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Sommario

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Editorial

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We are happy to introduce the inaugural issue of volume 25 of our journal. This issue contains two regular articles and seven special issue articles, all of them are written in English and have undergone double-blind peer-review to ensure the highest quality. The articles mainly cover issues related to preferences for functional food, contract farming, sustainability and circular economy.

The scope of the analysis is mainly local or national, covering geographical areas in Europe (Italy), South America (Colombia), and Asia (Indonesia).

The authors are affiliated with Institutions based in Italy, Colombia, Japan, and Indonesia.

The regular article "Healthy food consumption in the Covid-19 era: Empirical evidence from Italian consumers choices on functional products" by Dell'Unto, Meccariello, and Cortignani investigates the impact of the Covid-19 pandemic on the consumption of high-amylose soft wheat flour confectionery products (HACPs) in Italy. The study collected data from 312 Italian consumers through a survey and analyzed the factors that influence the consumption of functional foods during the pandemic using logistic regression analysis. Results show that two-thirds of respondents were willing

to pay a premium price for the functional product. The analysis of the Binary Logit model revealed that factors such as age, level of family income, satisfaction with family income during the pandemic, habit of purchasing food products on e-commerce channels, adoption of healthy eating styles, and belief that functional foods can improve well-being positively influence the perceived value of the functional properties. Conversely, family size, presence of dependent members, and high frequency of physical activity affect perceived value negatively. The authors suggest that these findings could help the food industry in Italy to identify market segments and target marketing strategies towards specific groups of consumers.

The second regular article, "Impact of Contract Farming on the Technical Efficiency of Broiler Farmers in Indonesia", by Rokhani, Mohammad Rondhi, Ebban Bagus Kuntadi, Anik Suwandari, Rizky Yanuarti, Ahmad Fatikhul Khasan, Yasuhiro Mori, and Takumi Kondo, investigates the impact of contract farming on the technical efficiency of broiler farmers in Indonesia. The study collected data from 94 broiler farmers, including 47 contract farmers and 47 independent farmers, and used stochastic frontier analysis to measure technical efficiency. The study found that contract farmers had higher technical efficiency than independent farmers and that the use of hybrid chickens and vaccines positively influenced technical efficiency. The study suggests that contract farming can improve the livelihoods of smallholder broiler farmers in Indonesia by providing them with technical assistance, better inputs, and market access.

The following part of the issue features a selection of articles presented during the "International Congress on Economics, Sustainability, and Circular Economy" held in August 2022 in Montería, Colombia. The congress was focused on sustainable and circular agriculture to promote interdisciplinary discussions and alternative approaches to global rural development. It featured two thematic areas: "sustainable agricultural technologies and innovation" and "economics and agroecology." The congress aimed to bring together researchers from various fields, including social sciences, engineering, and basic sciences, to discuss and propose scientific explanations for contemporary global changes.

The guest editors Rubén Darío Sepúlveda Vargas, Diego Alejandro Camargo Trillos, Deivi David Fuentes Doria, Carlos Eduardo Maldonado Castañeda, made a first selection of papers they deemed suitable for publication in *Economia agro-alimentare/Food Economy* and, with the support of Valeria Borsellino and Alessandro Palmieri, managed the standard review process required by the journal. The Guest Editorial "Bioeconomics and its Derivations: Ecological Economics and Political

Ecology" opens and introduces the Special Issue. We are happy to host these contributions, seven thematically based research papers dealing with issues such as floods, soil, and water and waste management. Five papers view these issues within the context of rural sustainable development, while one focuses on urban development and on the circular entrepreneurial economy. The seven paper deals with migration from the countryside.

Since 2011, we have made it a tradition to change some members of the Scientific Advisory Board (SAB) to provide more opportunities for the scientific advancement of our journal's community of practice. We extend our heartfelt gratitude to the SAB members who left the Board at the end of 2022, namely Riccardo Scarpa, Rodolfo M. Nayga, Dominique Barjolle, Livia Madureira, Nadhem Mtimet, and Nicola Cantore, for their invaluable service in the past years. We appreciate the excellent scholarly contributions of all SAB members and are grateful for their assistance in reviewing, suggesting reviewers, and evaluating papers for the "Best Paper Award" in the previous year.

The updated list of 48 Scientific Advisory Board (SAB) members for the year 2023 is available in the journal's front matter and on the journal's website https://economiaagroalimentare.it, and we are delighted to welcome the new members who will assist us in maintaining the journal's international character. Our current SAB comprises scholars from various institutions in Italy (13), USA (7), Germany and the UK (4), France and Greece (3), Brazil (2), Albania, Australia, Austria, Belgium, Hungary, the Netherlands, Norway, Poland, the Republic of Korea, and Sweden (1), as well as 2 international institutions. The Editor-in-Chief and the Editorial Board warmly welcome the new members and look forward to collaborating with all the SAB members.

There have been no changes to the Editorial Board of the journal. We want to take this opportunity to express our gratitude to the SIEA Presidential Board for renewing their trust in us. We are grateful for the continued support of the scholarly community represented by SIEA, and we commit ourselves to maintain the highest standards of academic excellence in all our editorial decisions.

We acknowledge the ongoing support of our community of authors, reviewers, and readers, for their contribution to the success of our journal. Specifically, we are grateful for the invaluable contributions of the reviewers, who play an essential role in ensuring the quality and relevance of the manuscripts we publish. Their insightful feedback and expertise are highly appreciated.

Finally, we would like to express our sincere gratitude to the staff of FrancoAngeli Edizioni for their excellent work in editing and publishing the journal. Their dedication to maintaining the high standards of our publication is remarkable, and we look forward to collaborating with them in the coming year.

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Healthy food consumption in the Covid-19 era: Empirical evidence from Italian consumers choices on functional products

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Abstract

This study provides an explorative analysis of the potential appreciation manifested by 312 Italian consumers for functional confectionery products, obtained from high-amylose soft wheat flours (high-amylose confectionery products, HACPs). An online questionnaire was administered in 2021, which assessed respondents' willingness to pay (WTP) a premium price for HACPs with respect to non-functional confectionery products. Detailed information about respondents and their families was collected and put in relation with the willingness, or not, to pay a premium price for HACPs through a Binary Logit model. Two thirds of respondents were willing to pay a premium price for HACPs, that stood at +12.3%. Analysis of the results of the Binary Logit model led to highlight that respondents' WTP for HACPs is positively influenced by age, level of family income, satisfaction with the latter during the COVID-19 pandemic, habit to purchase food products on e-commerce channels, adoption of healthy eating styles and belief that functional foods can contribute to improve well-being. At the opposite, respondents' WTP is negatively influenced by family size, presence of dependent members and, interestingly, habit to practice physical activity with high frequency. Based on these findings, useful insights also in support of confectionery industry and commercial distribution are finally reported.

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Introduction

Functional foods (FFs) have been recently defined by the Functional Foods Center as "natural or processed foods that contain biologically-active compounds, which, in defined, effective, non-toxic amounts, provide a clinically proven and documented health benefit utilizing specific biomarkers, to promote optimal health, reduce the risk of chronic/viral diseases and manage their symptoms" (Martirosyan *et al.*, 2021). Therefore, FFs are foods of common use, capable of bringing beneficial effects beyond the basic nutrition, in the quantities that are normally expected to be consumed with daily diet (Diplock *et al.*, 1999).

FFs represent a rapidly growing segment in the global food market, which reached the value of $180.59 billion in 2021, and is projected to grow up to $223.95 billion in 2026, at a compound annual growth rate (CAGR) of 4.4% (The Business Research Company, 2022). Market demand of FFs has expanded over the last decades in parallel with consumers awareness about the strong link between health and diet (Siró *et al.*, 2008). The outbreak of COVID-19 pandemic in 2020 boosted this trend, modifying consumers attitudes towards health and wellness, what allows to forecast a further positive impact on the global market of FFs in the next years (KBV Research, 2021). In any case, even before the pandemic, this rising awareness had already contributed to the considerable lengthening of life expectancy in developed Countries. This characterizes in first place the elderly, more concerned with their health and attentive to the health implications of diet (Siegrist *et al.*, 2008), willing to improve their life quality also consuming FFs (Roberfroid, 2000; Gibson and Williams, 2000). In turn, the progressive aging of population increases the incidence of chronic diseases, that can be prevented through a healthy lifestyle and diet, of which FFs are increasingly part (Jew *et al.*, 2009; Barauskaite *et al.*, 2018). In any case, the interest in FFs is also growing among young people, who are motivated in the consumption of healthy foods, containing natural ingredients, useful also for body weight control (Vorage *et al.*, 2020); additionally, young people are characterized by a positive attitude towards food innovations (Tuorila *et al.*, 2001; Jeżewska-Zychowicz, 2009; Bruschi *et al.*, 2015; Kraus *et al.*, 2017). Food industry is constantly committed in widening market offer of FFs, attracted by the strong expansion of demand and the high consumers Willingness To Pay (WTP) for these products (Khan *et al.*, 2014; Moro *et al.*, 2015). However, a frequent failure of new FFs in the attempt to establish on the market was evidenced (Saguy and Moskowitz, 1999; Moskowitz *et al.*, 2009). Many others have a short life cycle, at the point that half of the profits of the food industry comes from products that are withdrawn within the first two-five years (Stein and Rodriguez-Cerezo, 2008; Moskowitz *et*

al., 2009). Probably, this is in part due to an excessive attention paid to the technical feasibility of industrial production processes, which often leads to neglect consumers needs and preferences (Van Kleef *et al*., 2005; Bleiel, 2010). In other cases, as reported by Alongi and Anese (2021) in their extensive review on FFs development, a mismatch between FFs features and consumers expectations could occur. This is consequent to an imbalance in product development, more focused on intrinsic product features (relating to nutritional aspects), than on extrinsic attributes (relating to the way in which products are presented to consumers), what makes it necessary to settle effective communication strategies. Economic research has undertaken efforts to identify the most influent characteristics of FFs, and of their potential consumers, on willingness to purchase and pay for these products, also with the aim of supporting food industry and commercial distribution in developing a market offer of FFs appreciated by consumers. With reference to WTP, Plasek and Temesi (2019) reviewed the most common survey methodologies (experimental auctions, contingent evaluation, choice experiment, in-person and online survey), and then identified the most influent factors on it. These appeared related to consumers demographic characteristics, label specification of health claims, trust in FFs and in their production technologies, prior knowledge of the products or their ingredients and common perception of the combination between the type of staple food and claimed functional properties. However, there are still few empirical studies, like the present explorative analysis, that outline the attitudes of Italian consumers towards FFs, since many of the existing ones have been conducted in the United States and in other European countries (Bentivoglio *et al*., 2021).

This study provides an explorative analysis to evaluate the potential appreciation of Italian consumers for a particular typology of FFs, i.e., functional confectionery products, obtained with flours from a soft wheat line with high-amylose starch (hereinafter, HACPs). Within the global market of FFs, the sub-segment of functional confectionery products is still very narrow, as it reached a value of $1.8 billion in 2021 (1% of the total value of FFs market), despite over a decade of steady growth; however, it is forecasted to grow at a CAGR of 9.1% in the period 2022-2029, more than double that expected for the market of FFs as a whole, and to reach a value of $2.98 billion by 2029 (Data Bridge Market Research, 2022). With reference to the Italian context, recent market research by Euromonitor International (2022) has evidenced how people, also under the pressure of COVID-19 pandemic, are orienting towards healthier food options mainly represented by FFs, even for staple breakfast food and snacks. At least in part, this could overturn the reluctance that Italian consumers have always manifested towards FFs. The latter is evidenced by the fact that, still few years ago, Italy accounted

for only 11% of the Western-European market of FFs (Vicentini *et al*., 2016). This has always been related to peculiarities in culture and food traditions (Castellini *et al*., 2002; Annunziata and Vecchio, 2011), frequently healthier in themselves than those adopted in other Countries, as well as to an underestimation of the health benefits achievable from FFs (Van Trijp and Van der Lans, 2007). With specific reference to HACPs, a WTP analysis is even more interesting, since confectionery products are intrinsically less healthy than others (e.g., yogurt, cereals and fruit juices), and they could be seen less credible as FFs, negatively affecting willingness to buy and to pay (Ares and Gámbaro, 2007; Annunziata and Vecchio, 2011; Siegrist *et al*., 2015).This appears with evidence when considering the level of WTP for HACPs quantified in this study, much lower than that expressed for other FFs, object of similar studies, commonly deemed to be healthier. For instance, in face of an average premium price of +8% for HACPs, Palmieri *et al.* (2021) detected through an online questionnaire a WTP up to +50% (or more), on average, for functional pasta featuring prickly pear, with respect to the price of conventional pasta. Again, Palmieri *et al.* (2022) found that 75% of respondents to an online questionnaire were willing to pay a premium price up to +50% (or more) for functional eggs enriched with Omega-3, with respect to the price of conventional eggs. Vecchio *et al*. (2016), conducting an experimental auction, highlighted a WTP of +36.5% for functional yogurt with respect to conventional yogurt (whether additional information was provided to consumers about its properties). Similarly, Moro *et al*. (2015), through a stated choice experiment, evidenced an average premium price of +42% for a yogurt enriched with Catechins, with respect to conventional yogurt.

