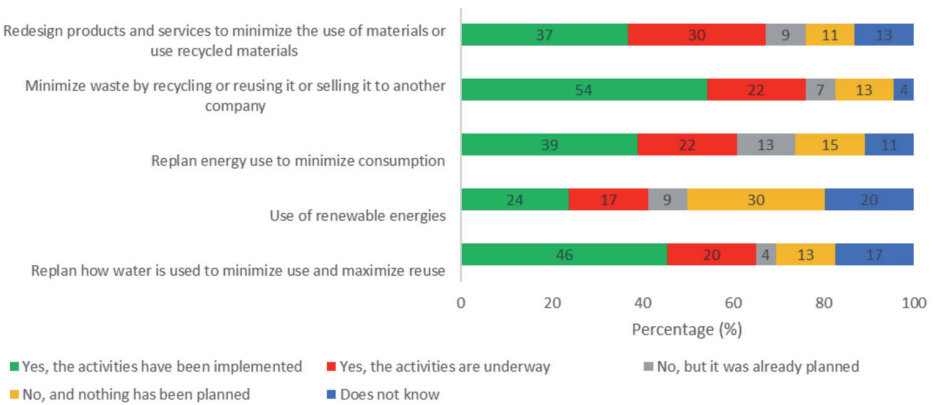
Figure 3 - Types of waste generated by economic sector



Regarding the analysis of waste generation, it was found that 95% of the waste from the textile sector in Colombia ends up in sanitary landfills, open dumps, soils, and bodies of water due to poor disposal. In addition, the cities that generate the most textile waste are Barranquilla and Bogotá, which dispose of this waste in their sanitary landfills (Quintero, 2022).

The key findings show that almost 18% of companies undertook some circular economy related activity with the most common being minimizing waste by recycling, reusing or selling to another company (25%), or re-planning energy use to reduce consumption (21%). This results correspond to the activities involved companies in European as report the Eurobarometer survey with the different that almost the 73% of companies undertook any activity there (European Commission, 2016). Companies' implementation state of some activities according to circular economy in Atlántico-Colombia are presenting in Figure 4.

Figure 4 - Companies' implementation state of some activities according to circular economy in Atlántico-Colombia



Looking at the activities in more details shows 67% of companies mention redesign products and services to minimize the use of materials or use recycled materials: 37% have already implemented this kind of measure, while 30% are in process of doing so. Around one in eight companies do not do this now, but around one in ten plan to do so in future, while 11% have no plans to do so in the future. The increase in waste and disposal, and remediation services would help to reduce unemployment, as was identified in Mexico where 44 jobs are directly generated per million dollars of production from waste and disposal; Likewise, it is estimated that this leads

to an increase of 1.1% in production with respect to the GDP in Colombia (Cempre, 2021).

Just over a half of companies have minimized waste by recycling or reusing waste or selling it another company. 22% have already underway any activity, while 7% plan to do. 13% have no plans to do so. According to a survey carried out by the Global Reporting Initiative – GRI – in 2018, regardless of their degree of progress between aspect management and impact mitigation, 81% of companies report recycling, taking advantage of or managing their solid waste. The companies have practices mainly of separation at the source and delivery to authorized waste managers depending on the type of waste (plastics, paper, hazardous, construction, electrical and electronic) so that the managers can recover the material or dispose of it in accordance with the applicable legislation. None of the company's report reintegrating their waste as raw materials for their process, by-products or other processes within the organization; and only 8% report making changes to materials to reduce environmental aspects such as the consumption of raw materials and environmental impacts such as the generation of solid waste (Giraldo-Bermúdez, 2020).