In order to evaluate WTP for HACPs, an online questionnaire was disseminated. The latter detected essential information on personal and family characteristics, economic and social conditions, lifestyle, health state and attitudes of purchase and consumption of respondents. The variables obtained from the questionnaire were used to estimate a Binary Logit model, allowing to evaluate their influence on WTP for HACPs. On the one hand, the findings from this study will support the confectionery industry in developing HACPs that effectively meet consumer needs; on the other, they will provide useful insights to distribution operators for marketing strategies aimed to ensure adequate commercial feedback to these products.

1. Materials and methods

1.1. *Characteristics of the soft wheat genotype and of the confectionery products*

HACPs will be obtained from flours of a non-transgenic soft wheat line with high amylose starch (Patent numbers: US20140212567, EP20120195780). Confectionery industry is currently developing production protocols that will make it possible to obtain different types of HACPs like biscuits, croissants, plum cake and muffins with a similar taste to non-functional ones, but potentially able to bring all the benefits associated with the high-amylose content. The latter improves resistance of starch to digestion, with positive effects on glycemic indices and benefits for the digestive system (Newberry *et al*., 2018). In their extensive review, Bird and Regina (2018) put in evidence that the high content of amylose, and consequently of resistant starch, could contribute to reduce the risk of developing diseases such as type II diabetes, cardiovascular disease and colon cancer.

1.2. *Questionnaire: structure, dissemination and variables obtained*

The questionnaire assessed respondents' appreciation for HACPs quantifying their willingness to pay a premium price over the basic price of non-functional confectionery products (biscuits, croissants, plum cake and muffins). Respondents involved were adults (over 18 years old) and were asked to choose a single premium price level among the proposed ones, jointly considering all product types.

Opting for online dissemination was necessary, due to the restrictions in force to face COVID-19 pandemic in the six months during which the questionnaire was administered (March-September 2021). Despite the loss of representativeness towards population (the next paragraph assesses some corrective actions put in place to overcome this limitation), the online method proves effective for collecting a high number of answers and a wide variety of information in a relatively short time (McCullough, 1998).

First, a brief introduction specified the aims of the research, provided respondents with the main information on HACPs and the potential health benefits obtainable from their regular consumption, in place of non-functional confectionery products.

Then a total of 28 questions were proposed, all with mandatory answer and with different types of answering (single choice between two or more options, multiple choice, ordinal scale choice, free answer in numerical or text format), organized into five distinct sections, as specified below.

- Section 1 (1 question): information on the frequency of consumption of non-functional confectionery products (biscuits, croissants, plum cake and muffins).
- Section 2 (3 questions): level of the premium price willed to pay for HACPs, i.e., no premium, +5%, +10%, +20%, +30%, +50% over the basic price range of non-functional confectionery products (2.40-4.00 €, assessed through direct surveys in the large-scale retail trade), and certainty level about the choice (sure, fairly sure, uncertain).
- Section 3 (12 questions): basic information on respondent and his/her household (age, gender, territorial area of residence in Italy, level of education[1], working condition, composition of the family unit, title of possession of the main home, family economic conditions and level of satisfaction with the latter).
- Section 4 (6 questions): information on respondent's lifestyle and health state (adoption of alternative diet, frequency of physical activity, presence of diet-related disorders and diseases, or other disorders and diseases).
- Section 5 (6 questions): information on food purchase and consumption habits (responsible for food shopping in the family, main channel of food purchase, meals eaten during the day, benefits deemed to be achieved from FFs, frequency of consumption of FFs, reasons for consumption of FFs).

A first draft of the questionnaire was personally disseminated to 30 respondents with different age, gender, level of education, working condition and income, to carry out a pilot test (complying with the privacy legislation, these answers were not considered in the analysis, since not anonymously collected). The final version of the questionnaire was shared for anonymous answer on the Microsoft Office Forms platform. Questionnaire answer was advertised by word of mouth and via social media, also through paid ads. The dissemination phase ended in September 2021) and yielded 312 valid answers.

Table 1 reports in detail the variables obtained from the questionnaire, also specifying their type and range of variation.

1. With reference to this aspect, it was opted for not considering BSc in the same way as MSc, since questionnaire answer was initially advertised by word of mouth also in the university setting; thus, almost all who declared to held a BSc were actually students attending MSc courses.

Table 1 - Variables obtained from the questionnaire

Variable description	Variable type	Variable range
Willingness to pay a premium price for HACPs and certainty level		
Willingness to pay a premium price	Ordinal	6 levels from 0% to +50%
Choice certainty level	Ordinal	3 levels from 1 (uncertain) to 3 (sure)
Personal information and other general characteristics		
Gender: female	Binary	1, yes; 0, no
Age	Discrete	≥ 18 years
Level of education: MSc and above	Binary	1, yes; 0, no
Working condition: permanent employees/retirees	Binary	1, yes; 0, no
Characteristics of family unit and satisfaction about income		
Number of family members	Discrete	>0
Presence of dependent family members	Binary	1, yes; 0, no
Number of dependent family members	Discrete	≥0
Full ownership of family home (no mortgage)	Binary	1, yes; 0, no
Family yearly income level	Ordinal	1 (<15,000 €) – 5 (>60,000 €)
Satisfaction about family income (COVID-19 effect)	Ordinal	1 (not at all satisfied) – 4 (fully satisfied)
Lifestyle and health state		
Adoption of healthy eating styles	Binary	1, yes; 0, no
Frequency of physical activity	Ordinal	1 (never) – 5 (daily)
Suffering from diet-related disorders/diseases	Binary	1, yes; 0, no
Suffering from other disorders/diseases	Binary	1, yes; 0, no
Food purchase and consumption habits		
Channel of food purchase: traditional shopping	Binary	1, yes; 0, no
Channel of food purchase: e-commerce	Binary	1, yes; 0, no
Consumption of confectionery products	Index	0.2 (never) – 1 (daily)
Consumption of FFs	Index	0.2 (never) – 1 (daily)
Benefits obtainable from consumption of FFs		
Well-being	Binary	1, yes; 0, no
Protection against severe diseases	Binary	1, yes; 0, no
Protection against food disorders	Binary	1, yes; 0, no
Motivations for consumption of FFs		
Attracted by advertising	Binary	1, yes; 0, no
Attracted by label indications	Binary	1, yes; 0, no
Experiencing health benefits	Binary	1, yes; 0, no
Experiencing pleasure	Binary	1, yes; 0, no
Preventing health problems	Binary	1, yes; 0, no
Other motivations	Binary	1, yes; 0, no

More than half of the variables obtained were binary (dummies), widely used to deal with qualitative traits. Others were discrete, like those related to some characteristics of respondents and of their families. The ordinal variables allowed to assess on an ordered scale respondents' WTP and certainty level, economic conditions and frequency of physical activity. Finally, frequency of consumption of confectionery products and FFs was quantified computing two indexes, in which frequencies of consumption of all the different product types (expressed by respondents on a five-level ordered scale) were jointly considered in a weighted average.

1.3. *Representativeness of respondents towards population*

The degree of representativeness of respondents towards the characteristics of Italian population, as described by the National Institute of Statistics (ISTAT), was gradually checked during the dissemination phase. The reference datasets are contained in the I. Stat database (http://dati.istat.it/), annually updated by ISTAT until 2020. The database provides information about Italian population and families, aspects of citizens' daily life and their opinion regarding various aspects of life. The three-year period 2017-2019 was considered as a reference, since the 2020 data were not yet available in all the datasets. Data referred to 2020 were instead considered to compare respondents' satisfaction about family economic conditions, since in the questionnaire it was specifically asked to express the satisfaction in the previous 12 months, thus referring to the year 2020, in which COVID-19 pandemic broke out. Divergences of respondents' characteristics from population were gradually smoothed by creating paid ads on social media, which advertised questionnaire answer to the least represented slices of the population for age, gender and level of education. However, as better specified in §2.1, the way in which questionnaire was disseminated (online) and its answer advertised, together with the relatively limited number of answers obtained and the concentration of respondents in central Italy, do not allow to generalize results to the whole Italian population. In any case, the good degree of similarity of respondents' characteristics with the population allow to provide useful insights to be confirmed with further analyses at a larger scale.

1.4. *Specification of the econometric model*

In order to identify respondents' characteristics that most affect their willingness, or not, to pay a premium price for HACPs, quantifying their impact, a Binary Logit model was estimated. Binary Logit models are

appropriate to use when the dependent variable (response) is expressed in a binary form, assuming one of only two possible states, like the presence or absence of an attribute of interest (Rodríguez, 2007): in this case the model predicts respondents' probability to be willing to pay a premium price for HACPs, regardless the actual level of the premium. The necessary simplification of the questionnaire, in order to make online answer feasible in a short time, as well as the relatively limited number of answers collected, did not allow to choose other estimation methods (e.g., ordered choice) accounting for the WTP level actually expressed by respondents with enough statistical robustness.

Therefore, the dependent variable (respondent's WTP) was binary (1, yes; 0, no), built on the homonym ordinal variable (WTP) listed in table 1. The independent variables (regressors) were also presented in table 1, and can be grouped as follows:

- PERS: personal information and other general characteristics of respondents (the variable of the Country of birth was not considered, since most of the respondents declared they were born in Italy).
- FAM: characteristics of respondent's family unit and satisfaction about family income.
- LIFHE: respondent's lifestyle and health state.
- CONS: respondent's food purchase and consumption habits (confectionery products and FFs).
- BENEF: benefits deemed obtainable by respondents from consumption of FFs.
- MOTIV: respondents' motivation for consumption of FFs.

An additional instrumental variable (CER) was introduced as a regressor in the model, relating to the certainty level about WTP choice.

The mathematical formulation of the Binary Logit model used in this study is represented in the following equation (1):

$$\begin{aligned} \boldsymbol{WTP} &= \text{logit}[\text{P}(\text{y} = 1)] \\ &= \beta_0 + \beta_1 \boldsymbol{CER} + \beta_2 \boldsymbol{PERS} + \beta_3 \boldsymbol{FAM} + \beta_4 \boldsymbol{LIFHE} + \beta_5 \boldsymbol{CONS} \\ &+ \beta_6 \boldsymbol{BENEF} + \beta_7 \boldsymbol{MOTIV} + \varepsilon_I \end{aligned} \quad (1)$$

In which β_0 represents the intercept, β_1 the coefficient related to the level of certainty in the choice, β_2 the coefficients related to personal characteristics, β_3 those related to the characteristics of the family unit, β_4 those related to lifestyle and health, β_5 those related to food purchase and consumption habits, β_6 those related to the benefits deemed obtainable from consumption of FFs, β_7 those related to the motivations for consumption of FFs.

Model estimation was performed using the statistical software EViews®12 University Edition (HIS Markit Ltd). Estimation method was based on

Maximum Likelihood principle (Quadratic hill climbing/Eviews legacy) and the software automatically computed coefficient covariance matrix using second derivatives.

In order to correctly interpret the coefficient of each regressor and its marginal effect, the odds ratio (OR) was calculated according to the following equation (2):

$$OR = e^{\beta_i}$$

The OR quantifies the percentage change determined in the dependent variable, in this case the probability of being willing to pay a price premium for HACPs, in response to a unit percentage change of each regressor, keeping all the others constant. OR values can range from zero to infinity. Values below one (associated to negative coefficients) indicate changes in the probability of being willing to pay a premium price less than proportional to the unit change of the regressor, while values greater than one (associated to positive coefficients) indicate changes in this probability more than proportional to the unit variation of the regressor. Instead, values equal to one indicate that no effect of the regressor exists on the probability of being willing to pay a premium price.

2. Results and discussion

2.1. *Respondents' characteristics*

Table 2 compares the characteristics of respondents to those of the population residing in Central Italy and Italy, as described by ISTAT, with reference to personal information, characteristics of the family units and satisfaction about family income.

Overall, the characteristics of respondents are quite in line with those of the population residing in the two territorial areas of Italy and Central Italy, what leads to be confident with the validity of the indications provided by this study. However, the way in which data was collected, together with the relatively small number of responses the questionnaire received, do not allow to generalize its findings. In any case, also recent studies conducted in the Italian context for different FFs (Bentivoglio *et al.*, 2021; Paffarini *et al.*, 2021; Palmieri *et al.*, 2021; Palmieri *et al.*, 2022) showed some limitations in representing the characteristics of population, which however is not the goal of explorative analyses.

Table 2 - Comparison among respondents' characteristics and population

		Sample	Central Italy	Italy
Personal information and other general characteristics				
Gender				
Female	%	57.1	52.3	51.9
Age	years	45.3	45.4	44.8
20-39	%	36.2	26.1	27.1
40-59	%	42.0	38.1	37.7
60 and older	%	21.8	35.8	35.2
Level of education: MSc and above	%	54.8	18.8	15.5
Working condition				
Permanent employees	%	33.7	26.7	24.8
Retirees	%	12.2	17.8	17.8
Characteristics of family unit and satisfaction about income				
Number of family members	n.	3.1	2.3	2.3
1	%	10.3	34.9	32.7
2	%	23.7	27.8	27.2
3	%	26.3	19.2	19.4
4	%	29.2	13.6	15.3
5 or more	%	10.6	4.5	5.3
Families with dependent members	%	35.3	43.5	44.7
Number of dependent members	n.	0.63	0.667	0.711
0	%	64.7	56.5	55.3
1	%	15.7	23.4	22.6
2	%	12.5	17.0	17.8
3 or more	%	7.1	3.1	4.3
Average family income	€	34,399	32,967	31,517
Satisfaction about family income (COVID-19 effect)	1-4	2.86	2.53	2.54
Very satisfied	4 %	4.8	4.6	4.7
Fairly satisfied	3 %	77.2	54	54.4
Little satisfied	2 %	17.0	31.4	31.3
Not at all satisfied	1 %	1.0	9.9	9.7

In this study, the main divergence from the population lies in the level of education: at a major extent, respondents held a MSc or post-graduate qualifications, compared to less than 20% in the population, and this might at least in part motivate the differences in average family income, and satisfaction about it. Smoother divergences concern gender distribution (with a slight prevalence of women), age (on average elder than population), percentage breakdown into age groups (with a lower frequency of over-60s and a concentration in the 20-59 years age group). This contributes to motivate differences in working condition (with a higher frequency in the sample of permanent employees and a lower frequency of retirees), and explains why more than half of respondent's family units includes three or four components, in face of only one third in the population.

Table 3 reports respondents' WTP and certainty level.

Table 3 - Willingness to pay of respondents

Number of respondents		**n.**	**312**
Willingness to pay a premium price for HACPs and certainty level			
Respondents willing to pay		%	65.1
	+5%	n.	80
	+10%	n.	60
	+20%	n.	45
	+30%	n.	15
	+50%	n.	3
Respondents willing to pay with certainty		%	68.9
Average premium price (only respondents willing to pay)		%	+12.3
Average premium price (all respondents)		%	+8.0%

About two thirds of the 312 respondents declared to be willing to pay a premium price for HACPs. It is worth to highlight that, as expected, the number of respondents willing to pay decreases as the level of premium price increases. Considering only respondents willing to pay, the premium price averages at +12.3%, while it decreases to +8.0% considering all respondents. The latter could be relevant for food industry and commercial distribution, though lower than premiums estimated for other FFs commonly believed to be healthier (Palmieri *et al.*, 2022; Palmieri *et al.*, 2021; Pappalardo and Lusk, 2016; Vecchio *et al.*, 2016; Moro *et al.*, 2015). This evidence confirms the findings of Siegrist *et al.* (2015), Annunziata and Vecchio (2011) and

Ares and Gámbaro (2007) about the strong interaction existing between the specific FF and the credibility of its functional properties in the eyes of consumers, which limits respondents' WTP in the case of HACPs. However, it is also important to consider that 68.9% of respondents willing to pay a premium price declared to be certain of this choice: this leads to believe that what was declared in the questionnaire may frequently translate into concrete purchase intentions and WTP. Acquiring information on respondents' certainty level about WTP choice was precisely aimed at reducing the potential gap, highlighted by Furno *et al.* (2016), between the declared WTP and the one that will be manifested at the time of purchase.

2.2. *Main results of the econometric model*

Table 4 describes, in the first section, the characteristics of respondents and of their families that most affect willingness to pay a premium price for HACPs, as evidenced by the Binary Logit model, the related effect, and level of significance, as well as the Odds Ratio (OR), which allows to correctly interpret the effects. In the second section, the detailed output of the model is reported.

Table 4 - Significant variables and detailed estimation output of the Binary Logit model

Significant variables

Variable description	Effect	Significance	OR
Certainty level	+	***	3.42
Age	+	**	1.03
Number of family members	–	***	0.64
Presence of dependent family members	–	***	0.08
Family income level	+	***	1.49
Satisfaction about family income (COVID-19 pandemic)	+	***	3.46
Adoption of healthy eating styles	+	**	1.92
Frequency of physical activity	–	*	0.84
Channel of food purchase: e-commerce	+	***	3.53
Well-being	+	**	3.39

*** p≤0.01; ** p≤0.05; * p≤0.1

Detailed estimation output

Independent variables (regressors)		Coefficient	Std. Error	z-Statistic	Prob.
	C	-9.45	2.12	–4.47	0.000
CER	CER	1.23	0.16	7.58	0.000
PERS	FEM	–0.14	0.37	–0.4	0.692
	AGE	0.03	0.01	2.02	0.043
	MASDE	–0.15	0.35	–0.42	0.673
	PERRET	0.58	0.4	1.46	0.145

Table 4 - continued

FAM	FAMSIZE	–0.44	0.14	–3.13	0.002
	DEPMEM	–2.51	0.56	–4.45	0.000
	INC	0.4	0.12	3.35	0.001
	INCSAT	1.24	0.4	3.12	0.002
	HOMOWN	0.08	0.35	0.22	0.827
LIFHE	HEALTYEATING	0.65	0.32	2.02	0.044
	PHYSACT	–0.17	0.1	–1.62	0.100
	DIETPAT	–0.05	0.36	–0.14	0.888
	OTHPAT	0.57	0.42	1.34	0.179
CONS	TRADSHOP	–0.18	0.42	–0.44	0.662
	ECOMSHOP	1.26	0.62	2.05	0.040
	CONFECT	2.14	1.38	1.55	0.121
	FUNCT	–1.3	1.57	–0.83	0.407
BENEF	WELLBEING	1.22	0.59	2.07	0.038
	SEVERE	0.62	0.46	1.33	0.185
	FOODISOR	0.02	0.39	0.04	0.969
MOTIV	ADVERT	–0.63	0.82	–0.76	0.445
	LABEL	0.36	0.67	0.54	0.588
	BENEF	–0.14	0.39	–0.36	0.716
	PLEASURE	0.19	0.39	0.49	0.623
	PREVENT	–0.28	0.44	–0.64	0.519
	OTH	–0.11	0.55	–0.21	0.835

McFadden R-squared	0.343	Mean dependent var	0.651
S.D. dependent var	0.480	S.E. of regression	0.387
Akaike info criterion	1.030	Sum squared resid	42.4
Schwarz criterion	1.370	Log likelihood	–132.6
Hannan-Quinn criter.	1.160	Deviance	265.3
Restr. deviance	403.8	Restr. log likelihood	–201.9
LR statistic	138.5	Avg. log likelihood	–0.425
Prob (LR statistic)	0.000		

First, the presence of choice certainty level among the variables that positively influence respondents' WTP for HACPs, as well as the magnitude of its effect (OR: 3.42), suggests that future information campaigns and marketing strategies might play a crucial role, if aimed at dispelling any possible doubt about the beneficial effects on health achievable through a regular consumption of FFs (and HACPs, consumed in place of non-functional confectionery products). Taking up the considerations made by Annunziata and Vecchio (2011), the direct involvement of competent public institutions (e.g., the Ministry of Health, medical research institutions, etc.) in such campaigns is desirable, since commonly these are seen more credible in conveying health information than private entities.

The only significant variable in the group of personal information is respondents' age, which, albeit slightly (OR: 1.03), affects in a positive way WTP at its increasing. This is in line with previous findings about consumers' willingness to pay (Moro *et al*., 2015; Vecchio *et al*., 2016; Karelakis *et al*., 2020), and to purchase FFs (Ares *et al*., 2009; Baglione *et al*., 2012; Cavaliere *et al*., 2015). As also stated by Topolska *et al*. (2021), this evidence confirms that, with aging, consumers pay greater attention to a healthy diet and to the benefits achievable from FFs consumption. However, other studies (e.g., Vorage *et al*., 2020) put in evidence a higher interest of young people towards FFs, while still others found no association of age with consumption of FFs (Moutinho *et al*., 2022), to the point that Baker *et al*. (2022), in their review on consumer acceptance towards FFs, had to conclude that literature findings were controversial in this sense. In any case, the need to address targeted information campaigns emerges, to raise awareness about health benefits achievable from HACPs also among young consumers. In fact, taking up the conclusions of Vorage *et al*. (2020), there is room for a spread in the consumption of FFs (and even more of HACPs) also in this market segment.

With reference to respondents' family units, increase in size (OR: 0.64) and in particular the presence of dependent members (OR: 0.08) strongly affect in a negative sense WTP, clearly due to the lower income available per-capita, at the same level of family income, compared to smaller families with a higher share of independent members. However, also in this regard literature evidence is controversial, as reported by Baker *et al*. (2022), with some Authors confirming these findings, while others maintaining that households with a high number of members are more likely to consume FFs. Probably, household size in itself is not indicative enough, and needs to be contextualized considering other aspects, like the presence of children and teenagers, and family income level. In any case, s HACPs should be made affordable also to consumers with large families and dependent members, through proper marketing strategies.

Looking at the economic factors, respondents' family income level positively influences their WTP for HACPs (OR: 1.49). This confirms the findings of previous studies on other FFs (Vecchio *et al*., 2016; Kavoosi-Kalashami *et al*., 2017), and is also fully reflected in the literature collected by Baker *et al*. (2022); besides, results of this explorative analysis add the evidence that WTP is strongly increased also by respondents' satisfaction with family income level in the COVID-19 era (OR: 3.46).

Moving on to consider respondents' lifestyle, the adoption of healthy eating styles (i.e., alternative diet, or the habit of eating frequent light meals) has a positive influence on WTP (OR: 1.92), as expected. An interesting finding is that the frequent practice of physical activity negatively affects

respondents' WTP (OR: 0.84). This is in contrast with previous literature evidence collected by Zanchini *et al.* (2022) in their review about lifestyle, psychological and socio-demographic drivers in FFs choice, but two complementary explanations could be provided. First, respondents who lead a sedentary life might believe to compensate the lack of physical activity consuming FFs; second, physically active respondents might choose of not consuming confectionery products (and consequently HACPs), underestimating in this case the complementarity of the benefits achievable from practicing a frequent physical activity and from consuming FFs, even if in the form of confectionery products.

Analysing respondents' food purchase and consumption habits, the only significant variable, which strongly increases respondents WTP (OR: 3.53), is the custom of purchasing food products through e-commerce channels, confirming the findings of Zhang *et al.* (2018) in relation to the WTP of Chinese consumers for safe vegetables. This suggests that the web could represent a crucial channel also for conveying information on HACPs, beyond their commercial distribution. This habit has certainly reinforced as a consequence of the restrictions imposed in Italy to face the COVID-19 pandemic, and will probably be destined to persist and consolidate in the future. Another innovative distribution channel, represented by the vending machines, which is gaining more and more importance for FFs shopping particularly in Italy (Henke and Sardone, 2020), was not considered in the questionnaire: in fact, we felt that, thought frequently adopted by many people, its contribution to consumers food expense would have been in any case limited. On the other side, the absence of any significant influence on WTP by respondents' habit to shop food through traditional purchase channels could suggest a reduced identifiability on the shelves of FFs.

Finally, with reference to the benefits deemed obtainable from consumption of FFs, respondents' belief to improve well-being is the only significant variable, and has a makedly positive effect on WTP (OR: 3.39). This reflects the considerations made by Baker *et al.* (2022), who report that beliefs about well-being improvement are determinant for FFs acceptance. However, no other possible benefit from FFs consumption, including the prevention from severe diseases or diet-related disorders, significantly affects respondents' WTP for HACPs, as well as no particular motivation for consumption of FFs proves influent. Again, this is probably due to the specific typology of FF object of this study, commonly considered as not so healthy, and therefore less credible in preventing such diseases. In any case, taking up the conclusions of Idda *et al.* (2008) and Del Giudice *et al.* (2009) for the Italian context, this evidence put the stress on the fundamental role of motivational analysis in designing consumer-oriented marketing strategies, whose output should be kept into careful consideration by food industry and commercial distribution.