Almost 39% of companies re-planned energy usage to minimize consumption while 24% are at least using renewable energy. 22% have already started doing this, while 13% are in the process of doing so. 28% have no plans to do so or do not know. 17% are underway of using renewable energies and 9% have already planned to do so. A half of companies have no planned or not plan to do so in the future. Colombia relies largely on hydropower (about 78.29% in 2017), which offers cost-effective and sustainable electricity. Colombia possesses tremendous potential for nonconventional energy sources, including biomass, wind, and solar. Moreover, numerous places in Colombia offer great wind generating capabilities in South America. In particular, the northern Colombian region is divided into winds of class 7 (above 10 m/s). But to take advantage of this potential, investment in these energy sources is necessary but it requires sustainable energy policies and political desire to make this possible (Awosusi *et al.*, 2022). Unfortunately, Colombia still uses fossil fuel in its energy mix, thereby promoting emissions and deteriorating the environment. The benefits of renewable energy sources are enormous. Such as stimulating environmental conservation and supporting sustainable growth (Adebayo & Kirikkaleli, 2021).

At least 66% of companies have re-planned the way water is used to minimize usage and maximize re-usage; 46% have already implemented this kind of activity, while 20% say such re-planning activities are underway. A further 4% plan to address their water usage in this way, while 30% have no plans to do so. Similar studies report that of the companies that

consume water, 29% carry out wastewater treatment, 13% recirculate the used water, however, they do not use it for their production process but for irrigation or sanitation, 8% reduce their water consumption by collecting rainwater, likewise not incorporating it into their production process but in other activities (except hydroelectric) and 4% measure their consumption associated with production (directly associated with their product, inputs and raw materials) through of the water footprint methodology (Giraldo-Bermúdez, 2020).

Beyond these actions, a growing body of literature report the failure of efficiency measures to conserve energy and resources in the current socio-economic environment. The manufacturers that implement energy, water and material efficiency measures can qualify as a top-performing "circularity developer" according to the published self-assessment questionnaire, it retained its linear business model; Similarly, it can resulted in a short-term and long-term rebound effect or backfire for being a system focused exclusively on efficiency was incapable of conserving resource use and delivering on Circular Economy decoupling promise (Konash & Nasr, 2022).

Looking by the documents and register designed and implemented by companies around de circular economy and management system, the survey results were presented in the Figure 5.

The 42% of the companies have at least one document required by the quality, security, safe or environmental management system. Almost three quarters of companies have an Occupational Health and Safety Management System (74%), are results is expected due to in Colombia it is a decree 1072 of 2015 and resolution 0312 of 2019 mandatory law. The 59% of companies have a Quality Management System, most of the time based on the ISO 9001. Furthermore, the 39% have an Environmental Management System. 17% of construction and 9% of education companies do not have any management system. However, the indicator of depletion of natural resources in the country is 211% higher than the countries of the Organization for Economic Cooperation and Development – OECD – compared to gross income in 2014 (Giraldo-Bermúdez, 2020).

By each economy type sector, most of the consulting in Management Services companies (100%) have an Occupational Health and Safety Management System, the set of others (92%), construction (83%), the Manufacture (71%), education (55%) and health (40%). Although most companies have an Occupational Health and Safety Management System, they are incomplete. the above, because only 42% have an Environmental Policy, 36% have Hazardous waste procedures, 34% have Waste Management Processes and 33% have a Corporate Social Responsibility Policy.

Figure 5 - Documents and register designed and implemented by companies around de circular economy and management system

None of the interviewed companies in the construction sector has Environmental Policy, Corporate Social Responsibility Policy, Waste Management Processes or Recycling Incentives.

In regard to companies with a Quality Management System by economy sector, the consulting in Management Services companies (75%) have this, 71% of the Manufacture companies, the set of others (62%), education (55%), construction (50%) and health (40%). Companies with an Environmental Management System constructed and implemented in Manufacture industry were the 71%, 54% by the set of others, 45% of the education companies, 25% of the consulting in Management Services companies, 20% of health and 17% of the construction companies.

One of the important activities undertaken by circular economy are the programs that try to save supplies, for this reason, companies interviewed were asked about that. The set of companies grouped as others, were the sector that save more supplies than the others economy sector taking into account in this study. One in two manufacture industry save at least one type of supply. On the other hand, one in five construction companies save at least one type of supply. One quarter of companies in average do not make any kind of savings.