4. Conclusions

The findings of this study confirm previous evidence by Annunziata and Vecchio (2011) with reference to the Italian market of FFs, suggesting that an investment in extensive information and communication campaigns on FFs and on HACPs could prove essential also for the affirmation of these products on the market. Equally important could be the direct commitment in these campaigns of public institutions, more trustworthy in conveying health information in the eyes of consumers than private entities. Furthermore, to maximize their effectiveness, it will be necessary to design such campaigns carefully considering the real purchase motivations expressed by consumers and addressing distinct messages to the different age groups. Then, with the constant support of scientific community, they will have to aim at spreading awareness about the role that FFs can play also in long-term prevention strategies of severe diseases. In this regard, a basic concept to convey pertains the synergy among benefits obtainable from a regular consumption of FFs (and also of HACPs in place non-functional confectionery products) and those deriving from a healthy lifestyle. Taking up the conclusions of Alongi and Anese (2021), this has also direct implications on public health, since adopting a healthy diet, of which FFs should be an integral part, is the first step towards limiting the onset of non-communicable chronic diseases, thus reducing healthcare costs. In this sense, the development of a specific regulatory framework for FFs, still lacking both at European and Italian level, and their recommendation by health and food policies will be of great importance.

The web can offer potentially unlimited spaces for actions that improve consumers' knowledge of FFs and HACPs, thus promoting their consumption. In this sense, online purchasing platforms could be set up or expanded, in which all the main product categories and brands are hosted in dedicated sections. Nonetheless, traditional shops could also represent a very effective channel of information and distribution, provided that these products are easily identifiable on the shelves. At least in large supermarkets and hypermarkets, dedicated sectors could be set up to facilitate the identification and purchase of these products; information material could also be made available in place to better orient less experienced consumers in their choice.

Further important actions to support the spread of FFs and of HACPs consumption reside in market offer diversification strategies, that could be adopted by food industry and commercial distribution for meeting consumers' needs and preferences, also accounting for household income constraints. For instance, "basic" product lines could be developed with more accessible prices and more convenient formats for large families, to encourage consumption also by consumers with lower incomes.

To conclude, we believe that this explorative analysis of the WTP for HACPs in the Italian context provides some useful information and interesting insights to understand consumers behavior towards these products, and in this resides its main contribution to the advancement of the state of art of economic research on FFs. Possible future developments consist in broadening the horizon of the analysis, increasing the number of respondents involved and diversifying their provenience. Anyway, despite its intrinsic limitations, the online questionnaire proved to be an effective tool in allowing a good number of respondents to be reached in a short time; in addition, its employment proved essential during the COVID-19 pandemic, when health contingencies would have substantially prevented this analysis from being carried out.

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Appendix

Table A.1 - Variables employed in the Binary Logit model

Group	Name	Description
	Willingness to pay a premium price for HACPs and certainty level	
	WTP	**Willingness to pay a premium price (binary)**
CER	CER	Choice certainty level
	Personal information and other general characteristics	
PERS	FEM	Gender: female
	AGE	Age
	MASDE	Level of education: Master's degree
	PERRET	Working condition: permanently employed/retired
	Characteristics of family unit and satisfaction about income	
FAM	FAMSIZE	Number of family members
	DEPMEM	Number of dependent family members
	INC	Family yearly income bracket
	INCSAT	Satisfaction about income (COVID-19 effect)
	HOMOWN	Full ownership of family home (no mortgage)
	Lifestyle and state of health	
LIFHE	HEALTYEATING	Adoption of healthy eating styles
	PHYSACT	Frequency of physical activity
	DIETPAT	Suffering from diet-related disorders/diseases
	OTHPAT	Suffering from other disorders/diseases
	Food purchase and consumption habits	
CONS	TRADSHOP	Channel of food purchase: traditional shopping
	ECOMSHOP	Channel of food purchase: e-commerce shopping
	CONFECT	Frequency of consumption of confectionery products
	FUNCT	Frequency of consumption of FFs
	Benefits obtainable from consumption of FFs	
BENEF	WELLBEING	Well-being improvement
	SEVERE	Protection against severe diseases
	FOODISOR	Protection against food disorders
	Motivations for consumption of FFs	
MOTIV	ADVERT	Attracted by advertising
	LABEL	Attracted by label indications
	BENEF	Experiencing health benefits
	PLEASURE	Experiencing pleasure
	PREVENT	Preventing health problems
	OTH	Other motivations

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Impact of Contract Farming on the Technical Efficiency of Broiler Farmers in Indonesia

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Abstract

The objective of this paper is to estimate the effect of Contract Farming (CF) on the efficiency of broiler farmers in Indonesia. We used comprehensive socio-economic data of 438 broiler farmers in Indonesia. To achieve the objective we used *causal-comparative research* (CCR) design. Stochastic frontier production (SFP) employed to estimate farm efficiency. Then, the effect of CF on farm efficiency was estimated using propensity score matching (PSM). The results showed that the average technical efficiency of broiler farmers is 74.22%. Participation in CF increases TE by 7.4% and chick productivity by 12.5%. A policy that promotes farmer participation in CF is likely to improve the efficiency of broiler farmers since it is associated with improved input use intensity.

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1. Introduction

The Indonesian broiler sector experiences significant growth due to increasing population and per capita incomes. The consumption of broiler meat is higher than that of other meat such as beef and lamb. Although per capita consumption of broilers in Indonesia is 5.6 kg per year, which is lower than in other broiler producing countries, the growth increased by 8.9% annually for the last ten years (Ministry of Agriculture, 2018). An increase in productivity is needed to meet the demand for broiler meat. Technological and institutional development promises means to increase broiler sector productivity since the broiler sector is primarily dominated by smallholder farmers that are characterized with limited capital, low technology, and fluctuating market (Rondhi *et al*., 2020).

Contract farming (CF) can be regarded as a solution for market imperfections. Specifically, contracts are a result of three factors: quality, timing and risk (Patrick, 2004). Risk management is the application of risk reduction (Harwood *et al*., 1999). Despite the uncertainty in production and price, risk in all decision-making processes of farming arrangements is very common (Adnan *et al*., 2020; Kimura *et al*., 2010). Agricultural processing industries often require a sustainable supply of specific quality or type of product. To avoid the uncertainty associated with the spot market they strike contracts with farmers to ensure prompt delivery of a highly specified product (MacDonald *et al*., 2004; Prager *et al*., 2020).

Formally CF is an institutional arrangement to coordinate smallholder farmers and overcome the limitations of small-scale farming. CF facilitates farm technology adoption (Mao *et al*., 2019), improves the use of quality inputs (Abebe *et al*., 2013), and enhances the dissemination of technical knowledge through the provision of extension services (Khan *et al*., 2019). These features of CF lead to increase productivity and farm technical efficiency. Several studies have assessed the effect of CF on the efficiency of broiler farmers. Harianto *et al*. (2019) estimated the efficiency of 87 broiler farmers in West Sumatra (Indonesia) under formal and informal CF and found that farmers under formal CF have higher efficiency. Similarly, Begum *et al*. (2012) studied 75 broiler farmers in Gazipur (Bangladesh) and found that CF increases technical, allocative, and economic efficiency. However, a similar study conducted in Bangladesh (Kishoreganj district) using a sample of 90 farmers found no statistically different effect of CF on technical and allocative efficiency (Akhter & Rashid, 2008).

The results of previous studies indicate that the use of small-sample case studies may lead to biased finding. Small-sample data is often found in primary survey research. Simmons (2018) stated that smaller sample sizes get decreasingly representative of the entire population and could affect

the reliability of a survey's results because it leads to a higher variability, which may lead to bias as the result of non-response. Non-response occurs when some subjects do not have the opportunity to participate in the survey (Prince, 2012). Moreover, Suwandari *et al.* (2020) stated that the use of small-sample case study is not suitable as a basis for policymaking at a national level. Hence, this study aimed to analyze the effect of participation in CF on broiler farmers technical efficiency using comprehensive and nationally representative data. This study has two significant contributions. First, it will provide necessary information for policymakers in the Indonesian broiler sector, especially on the effort to improve the productivity sector. Second, the study on the effect of CF on-farm performance in developing countries is well established, but those who utilize nationally representative data is scarce. Thus, this study will contribute to the literature of CF by providing insight into how CF affects nation-wide smallholder farmer performance in developing countries.

2. Materials and methods

Research Design

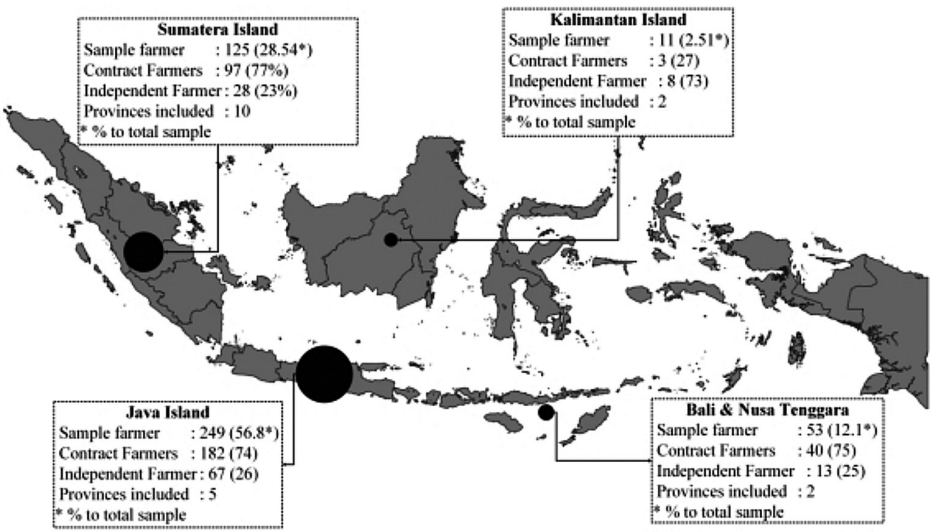
This study used *causal-comparative research* (CCR) design. CCR is a quantitative nonexperimental research that investigates or compares two or more groups in terms of a cause (or independent variable) that has already happened (Creswell, 2014). In this study, the aim is to investigate how participation in contract farming (the cause/independent variable) affects the technical efficiency of broiler farmers in Indonesia. The study consisted of two steps. First, the technical efficiency of broiler farmers was estimated using stochastic frontier analysis (SFA). Second, the impact of CF participation on the technical efficiency of broiler farmers was estimated using propensity score matching (PSM) analysis. Furthermore, the impact of CF on inputs use intensity (feeding intensity, labor workload, vaccine, vitamin, and medication intensity) and farm performance (feed conversion ratio and chick productivity) were estimated. The next section describes the data used in the study.

Data

The research employs nationally representative data of Indonesian broiler farmers. The data was the result of *Survei Rumah Tangga Usaha Peternakan 2014* (STU2014) created by the BPS (Indonesian Statistical Agency). STU2014 used a two-stage stratified sampling design (BPS, 2016). The first stage was aimed to select a sample block from the *block sampling frame*

(block population) using *systematic probability proportional to size* method based on the number of the farmer in each block. The eligible sample block is those with the size of at least ten farmers. Then, the second stage was aimed to select sample farmer from the *farmer sampling frame* (farmer population) using a *systematic sampling* method. The eligible sample farmer is those who have at least 100 birds. Figure 1 shows the sample distribution.

Figure 1 - Distribution of sample farmers



The original STU2014 data consists of 1142 farmers where 513 (44.9%) are contract farmers and 629 (56.11%) are independent farmers both with varied bird population number. However, this study used farmers with the bird population of 3000/production cycle or more. The purpose of this selection is to create a comparable group between the contract and independent group. So, the final data consist of 438 farmers where 322 (74%) are contract farmers and 116 (26%) are independent farmers. The data has an unbalanced panel structure with each farmer has production cycle ranging between one to twelve cycles. Then, the average value for each farmer was used to create the final data consisting of 438 farmers. The variables used in this study were grouped into two categories. First, the variables used to estimate the technical efficiency (SFA) and second, the variables used to estimate the impact of CF participation on TE (PSM).

Analytical Procedure

This study used the stochastic frontier production function (SFPF) to estimate the technical efficiency of broiler farmers (**first step**). The SFPF estimate the actual farm production relative to its highest potential production. Thus, the estimated TE values inform the potential of attainable production in the sector. The estimation of SFPF was divided into individual and pooled estimation. The former analyzed the contract and independent group separately, while the latter estimated the whole sample. The *Cobb-Douglass* production model was used to estimate the SFPF. Equation 1 specifies the estimation formula of SFPF (Mahaboob *et al*., 2019).

$$Y = \beta_0 X_1^{\beta_1} X_2^{\beta_2} \ldots X_n^{\beta_n} e^{\varepsilon i} \tag{1}$$

Where Y is the annual broiler production for farmer i, β_0 is the constant, β_i is the input coefficient to be estimated, X_i is the farm input (variables coded SFA), and e_i is the regression error term. Then, the technical efficiency was estimated using the formula in Equation 2 (Porcelli, 2009).

$$TE = Q_i \,/\, \left[\exp\,(x_i, \beta)\right] = \exp\,(-u_i) \tag{2}$$

Where TE is technical efficiency of farmer i, Q_i is output for farmer i, and $exp\ (x_i, \beta)$ is the estimated output for farmer i, and u_i is the technical inefficiency of farmer i.

In the **second step**, we used PSM analysis to estimate the average treatment effect (ATT) of CF participation on the technical efficiency of broiler farmers. The PSM analysis was consisted of several stages (Pan dan Haiyan, 2015): creating model to estimate propensity score, choosing matching algorithm, a test on common support area both for treatment and control group, and assessing matching quality. Logistic regression model (LRM) was used to estimate the propensity score of farmers. The propensity score estimation was used to create a comparable group between the contract and independent farmers. There are seven variables used to generate the propensity score (variables coded PSM). Equation 2 specifies the LRM.

$$Y_i = 1\mathrm{n}\left(\frac{p_i}{1-p_i}\right) = \frac{e^{\sum_{i=0}^{?} b_i x_i}}{1 + e^{\sum_{i=0}^{?} b_i x_i}},\ i = 1,\ldots,7 \tag{3}$$

Where Y_i is farmer participation in contract farming (1 = contract farmers, 0 = independent farmers) and x_i are the independent variables. The used

matching algorithms are Nearest Neighborhood Matching (NNM), Kernel Matching (KM), and Radius Matching (RM). The used of different matching method will be helpful for the interpretation of different effect estimates found within the analysis (Fullerton *et al*., 2016; Yanuarti *et al*., 2019).

The next stage is to test on common support area. The component is essential for the reason that it rules out the phenomenon of perfect predictability of D given X (Caliendo & Kopeinig, 2008):

$$0 < P\,(D = 1|X) < 1 \tag{4}$$

It ensures that persons with the same *X* values have a positive probability of being both participants and non-participants (J. Heckman *et al*., 1999).

For the record, PSM doesn't solve the bias derived from unobservable variables, which could characterise the treated and the control groups differently. PSM eliminates a substantial portion of the sample and may limit the ability to make valid generalizations outside common support (Cram *et al*., 2009; J.J. Heckman *et al*., 1998). Moreover, PSM does not address most concerns relating to self-selection or endogeneity that present the largest obstacles to proper identification (i.e., the inability to accurately identify and measure all constructs relating to treatment and outcome) (Shipman *et al*., 2016).

The following stage in the PSM analysis is the estimation of average treatment effect on the treated (ATT). In this case, the treatment is participation in CF. Thus contract farmers belong to the treated group, and independent farmers belong to the control group. ATT is the difference in the value of outcome variables between the treated and control group. We made two assumptions in the PSM analysis, the overlapping and conditional-independence assumptions. The former assumes that each farmer has a positive probability of participating in CF, and the latter assumes that the common factors that affect the outcome variable are observable. Equation 3 specifies the formula to estimate the ATT.

$$ATT = E\left(TE_{1j} \middle| D_j = 1, p(x_{ij})\right) = E\left(TE_{0j} \middle| D_j = 0, p(x_{ij})\right) \tag{5}$$

Where TE_{1j} is the technical efficiency of contract farmer *j,* and x_{ij} are farmer's observable characteristics. The nearest-neighbourhood matching (NNM) algorithm was used in estimating Equation 3 using STATA software. We performed a balance test to evaluate the robustness of the estimation results.

3. Results

Technical efficiency of broiler farmers in Indonesia

Table 1 provides descriptive statistics of overall farmers profile which include all variables used in the estimation of TE. Contract farmer (CTF), on average, has higher production (11056.05 kg/cycle) than that of independent farmer (10976.60 kg/cycle) (IF). Consequently, CTF recorded a relatively similar input uses such as chick, feed, VMV (vaccine, medication, and vitamin), and house size. The contract farmer has a slightly lower stocking density (13.27 birds/sqm) than that of the independent farmer (22.04 birds/sqm). However, both CTF and IF, on average, use the same number of laborers.

Table 1 - Descriptive statistics of overall farmers profile include all variables used in the estimation of technical efficiency

Group	Variable	Independent farmers			Contract farmers		
		Mean	S.D.	Freq.	Mean	S.D.	Freq.
SFA	Production (kg)	10976.60	12194.16		11056.05	12129.40	
SFA	Chick (bird)	7066.42	6763.13		7074.73	6703.50	
SFA	Feed (kg)	12403.03	13316.59		12459.68	13194.23	
SFA	VMV (kg)	737.67	2716.45		721.40	2677.89	
SFA	VMV (liter)	167.58	957.55		174.71	946.78	
SFA	VMV (cc)	1870.43	6792.57		1959.73	6836.75	
SFA	VMV (doses)	671.13	2855.81		651.23	2815.32	
SFA	Labor (number of labor)	2.81	2.06		2.79	2.04	
SFA	House size (sqm)	927.76	1397.29		927.50	1381.07	
SFA/PSM	Stocking density (bird/sqm)	22.04	24.05		13.27	16.01	

Table 2 summarizes the estimation results of the production function in Equation 1. The results show that four out of nine factors significantly affect technical efficiency. Chicks and feed have positive and significant effect while broiler house size and stocking density have a negative and significant effect on technical efficiency. In contrast, labor and all types of VMV have no statistically significant effect. The gamma values, sigma-squared and log-likelihood show that the estimation results are robust.

The average technical efficiency of broiler farmers is 74.22% (Table 3). However, comparing the technical efficiency of contract and independent farmers indicates that the former group has higher efficiency. Technical Efficiency (TE) indicated the relationship between actual production and potential production, if the resources are well used, where 1 = technically efficient (100% score) and 0=technically inefficient (< 100%) (Akazili *et al.*, 2008).

Table 2 - The estimation result of cobb-douglas production function

Variables	β	S.E	t value
Ln Chicks	9.83***	2.63	3.74
Ln Feed	0.02***	0.01	2.23
Ln Labor	-0.03 ns	0.02	-1.42
Ln Household size	-8.82***	2.63	-3.35
Ln Stocking density	-8.88***	2.63	-3.38
Ln VMV (kg)	-0.0024ns	0.00	-0.96
Ln VMV (liter)	-0.0005ns	0.00	-0.14
Ln VMV (cc)	-0.0018ns	0.00	-0.75
Ln VMV (doses)	0.0003ns	0.00	0.10
Constant	0.59***	0.20	2.95
Robustness Check			
sigma-squared	0.20	0.02	10.40
gamma	0.89	0.03	31.80
Log-likelihood	-68.73		

Note: *** significant at 1%, ** significant at 5%, * significant at 10%, ns not significant.

Table 3 - Technical efficiency estimates of broiler farmers

Estimates Of Technical Efficiency	Contract	Independent	Pooled
< 50%	18 (5,59%)	21 (18,10%)	39 (8,90%)
50-70%	57 (17,70%)	39 (33,62%)	96 (21,92%)
70.01-80%	88 (27,33%)	23 (19,83%)	111 (25,34%)
80.01-90%	132 (40,99%)	28 (24,14%)	160 (36,53%)
>90%	27 (8,39%)	5 (4,31%)	32 (7,31%)
Mean	76,62	67,564	74,22
Maximum	95,50	95,00	22,59
Minimum	25,40	22,59	95,50
N	322	116	438

The average technical efficiency of contract farmers is 76.62% and 67.56% for the independent farmers. The majority of independent farmers operate at a lower-level efficiency. The percentage of independent farmers who operate below 70% efficiency is 51.72%, much higher than that of contract farmers which only 23.29%. In contrast, the percentage of contract farmers who operate at higher-level efficiency is higher than those of independent farmers. 40.99% of contract farmers operate at a 70-80% efficiency level and 8.39% of them operate at efficiency level higher than 90%. Meanwhile, only 24.14% of independent farmers operate at 70-80% efficiency level and 4.31% operates at

higher than 90% efficiency level. The results indicates that contract farmers, on average, have a higher technical efficiency than that of independent farmers. However, a propensity score analysis is required to make a robust comparison.

The estimation results of production function demonstrate that chicks and feed have a positive and statistically significant effect on broiler production. In contrast, broiler house size and stocking density have a negative and statistically significant effect on broiler production. Chicks has a coefficient value of 9.83 which means that a 1% increase in chick quantity will increase production by 9.83%. Similarly, interpretation applies to feed with coefficient of 0.02 which means that a 1% increase in the amount of feed will increase production by 0.02%. However, broiler house size and stocking density have coefficient values of -8.82 and -8.88 respectively. That values mean that a 1% increase in broiler house size and stocking density will decrease production by 8.82 and 8.88% respectively. The results suggest that chick, broiler house size and stocking density have the high production elasticity.

Chick and feed are crucial inputs in broiler farming. Ullah *et al.* (2019) who studied broiler farming at Charsadda district, on Khyber Pakhtunkhwa, in Pakistan found that DOC and feed have partial production elasticities of 0.45 and 0.21% respectively. Similar results were also found in the studies of broiler farming in Punjab, Pakistan (Ali *et al.*, 2014), in Mampong Municipality, Ghana (Ahiale *et al.*, 2019), and in Limapuluh Kota, West Sumatera (Pramita *et al.*, 2018). Labor is not significant to the production of both contract and independent farmers. The sample in this study used farmers with similar farm size (population larger than 3000 birds/cycle) and implies that both group have similar technological adoption and inputs quality which reduces labor intensity in the production stages (Ruml & Qaim, 2019). In contrast, broiler house size and is significant to the production of broiler farmers. The arrangement of broiler CF requires farmers to provide a house with specific minimum capacity and specification (Shumba, 2013).

Stocking density significantly decreases farm technical efficiency. The estimation result reveals that an increase of stocking density by 1% decreases farm technical inefficiency by 8.8%. Several studies have shown that stocking density significantly affects production, health, and welfare of broiler farm. (Weimer *et al.*, 2020) found that broilers raised in high stocking density have a higher prevalence of hock burn. Similarly, Li *et al.* (2019) found that high stocking density reduces muscle and bone growth of broiler which resulted in reduced production. Vaccine, medication, and vitamin (VMV) has no significant effect on technical efficiency. The use of VMV is crucial in improving broiler health and productivity, such as demonstrated by Almeida Paz *et al.* (2019) and Aye Cho *et al.* (2020). However, the non-significant effect of VMV might be caused by the characteristics of farmers in this study.

The impact of CF on the technical efficiency of broiler farmers in Indonesia

Table 4 provides descriptive statistic for variables used in logistic regression in order to asses impact of CF on TE. CTF attained higher education than IF, although both groups, on average, have similar age and household size. The contract farmer has longer broiler farming experience than those independent farmers. Also, the contract group has a higher percentage of farmers who receive the agricultural extension and cooperative services and participate in the farmer group. Factors that affect farmer decision to participate in CF obtained from Rondhi *et al.* (2020) who utilize similar data. There are six variables in this category: education, house size, chick, cooperative services, agricultural extension, and farmer group membership.

Table 4 - Descriptive statistics of overall farmers profile include all variables used in the estimation of logistic regression

Group	Variable	Independent farmers			Contract farmers		
		Mean	S.D.	Freq.	Mean	S.D.	Freq.
PSM	Education (yr)	10.26	5.33		10.30	5.34	
PSM	Age (yr)	44.82	10.69		44.76	10.70	
PSM	Household Size (person)	4.39	1.55		4.39	1.54	
PSM	CF Participation						
	Independent farmers			116(26.48)			0(0)
	Contract farmers			0(0)			322(73.52)
PSM	Farming experience						
	<1 year			8(6.8)			16(4.9)
	1-5 years			33(28.4)			154(47.5)
	5-10 years			39(33.6)			86(26.7)
	>10 years			36(31)			66(20.4)
PSM	Agricultural extension						
	not received			99(85.3)			192(59.6)
	received			17(14.7)			130(40.4)
PSM	Cooperative service						
	not received			106(91)			303(94)
	received			10(9)			19(6)
PSM	Farmer group membership						
	not member			107(92.2)			277(86)
	member			9(7.8)			45(14)
	Sample size (N)			116			322

The estimation of LRM (Table 5) in the first trial demonstrates that farmer's education, farming experience, access to agricultural extension and cooperative, and stocking density have a significant effect on participation

in contract farming. Furthermore, the propensity score generated from this model passed the balance test and is suitable for further analysis. However, we removed the institutional variables (agricultural extension and cooperative services) since both variables are correlated with the participation in contract farming. Thus, we selected variables that have direct effect on technical efficiency: farmer's education, farming experience, and stocking density. The second model satisfied the balancing property and made a relevant group for comparison. The log-likelihood of the LRM also demonstrates that the estimation results are robust.