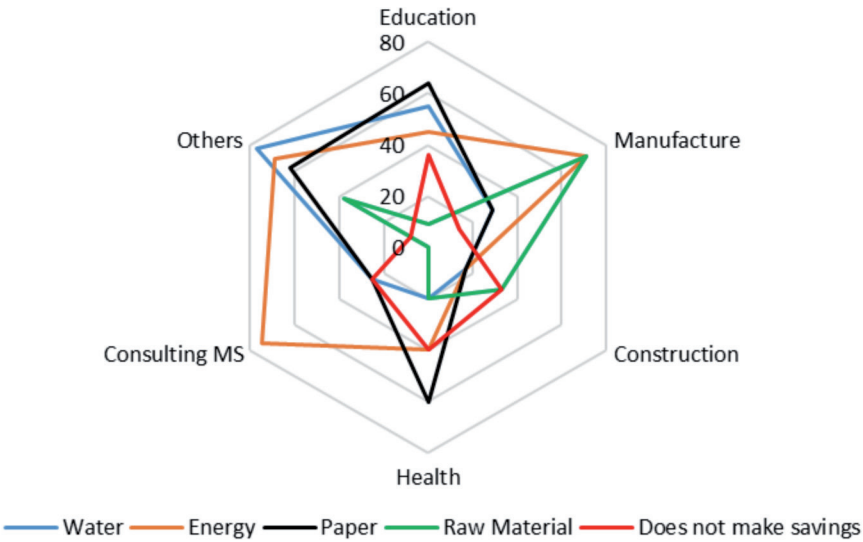
Energy is the most saved supplies by companies (53%); energy is saved by the 75% of consulting MS companies, 71% of manufacture industries and 69% of the set of companies grouped in others. Education (45%), health (40%) and construction (17%) are the economic sectors that less saved energy (Figure 6).

The less supply saved by companies were raw materials using in their productive process (38%). Most of Manufacture companies saved raw materials (71%), one in third construction companies, one in five health companies and one in ten of education companies saved this (Figure 6).

Paper were the supply more saved by education (64%), the set of others (62%) and health (60%) sectors, construction were the sector companies that less save paper (17%). The set of others (77%) and education (55%) were the companies' economy sector which the most saved water. Almost one third of manufacture companies save paper and water (29%), and one quarter of consulting MS save paper and water (25%) (Figure 6).

Although management systems are applied and the Atlántico industry shows its interest in these issues, the literature report that the key limitations are related to: lack of a holistic structure with systematization of practices, focus on single innovation stages, lack of analytical and decision-support structures, and marginal consideration of institutional and strategic aspects, as well as interdependencies with other business processes (Pieroni *et al.*, 2021).