Table 5 - Estimation results of logistic regression model

Variable	**1st trial**			**2nd trial**		
	β	**S.E.**	**z**	**β**	**S.E.**	**z**
Education	0.05	0.02	2.32**	0.05	0.02	2.43**
Age	0.01	0.01	1.13^{ns}	*Removed*		
Household size	-0.05	0.07	-0.75^{ns}	*Removed*		
Farming experience	-0.40	0.13	-3.07***	-0.33	0.12	-2.67
Agricultural extension	1.34	0.30	4.45***	*Removed*		
Cooperative service	-0.79	0.44	-1.78*	*Removed*		
Farmer group membership	0.37	0.42	0.37^{ns}	*Removed*		
Stocking density	-0.02	0.00	-3.75***	-0.02	0.00	3.98***
Constant	0.97	0.69	1.42^{ns}	1.80	0.45	3.98***
Robustness Check						
Balance test	*Satisfied*			*Satisfied*		
Pseudo R^2	0.12			0.06		
Log-likelihood	-222.38***			-237.85***		

Note: *** significant at 1%, ** significant at 5%, * significant at 10%, ^{ns} not significant.

The analysis proceeded to the estimation of ATT (Table 5), which shows that participation in CF increases technical efficiency by 7.4%. The results also demonstrate that contract farmers have higher feeding and VMV intensity than those of independent farmers. Contract farmers allocate 1.31 kg feed/chick, significantly higher than that of independent farmers (1.30 kg feed/chick). Similarly, the contract farmers used higher VMV of 96.3 kg/1000 chicks, significantly higher than that of independent farmers (62.4 kg/1000 chicks). However, both contract and independent farmers do not differs significantly in the use of labor, VMV (l), and VMV (cc). The analysis also estimate the productivity difference between contract and independent farmers. There are two variables used to estimate the productivity of

broiler farmers, feed conversion ratio and chick productivity. Contract and independent farmers do not differs significantly in term of feed conversion ratio. The contract farmers recorded higher chick productivity than that of independent farmers. On average, contract farmers produce 1.61 kg per chick, significantly higher than that of independent farmers 1.41 kg per chick.

Figure 2 represent the common support area related to propensity score estimation both for broiler farmer who participate in CF and not. Both top and bottom of the diagram show the distribution of propensity scores for participants and CF participants. The Y axis represents the propensity values of the two groups. According to the figure, it is known that the distribution of propensity scores for the two groups is in the common support area, which is between 0 to 1 or between the minimum and maximum values obtained, as stated by Caliendo & Kopeinig (2008). This means that each respondent has a positive and good probability of being a participant and non CF participant.

Figure 2 - Distribution of propensity scores in the common support area

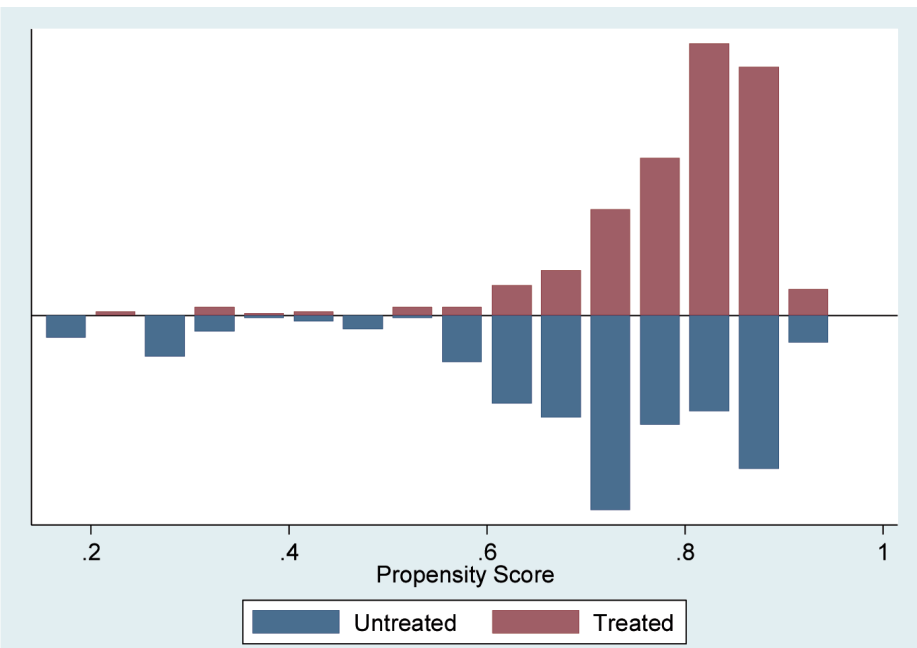


Table 6 display the assessment of matching quality using NNM, KM, and RM. Table 6 showed a decrease in the mean bias and median bias before matching compared to after matching using NNM, RM, and KM. The

Table 6 - Balance Test Results for Propensity Scores using NNM, RM, KM

Matching Algorithm	Pseudo-R^2		$P > Chi^2$		Mean Bias		Median Bias	
	before	after	before	after	before	after	before	after
Technical Efficiency								
NNM	0.073	0.024	0.000	0.000	36.2	16.1	28.7	12.6
KM	0.073	0.005	0.000	0.001	36.2	8.6	28.7	6.8
RM	0.073	0.022	0.000	0.000	36.2	17.2	28.7	16.0
Feed conversion ratio								
NNM	0.073	0.025	0.000	0.000	36.2	16.1	28.7	12.6
KM	0.073	0.005	0.000	0.001	36.2	8.6	28.7	6.8
RM	0.073	0.022	0.000	0.000	36.2	17.2	28.7	16.0
Productivity								
NNM	0.073	0.025	0.000	0.000	36.2	16.1	28.7	12.6
KM	0.073	0.005	0.000	0.001	36.2	8.6	28.7	6.8
RM	0.073	0.022	0.000	0.000	36.2	17.2	28.7	16.0
Feeding intensity								
NNM	0.073	0.025	0.000	0.000	36.2	16.1	28.7	12.6
KM	0.073	0.005	0.000	0.001	36.2	8.6	28.7	6.8
RM	0.073	0.022	0.000	0.000	36.2	17.2	28.7	16.0
Labor workload								
NNM	0.073	0.025	0.000	0.000	36.2	16.1	28.7	12.6
KM	0.073	0.005	0.000	0.001	36.2	8.6	28.7	6.8
RM	0.073	0.022	0.000	0.000	36.2	17.2	28.7	16.0
VMV intensity (kg/1000 birds)								
NNM	0.026	0.009	0.027	0.089	12.8	12.1	22.7	12.8
KM	0.026	0.001	0.027	0.807	22.8	3.5	22.7	2.5
RM	0.026	0.014	0.027	0.015	22.8	13.9	22.7	9.7
VMV intensity (l/1000 birds)								
NNM	0.026	0.009	0.027	0.089	22.8	12.1	22.7	12.8
KM	0.026	0.001	0.027	0.807	22.8	3.5	22.7	2.5
RM	0.026	0.014	0.027	0.015	22.8	13.9	22.7	9.7
VMV intensity (cc/1000 birds)								
NNM	0.026	0.009	0.027	0.089	22.8	12.1	22.7	12.8
KM	0.026	0.001	0.027	0.807	22.8	3.5	22.7	2.5
RM	0.026	0.014	0.027	0.015	22.8	13.9	22.7	9.7

distribution of the covariates is balanced if the mean and median values of the bias between the treatment and control groups decrease after matching (Rosenbaum & Rubin, 1985). The analysis value of mean and median

have decreased after matching, so it can be said that the distribution of the covariates is balanced.

The pseudo-R^2 value describes the ability of the covariates to explain the possibility of farmers participating in CF. Theoretically, after the matching process, pseudo-R^2 value must be lower (Sianesi, 2004). In Table 5, the pseudo-R^2 value decreased for each pairing process. This means that there was no difference in the distribution of the covariates between the treatment and control groups. So from the results of the covariate balance analysis that has been carried out, it can be concluded that the matching process has succeeded in balancing the covariate distribution between the two groups. This can be interpreted that the difference that may occur in farmers' income is caused by the treatment, namely the participation of farmers in CF.

The ATT estimate for technical efficiency demonstrates that participation in CF, on average, increases broiler farmers technical efficiency on each matching process by 5,316%; 6.056%; 6.518% respectively from NNM, KM, RM. Furthermore, contract farmer has higher chick productivity than that of independent farmer. The positive value of ATT for chick productivity demonstrates that contract farmer has higher production than that of independent farmer. The improvement in technical efficiency of contract farmers is associated with higher use of feeding and VMV intensity. The positive ATT value for feeding intensity indicates that contract farmers used more feed for each chick placed in each production cycle. Similarly, the positive value of ATT for VMV (kg and l) intensity demonstrates that contract farmers used more VMV that of independent farmers. However, CF participation does not affect feed conversion ratio in all matching method and labor workload in RM matching). The results of this study confirm the findings of previous studies, such as Harianto *et al.* (2019) and Begum *et al.* (2012). Both of these studies associated the improved technical efficiency of contract farmers to improved access to quality inputs which is confirmed by the finding of this study.

Contract farming arrangements address the problem of liquidity and enhance access and better use of agricultural inputs in production. Farmers who are contracted attain higher technical efficiency because as part of their contract farming arrangements, the contractor provides extension support and specialized farm training to improve farm productivity. Le Ngoc (2018) found that participation in CF increases farm TE compared to conventional farming practices. (Mishra & Dey, 2018) state that farmer participation in CF significantly increases TE.

Furthermore, Benalywa *et al.* (2019) stated that government intervention on broiler production is needed in order to make the broiler industry efficient and enhance its competitiveness. Putri & Rondhi (2020) suggest to provide facilities such as technical counseling and coaching for farmer who applied

Table 7 - The estimation results of PSM analysis

Variable	ATT		
	NNM	**KM**	**RM**
Technical efficiency (%)	5.316	6.056	6.518
Feed conversion ratio (kg feed/kg bird)	-0.106	-0.042	-0.0027
Productivity (kg/chicks)	0.170	0.196	0.213
Feeding intensity (kg feed/chicks)	0.094	0.232	0.314
Labor workload (bird/person)	753.68	282.091	-61.836
VMV intensity (kg/1000 birds)	68.360	78.726	89.456
VMV intensity (l/1000 birds)	115.737	117.193	115.524
VMV intensity (cc/1000 birds)	-5540.21	-2502.405	-1114.86

Note: NNM (Nearest neighborhood matching), KM (Kernel matching), RM (Radius matching).

CF. Suwarta & Hanafie (2021) added that in order to reduce the cost of cultivating broiler chickens, farmers need to be assisted by setting competitive prices for DOC and feed. Broiler chicken contract farming should be disseminated to other farm communities in rural areas in view of the fact that CF has improved the welfare of the rural community through increased income (Setiadi *et al*., 2022).

4. Conclusions

This study aimed to estimate the impact of participation in contract farming on the technical efficiency of Indonesian broiler farmers. This study found that participation in contract farming increases the technical efficiency of broiler farmers by 7.4% and chick productivity by 12.5%. The improvement in technical efficiency of contract farmers is the result of increased access to farm inputs. Contract farmers used more feed, VMV, and lower stocking density than independent farmers. An improvement in feeding and VMV intensity as well as stocking density is crucial for maximizing the attainable production potential of Indonesian broiler sector. Furthermore, increasing farmer participation in contract farming is imperative since it associated with input use (feed and VMV) intensity and stocking density.

There is a limitation in this study. This study discusses impact of farmers' participation in CF with national dataset but is not be able to linked and capture the possibility of different region characteristic that might influence farmers' decision and TE. To have to do that, it would be necessary to conduct a primary data collection in order to strengthen the secondary

national dataset. Further studies need to be carried out in this field, in particular with reference to the possibility of significant efficiency differences by farmers from different regions.

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Guest Editorial
Bioeconomics and its Derivations: Ecological Economics and Political Ecology

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Correctly understood Bioeconomics is (and entails) a critique of Political Economy. To-date, two quite different critiques of Political Economy are recognized: First, the well-known Marxist critique; second, the critique carried out by N. Georgescu-Roegen, the father of Bioeconomics. It is precisely this salient feature that lets us understand the two derivations of Bioeconomics, namely Ecological Economics, and Political Ecology.

A critique of Political Economy just means that the economy must be understood and judged vis-à-vis its responsibility toward society as a whole or toward each and every individual, and especially vis-à-vis its compromises with nature. Such responsibilities and compromises are, to be sure, political in the widest but strongest sense of the word. Briefly stated, every economic decision – whether commercial, financial, monetary or entrepreneurial, has strong direct social, environmental and political consequences. Such consequences cannot, by any means, be taken for granted.

Understood thusly, Bioeconomics does not have anything to do with (wrong) interpretations regarding the Cyclic Economy, Orange Economy, Blue Economy, Circular Economy, and definitely nothing to do with the 2015 Millennium Development Goals, the 2030 Sustainable Development Goals (SDG), and the like. Moreover, and more radically, Bioeconomics does not have any relation whatever with classical, neoclassical, Marxist, or neoliberal models or even to the scale economies since Bioeconomics

is a strong and direct critique of the production function (whereas the former economic frameworks and models leave the production function intact).

Broadly stated, the production function can be expressed by the following equation:

$$H = \frac{1}{N}$$

expressing that the human beings (H) are conceived as external, distinct and superior to nature (N), and, thereafter, nature is conceived as a means, i.e., a resource to satisfy human needs, wants, and desires. The equation truly condenses the entire history of Western civilization[1].

Consequently, the Western world can be said to be born sick. Borrowing terminology from medicine, its disease can be identified as a mixture of a chronic, an acute, an orphan as well as a complex disease. The constitutive equation of the West does know everything about the human beings, in a generous sense, and yet, nothing about nature and the weave of life. To be sure, caring for the human being in general is important. Nonetheless, it is insufficient.

This systemic illness afflicting the Western world is called: anthropocentrism, anthropologism, anthropomorphism – three different labels that condense the idea that human beings are the center of the universe and everything else is taken up as a means or as a rod.

Thanks to E. Schrödinger, a new scientific framework was formulated for the first time, namely an inquiry about the nature and logic of life (Schrödinger, 2012). This radical new paradigm shift places life – and not just human beings – at the center of attention. Schrödinger's book is now seen as a foundational source for the understanding of Bioeconomics.

Meaningfully, the guiding thread that makes Bioeconomics possible consists in the interplay between Economics and Thermodynamics; more

1. The most commonly known production function equation is the Cobb-Douglas equation, which also admits different formula. The equation mentioned and introduced above aims to precisely identify the social, environmental and political dimensions of the production function.

specifically, it is about the relationship between Economics and the Second Law of Thermodynamics, entropy. Bioeconomics is an economy that considers life as well as nature, in the largest, deepest and strongest sense of the word. In other words, Bioeconomics can be safely interpreted as an economy for life, or also as an economy of life. Therefore, "bios" stands as a core concept and "economics" is just a suffix. In sharp contrast with classical economic frameworks and models, an economy for life has emerged that does not focus exclusively the several features that characterize normal economic frameworks such as markets, enterprises, consumption, production, growth, efficacy, efficiency, entrepreneurship, start-ups, competitiveness, and even government.

It is important to consider that thermodynamics is a single science that comprises two different kinds of systems or phenomena. On the one hand, it is concerned with closed or isolated systems i.e., systems that are defined in terms of equilibrium. On the other hand, thermodynamics also deals with open systems, i.e., phenomena that are far from equilibrium. Life, i.e., living beings, exist and develop far from equilibrium.

Closed systems tend inevitably towards equilibrium; in other words, death. This is exactly what entropy means. The Second Law of Thermodynamics states that all closed or isolated systems tend inevitably to entropy. In contrast, open systems reduce entropy and keep it low precisely by keeping themselves far from equilibrium. Economically speaking, the generation of value is possible under the proviso that entropy remains low. Plainly put, the generation of value is directly proportional to low entropy. Thus, what is truly at stake in the generation of value is the fact that biological existence is all that matters – not consumption, productivity, economic growth, revenues, and the like.

This said, Bioeconomics is articulated into two derivations, Ecological Economics and Ecological Politics. While the former focuses on the relationship between political, economic, and social factors, as well as environmental conflicts and changes, the latter concentrates on the management and valuation of sustainability. Whereas Ecological Economy can be viewed as a rather conservative and institutional approach, Ecological Politics is critical, considers alternatives to development and leads to a critique of the Political Economy, and the relationship between the State, the Government and the Economy.

In fact, Bioeconomics can be said to have developed along two parallel paths. The first follows Georgescu-Roegen's study (Georgescu- Roegen, 2014) showing that human beings can use any low-entropy system or phenomenon

only once. Nature is the position of low entropy par excellence. In other words, nature is not a resource by any means or in any sense of the word. Social, cultural, economic, and political consequences follow thereafter. Most of the goods, services and products provided by the free-market system are not necessary – certainly not biologically necessary. It is perfectly possible to live with less.

At the same time, Passet's contribution to Bioeconomics lead to an understanding that the biosphere is the entire framework of the economy, and life in general is perfectly indistinguishable from evolution towards complexity, i.e. the way in which biology pervades complexity and the human and social sciences. Accordingly, it is impossible to be concerned with economics at large without explicitly knowing about evolution, ecology and biology in the largest and deepest sense of the word. Consequently, any economic process that goes against nature is doomed to fail, and result in disasters and suffering (Passet, 1996).

In contrast to the constitutive equation of Western civilization, a quite different relationship between humans and nature can be stated:

$$H \in N$$

where human beings are viewed as part of nature, as belonging to the biosphere, and definitely not distinct from it. Thus, Bioeconomics entails a radical new relationship and way of living concerned with how to live, and living-well, about which several historical and anthropological explanations can be found, for example: *eupraxein*, in Ancient Greece, *vivere beate*, in the Middle Ages, *suma qamaña* and *sumak kawsay*, in Quechua and Aymara languages and cultures, and *utz' kaslemal*, in quiché, the main language for the Mayans.

Economically speaking, knowing how to live and living-well consist in living according to low entropy. Two fundamental consequences follow regarding the carbon footprint, and particularly in the context of the information and knowledge society, the digital footprint. It is possible to empirically and practically measure, assess and radically modify both the carbon footprint and the digital footprint.

Living-well and knowing how to live consist, in short, in achieving a low or null carbon and digital footprint, something that is easily said but very hard to do. To succeed, we must distinguish between what we need and what we want, without being just consumers, workers or producers.

The two derivations of Bioeconomics extend into a manifold of domains, practices and modes of knowledge. Some of these pertain to food sovereignty and food safety, a clear-cut independence vis-à-vis the financial and bank systems, the importance and meaning of bartering, the emergence of self-regulatory, self-organized and self-managed groups and communities, all possible alternatives to development, the implications of zero tillage, the critique and rejection of hyper-consumerism, and the connected establishment of a close relationship with nature – namely, air, water, the seas, animals and plants – metafisically intended as with the universe.

Living-well and knowing how to live, the main outcomes of the derivations of Bioeconomics, certainly acknowledge the importance of education, information, science and technology, research, arts and philosophy – particularly in the context of the Information Society, the Knowledge Society and the Network Society. And yet, above all, Bioeconomics is an invitation to something that Western civilization ignores, namely wisdom. Indeed, information, science, technology and research are necessary, but insufficient to live-well and know how to live. A bit of wisdom is also needed. The trouble is that wisdom cannot be taught, but it can be learned. Against all odds, Bioeconomics brings forth the possibility to learn wisdom while learning how to live with nature or according to nature, in the largest and gentlest sense of the word.

* * *

As noted above, the economy must be understood and judged vis-à-vis its responsibility toward society as a whole or toward each and every individual, as well as vis-à-vis its compromises with nature. It is exactly this epistemological perspective that fosters Bioeconomics' strong critique of the production function. Thus, this issue of the Journal gathers seven articles that reflect upon and debate theories, methodologies and practices aiming to drive harmonic relationships between economics and nature. The papers published here are grounded on cross-disciplinary approaches in which economic, environmental, and engineering methodologies converge to make evident socio-economic problems and conflicts, while proposing alternatives toward sustainable agriculture.

The seven thematically based research papers invite readers to look at floods, soil, the management of water and of waste. Five papers view these issues within the context of rural sustainable development, while one regarding urban development focuses on the circular entrepreneurial economy. The seventh paper describes migration from the countryside to the

city from an econometric perspective, identifying the structural challenges of the rural job market. A description of each paper follows:

The article on water management for biodiversity and food safety named "**Socioecological practices and community resilience strategies for sustainable agriculture in lower Sinú, Colombia**" was written by Rubén Darío Sepúlveda Vargas, María Alejandra Taborda Caro, Deivi David Fuentes Doria, Carlos Eduardo Maldonado Castañeda, and Ivan Darío Sepúlveda Calderin. It examines various socio-ecological rural practices aiming to identify strategies of common resilience and address ongoing socio-environmental conflicts caused by limited access to water, and the loss of biodiversity and ancestral knowledge. It is transdisciplinary, exploratory, non-experimental research carried out as a case-study. Three organized rural associations were selected for a sample of thirty interviewed people. The results show that models of self-management do promote the articulation of sociological systems, environmental sustainability and the equitable management, use, and access to eco-systemic services.

The paper "**Qualitative indicators for community water resilience in floodable areas: Agricultural pantry of La Mojana, Colombia**", written by María Alejandra Taborda Caro, Rubén Darío Sepúlveda Vargas and Carmen Auxiliadora Ortega Otero, develops qualitative indicators that aim to systematize the hydric resilience in infringed communities due to floods in the sub-region of Mojana, Colombia. A sample of two hundred and thirty-one people of different ages and genders was considered. La Mojana is a geostrategic territory in the country that holds a huge reserve of fresh water, rich in biodiversity and productive wetlands that favor large-scale rice cultivation, which constitutes the basis of the region's economy and supplies the majority of the internal production for the country. The indicators, which one can infer as addressing hydric resilience, are grounded on the following categories, namely wisdom exchange, applied ancestral wisdom and memory, socio-environmental conflicts, governance, and climatology.

Furthermore, the article "**Housing vulnerability, agricultural production, and goods lost estimated to floods in Rio Nuevo a rural community in Colombia**" by Gloria Esther Urrea-Ceferino, Camila Andrea Pinto Suarez, Dina Luz Jimeno Carrascal, Daniela Alejandra Yánez Ventura, and Hernán José Tapia Contreras, studies the degree of determination of physical vulnerability and the economic loss in crops and estates due to floods in the community close to Río Nuevo, Valencia, Colombia. The outcomes reveal a high physical vulnerability with a value of 0.63 in a scale from 0 to 1, whereas the estimated economic loss of land and crops is estimated to be 169,555.56 US dollars.

Dealing with the management of the soil, the paper "**Application of Participatory Methods to Explore Changes in Land Use of a Tropical Dry Forest Basin**" by Yhonattan Méndez Nobles, Humberto Ávila Rangel, and Lina García Corrales explores the causes of the change of use of soil in a hydrographic basin of the dry tropical forest. Thus, the unit of analysis is the basin of the Canalete river, in Colombia. It is argued that the main causes for the change of the use of soil are associated with biophysical factors, whereas the shrubland-forests and the crops changed because of direct and underlying socio-economic factors. The prospective analysis grounded on participatory mapping shows a hoped-for scenario of land use for the year 2030, bearing a decrease of more than 16,2 ha of grass that is compensated for by an increase of nearly 2.4 mil ha of crops, and 13,8 ha forests and shrubs.

Regarding circular Bioeconomics, two papers reflect upon the management of agricultural and industrial waste with proposals aiming at profiting from residual biomass so that the principles of Bioeconomics can be fostered. The first article, "**Crop waste management proposal in rice systems at the department of Cordoba, Colombia**", written by Gloria Urrea-Ceferino and Manuel Alejandro Grimaldos Mojica, focuses on the current market and its challenges with a proposal for the correct management of the waste from rice crops within the framework of circular Bioeconomics in the rice economic system of the state of Cordoba, Colombia. It is claimed that the farmers, researchers, rice federation, and public policies need to work at improving the nutrients of the soils, the quality of harvest, and the management of the waste that remains from the windmills and the places where rice is cultivated. Besides, it is argued, it is compulsory to increase the investment to obtain products that satisfy the current demands from the market regarding renewable materials and processes.

The second paper, "**Industrial perspective regarding circular economy activities in Atlántico – Colombia**" by María Bernarda Alvarado Bawab and Sandra Margarita Villa Marenco, diagnoses the entrepreneurial scope of forty-six small, middle and large enterprises in the state of Atlántico, in Colombia. This article presents the strengths and weaknesses faced by policies for a circular economy, particularly regarding the waste generated, the resources used, and the systems or methodologies of management implemented. The results show that minimizing the waste through recycling or re-using, re-planning and saving water are the main actions that help implement circular activities. In order to increase the positive impact of such actions, a holistic structure is needed that systematizes practices, focusing on each and every stage of innovation, and on barriers such as lack of experience and judicial and administrative procedural complexity.

Finally, from an econometric perspective, the dynamics of the market of rural jobs in the state of Cordoba, Colombia, is explained in the article "**Occupation Choice in the Rural Labor Market from the Córdoba Department in Colombia**", by Alfredo Rafael Anaya Narváez, Jhon William Pinedo López, and Carlos Fernando Doria Sierra. This paper focuses on the structural hurdles that the rural work force encounters that leads them to seek alternative jobs in urban areas – via factors such as human capital, age, residence, gender, and others, that affect the choice of job. The econometric Logit multinomial model was used together with the information provided by the Great Integrated Household Survey (GEIH, in Spanish) carried out by the National Administrative Department of Statistics (DANE, in Spanish), during the third trimester of 2019.