Figure 6 - Type of resources savings by companies



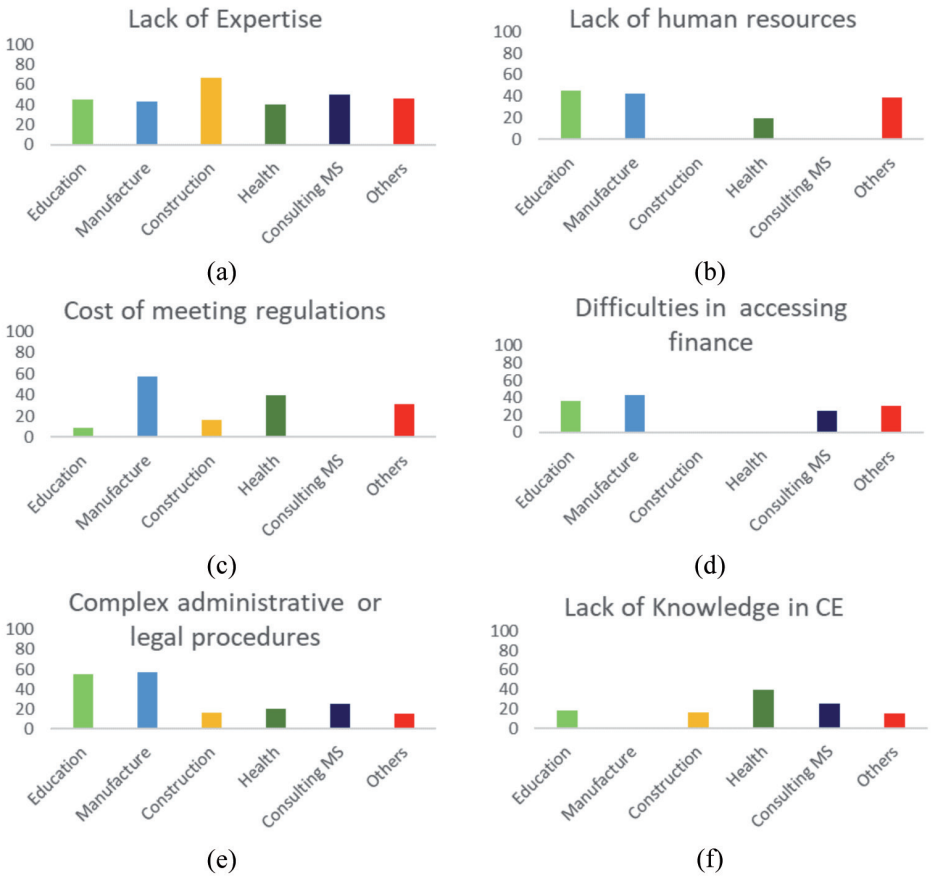
For these reason, systematic process model for Circular Economy business model innovation developed for manufactured companies contains four stages (prepare, sense, seize and transform) with recommendations of institutional, strategic and operational practices (including activities, tools, interdependencies, decision gates, and recommended mindset and attitudes) (Pieroni *et al.*, 2021).

MATChE, is other model, but it is a web-based platform enables a self-assessment of manufacturing companies' readiness to transition to Circular Economy. In addition, allow the understanding of strengths and gaps for Circular Economy implementation across eight key dimensions (e.g. strategy and business model innovation), the tool enables internal and external benchmarking studies (at the company or business unit levels); the prioritization of focus areas based on strategic drivers; and the development of transition paths with support of Circular Economy-related tools, methods and approaches (Pigosso & McAloone, 2021). As a future, we pretend like MATChE, to develop a method to apply circular economy in the departamento del Atlántico considering social and environmental aspect to ensure the success.

Regarding the limitations to undertake circular economy activities, the interviewees mentioned as shows in Figure 7.

For companies, the most mentioned issues to make activities related to the circular economy encountered were due to lack of expertise (48%),

Figure 7 - Limited aspect to undertake circular economy activities



complex administrative or legal procedures (33%), lack of human resources (30%), difficulties accessing finance (26%), costs of meeting regulations (26%) and lack of knowledge in Circular Economy (17%). Similar results find a study where the main barrier regarding the industrial adoption is its financial viability (Prosman & Cagliano, 2022). Comparing with the findings in European companies, it shows that the lack of expertise is not a problem there, then it is necessary to invest in educational program around the circular economy. The amongst companies that answer the others limited reason to undertake activities related are the same (European Commission., 2016). The pharmaceutical industry not only acknowledges the regulation gaps as a limitation but also introduce the intellectual property ownership issues (Ang *et al*., 2021). This fear of losing product ownership was reported

as a barrier when including stakeholder partnerships and collaboration in the circular economy processes of the manufacturing industry (Garza-Reyes *et al*., 2019).

Additive manufacturing is one of the technologies proposed for driving the shift to Industry 4.0 through a transition reconfigures the supply chain to achieve the ideal circular economy along with improved resource efficiency. With this technology the role of the customer and the maturity of the technology are considering cornerstones. Five key clusters that need to be considered when implementing Additive Manufacturing at contingency analysis phase are: (1) supply chain actors, (2) drivers, (3) key Additive Manufacturing decisions, (4) Circular Economy implementation strategies and (5) operational practices (Hettiarachchi *et al*., 2022). Moreover, government and corporate policies can drive by introducing incentive schemes to support recycled material suppliers while encouraging R&D to invent novel recycling methods supporting Circular Economy (Sun *et al*., 2020).

One of the possible limited reasons why the construction and health sector considers the difficulties in accessing financing may be due to the fact that the government, in order to encourage some sectors, restrict others from participating in calls and banks loans. Likewise, the low participation in these funding calls is complemented by the complex administrative and legal procedures that most of the type of companies selected. Several external and internal barriers in many sectors had been identified to achieve the market penetration of circular economy business models, ranging from technical and non-technical. External barriers, such as customers' preferences for 'new' products, regulatory restrictions, or lack of infrastructure, are extremely relevant. Organizational barriers related to a hesitant culture or limited awareness information, and competencies are considered by executives equally or even more pressing than external barriers (Pieroni *et al*., 2021).

Something similar had been published in a work carried out in 2019 for medium-sized companies in Barranquilla, where an absence of organizational culture, risks associated with recycling activity, and non-compliance with the formalization stages were reported (Oyaga Martínez *et al*., 2021). A study developed in a Colombian construction sector enterprise that used the methodology proposed by Jaca and colleagues to implement the Circular Economy in Small and medium enterprises found five drivers are relevant: fertile ecosystem, management commitment, identification of valuable materials, green teams, and Circular Economy intermediaries (Torres-Guevara *et al*., 2021).

Other study in Colombia and to identify the main interventions that are required to support a transition towards a more circular economy shows that it does not yet have the right enabling conditions for a Circular Economy.

Several opportunities are identified: greater political coherence; a suitable fiscal framework for sustainable practices; a robust Information Tecnology infrastructure; and use of Information and Comunication Technology by enterprises to develop Circular Economy business models. Moreover, a safe and profitable recovery of materials requires enhancing current practices of recycling. Finally, it is important to promote financing schemes and to develop design-led approaches to production among the industrial sector to foster innovation as a key building block of a Circular Economy as well as educational and raising awareness initiatives to support a mind-set shift. The findings of this work are specific to Colombia but have relevance for Circular Economy transitions in other low and middle-income economies (Garcia & Steve, 2019).

4. Conclusions

The study allows developing opportunities to improve and implement circular economy policies for small and medium-sized companies. It shows that the companies of the Department of Atlántico-Colombia want to apply circular economy and sustainable development activities; however, it is necessary for government entities to further socialize the administrative and legal processes to execute circular economy activities.

Most of the companies concentrate their activities on the proper disposal of waste and campaigns to save water and energy, but do not apply strategies for changing raw materials or reducing their consumption, as well as the implementation of renewable technologies for the generation of energy and reincorporation of wastewater into processes. It is worrying that some companies do not seek or do not plan in the immediate future to apply clean technologies and improve processes, and much of this is due to the fact that they do not have financial support and experienced trained personnel for their implementation strategies.

As future work, it is intended to propose a circular economy methodology relevant to the dynamics, culture and socioeconomic aspects of agri-food companies in the department of Atlántico. For this, some successful circular economy methodologies in the international context will first be selected, then companies will be characterized and selected to implement them by a public announcement. Finally, the results obtained will serve to identify the strengths and weaknesses of each applied methodology that will allow us to design one that is capable of overcoming the obstacles found in the region.

In this study, an investigation will be conducted to assess and offer recommendations for the circular economy in the agri-food sector of the department of Atlántico in Colombia. The following steps will be taken:

(1) a review of the current state of circular economy methodologies, (2) comparison of the methodologies using established indicators to highlight the strengths and weaknesses of each, leading to the selection of methodologies to be applied in the case studies of agri-food sector companies, (3) design and implementation of measurement tools to characterize the participating companies, (4) training of technical and managerial staff on the chosen methodologies, with selection of those responsible for execution, and (5) collection of continuous qualitative and quantitative information during implementation for statistical analysis, leading to conclusions and the development of an adapted methodology for the departmental context.

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