All in all, this special issue presents alternative views to the academic and scientific community that look toward a sustainable management of the economy in the framework of rural development and its connection to the city. To be sure, the ideas of Georgescu-Roegem the father of Bioeconomics, is a guiding thread in the papers selected here, which all aim at a solid critique of the very grounds of political economy.

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Socioecological practices and community resilience strategies for sustainable agriculture in lower Sinú, Colombia

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Abstract

This research examines the socioecological practices of rural communities as an epistemological foundation to configure community resilience strategies and face socio-environmental conflicts due to limited access to water, loss of biodiversity and ancestral knowledge. To meet this objective, a qualitative approach was used with a non-experimental transectional research design of exploratory type with a case study method in the Association of Producers for Community Development of the Cienaga del Bajo Sinú-Asprocig, Colombia. As a main result, it is argued that the rural communities of the lower Sinú organized in associations carry out self-management models that promote the articulation of social and ecological systems, socio-environmental sustainability and make an adequate management of use and access to ecosystem services.

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Introduction

The social and economic changes of particularly the last two decades have increasingly led to environmental changes, such as climate change. The impacts of this phenomenon on peasant communities and traditional agriculture are manifested by a possible reduction of up to 50% in crop productivity due to higher temperatures, droughts and heavy rainfall (M. Altieri & Nicholls, 2008).

The effects of climate change and variability on agricultural production systems are increasingly evident in vulnerable populations in smallholder and subsistence agriculture is exposed (Doering, Randolph, Southworth, & Pfeifer, 2002; Morton, 2007). Scientific studies show that the potential impacts on maize production in Africa and Latin America by the year 2055, foretell signs of concern about the challenges of ensuring food security and reducing poverty (Jones & Thornton, 2003). Therefore, it is evident, two decades ago, the affectation on the overall productivity of the crops (Reddy & Hodges, 2000), generated in turn by recurring climate variability events (Rosenzweig & Hillel, 1998, 2008).

There is also scientific evidence of agroforestry management as an adaptation strategy for coffee agriculture in the face of possible extreme microclimate changes (Lin, 2007) and droughts and desertification in West Africa (Mortimore, 1989). These attempts to understand the ecology and ensure food self-sufficiency are being developed by rural communities highly vulnerable to climate change and in condition of poverty to ensure local quality of life (M. Altieri & Nicholls, 2008; V.M. Toledo, Carabias, Mapes, & Toledo, 1985; V.M. Toledo & Solis, 2001).

Agro-ecological innovation schemes aimed at increasing food production under the participatory model (Uphoff, 2002) and the yield advantages of intercropping and irrigation systems (Natarajan & Willey, 1986), are alternative models of peasant agriculture management that offer responses to the adversities of climate change and food sovereignty, trends that are increasingly developing worldwide (M. Altieri & Nicholls, 2012a).

In this context the notions of community resilience and the integrated system of self-organization (Berkes & Ross, 2013; Marasco, Kammouh,

& Cimellaro, 2022) are externalized as other ways of thinking about the relationship between human beings and nature, which point to new paradigms of rural development and conception of the world of life in the face of the current ecological crisis (Becker, 2012; Ocampo-Fletes & Escobedo-Castillo, 2006; Zemelman, 2000, 2003). Community resilience is understood as experiences of collective action to defend themselves from the effects of climate change and protect their crops (Belloni, 2017).

This research paper focuses on the context of socio-ecological practices of rural communities to overcome environmental problems and conflicts around water and territory (Altieri & Nicholls, 2012b; Martinez-Alier, 2008; Martinez-Alier, Kallis, Veuthey, Walter, & Temper, 2010; Sepulveda, 2015; Sepulveda, Taborda, & Fuentes, 2020; Toledo, 2013). Social-ecological practices have recently gained importance not only in rural agro-ecosystems (M.A. Altieri, 2018; LaRota-Aguilera, Delgadillo-Vargas, & Tello, 2022) as studied in this paper, but also in private organizations in their eagerness to commit themselves to the causes of the ecological crisis, although in many cases these are empty intentions or facades (Meisinger, 2022).

The interest of this research arises from the significant trajectory and management of the Asprocig association with the creation of family and collective ecological agroecosystems, positively impacting the management of soil, water and biodiversity. The resilience practices and strategies carried out benefit the community (social impact) and the conservation of nature (ecological impact), actions that are nationally and internationally recognized and are studied to explore in them, the knowledge and experiences to be discussed in scientific meetings.

From this perspective, the objective is to examine the socioecological practices and resilience strategies of three associations belonging to the Association of Producers for the Community Development of the Lower Sinú Swamp – Asprocig –, in order to validate whether they are a viable alternative to control water and territory and neutralize the driving forces that generate territorial disputes. Asprocig currently groups 13 associations located in the lower Sinú basin, Colombia.

Asprocig was created in 1987, in the municipality of Lorica, department of Córdoba, near the perimeter of the Ciénaga Grande del Bajo Sinú (Colombia). It is a grassroots community organization, organized by peasants, fishermen and indigenous people who bring together 6,200 families in 2,332 areas of land (hectares) (CORSOC, 2016). Its proposal for territorial rural development seeks to rescue the ancestral culture of the Zenú people, in relation to water management for agricultural activities, the integrated management of local wetlands, the promotion of agroecological production and the training/administration of community projects.

The model is based on the principles of non-violence (peaceful resistance), autonomy, solidarity, resilience, adaptability, cooperation and sustainability. It is a commitment to life and the need to consolidate actions that contribute to improving the well-being of communities and the conservation of the region's natural resources, especially water.

The history of Asprocig can be divided into four moments; the first from 1990-1994 was characterized by the beginning and reorganization of the association; the second from 1995-1998 which explains the struggles for the defense of the territory and culture; the third from 1999-2000 period in which political and economic forces were acquired to carry out the institutional mission. Two important social and legal events stand out in this period: the resistance to the URRA I dam and the tutela action brought before the Constitutional Court in 1999, with a ruling in favor of Asprocig. In economic terms, alternative agriculture and aquaculture programs were developed and later consolidated as family and collective agroecological systems with a positive impact on the community.

The fourth period, 2001-2004, was characterized by Asprocig's strong opposition to the execution of the URRA I hydroelectric power plant, the development of the local shrimp industry and the construction of several irrigation canals that affected the water dynamics of the Sinú river basin.

The paper is organized in four sections. The first one presents the theoretical bases of socioecological practices and community resilience strategies, then in materials and methods (second section), the research approach is explained, which is qualitative and exploratory, with case study method and bibliographic repertoires techniques, participant observation and in-depth interviews with 30 reporting members of the Asprocig association. The processing and analysis of the information was done with the use of Atlas.ti V8 software. The third section presents the results. At the end, some conclusions are drawn.

1. Background

1.1. *Theoretical bases of social-ecological practices and community resilience strategies*

Ariztía (2017) indicates that research on the theory of social practices is studied from three standpoints, namely sociology (Giddens and Bourdieu), ethnomethodology (Harold Garfinkel), and philosophy (Theodore Shatzki and Wittgenstein). The author indicates that in this disciplinary field, the advances in the field of environmental sociology and sustainable consumption are recognized, which lead to the understanding of the social world as

a practical result, and constitutes a theoretical reference to explain the processes of transformation and social change through the categories of structures, relations, dynamics and evolution in the spectrum of social and environmental practices.

The notion of social-ecological practices has been investigated in recent scientific literature. Theoretical and methodological contributions revolve around the study of the social-ecological resilience of agroecosystems to the effects of social and environmental phenomena, the most important of which are climate change and human appropriation of nature (M. Altieri & Nicholls, 2012b; Belloni, 2017; Henao Salazar, 2013; Nicholls Estrada, Ríos Osorio, & Altieri, 2013; Sepúlveda & Diaz-Cid, 2019; von Glasenapp & Thornton, 2011).

The concept of resilience has been of great academic use in various disciplines, including physics, which is considered the pioneer in using it to express the condition of elasticity and plasticity of a substance (Greene, R. y Conrad, 2002). On the other hand Holling (1973) uses the term to explain the complexities of ecological systems, contributions that contribute to the social sciences, particularly psychology, with Rutter (1993) and Werner (1994) guiding to the study of successful adaptations in the individual in the face of perturbations due to biological risk factors.

The studies of individual resilience approached from psychology contributed to other fields of social sciences to recognize in the concept a response to conflict and crisis situations, no longer in the context of the individual or family but rather at the social or community level. Thus, since the end of the 1980s, discourses with different points of view have become known, debating the so-called "crisis of civilization", understood, in some cases, as a crisis of the economic rationality of capitalism and where rural peasant communities are shown as the basis for the construction of community or social resilience in the face of the crisis of civilization with the development of local knowledge to face socio-environmental problems in their territories (Azkarraga *et al*., 2012; Fuente, 2012).

In this regard Zemelman (2000) reflects on how to minimize the risks of pressure on the current economic system, which translates into a call to life in general and to lessen the pressures and ideologies that promote limitless consumerism and productivity engendered in the capitalist system. Therefore, it is urgently necessary the construction of a social knowledge that recovers the link between human being-nature, between the subject and the conflicting thing.

According to Maldonado (2014) such a link is achieved by reducing the arrow of time of entropy that is produced in the current economic system, by another arrow of time, that generates both life and possibilities, capable of building a new civilization. This other arrow corresponds to what

Prigogine called "dissipative structures" that are far from equilibrium, from the dominant order and with the capacity to self-organize a new order. In this regard Angel Maya (2002) states that "it is not possible, however, to confront the environmental crisis without a profound reflection on the very foundations of civilization" (p. 23), where Leff (2014) calls for the recovery of nature's capacity to regenerate, that is to say, the negentropic capacity of the ecological system. In this order of ideas, it is urgent to reduce the entropy that cohabits in the socioeconomic system, energy in disorder that reduces the possibilities of life of the planet.

Taking into account the what precedes and the considerations that ecology is an essential dimension for the life of rural communities, it is evident that there is a declared emergency, widely debated in the scientific community on the notions of traditional practices, local knowledge and exchange of ancestral knowledge, which seek to question the unfavorable actions of the dominant system and in turn offer solutions with ecological agriculture schemes (Einbinder *et al*., 2022; Favretto, Stringer, Dougill, & Kruger, 2022).

2. Materials and methods

2.1. *Research hypothesis*

The research hypothesis here is that Asprocig socioecological practices and resilience strategies help promote socio-environmental sustainability and make an adequate management of local natural resources to guarantee the use and access to ecosystem services.

2.2. *Research design*

A qualitative approach is used via a non-experimental transectional research design of exploratory type, which allows getting to know a community and its context at a given time, addressing a "previously unknown or little addressed phenomenon" (Hernandez, Fernandez, & Baptista, 2014, p. 91). The case study method is recommended to investigate socioeconomic events in communities and population groups (Hakim, 2000), which allows measuring and systematizing the behavior of people who are part of the studied phenomenon from qualitative and quantitative sources of information, the former being frequently used for exploratory, descriptive and explanatory research (Martínez, 2006).

The case study method is relevant for this research, because it aims to explore and understand the worldview of the affected communities and the forms of action in the face of a specific phenomenon that arises from everyday

life, with the use of qualitative techniques such as in-depth interviews. that obtain narrated data from the subjects from their explanations (Castro, 2012). Table 1 shows methodological aspects, theoretical and conceptual framework and general research questions that guide data collection.

Table 1 - Theoretical-conceptual and methodological framework guiding data collection

Theoretical framework	**Conceptual framework**	**Methodological aspects of the research**		**Data capture research questions**
Agroecology		Methodology		
Political	Socioecological			¿What are practices for the association and how do you systematize them?
Ecology	practices		Qualitative	
	Community resilience strategies	Method	Case studies	¿How do the daily experiences and practices create knowledgefor the association'smanagement? ¿What are the main strategies of the association to face and overcome the adversities ofclimate change and food insecurity? ¿How to guarantee food security to the families grouped in each association based on the socioecological practices developed by Asprocig?
		Technique	Bibliographic repertoires	
			In-depth interviews	
			Participant observation	

Source: Own elaboration (2021).

2.3. *Sample and data collection techniques*

Supported by the non-probabilistic purposive sampling technique (Otzen & Manterola, 2017), a sample of fifty-two (52) bibliographic repertoires was selected taking into account the organization of the documents indicated by Miguel *et al*. (2012) by subgroups, namely; scientific articles consulted in databases (Elsevier, Redalyc, Scielo, Latindex), electronic periodicals libraries (Dialnet, institutional repositories of public and private universities) and books. The selection criteria for the repertoires were made using search equations after formulating research questions (Gómez *et al*., 2014) (see Table 2).

Table 2 - Sample of bibliographic repertoires

Search equation	Bibliographic repertoire consulted	Type of repertoire	Quantity
Agriculture AND climate change	Scientific articles	Electronic	Eighteen
Civilizational crisis OR alternatives to development	Scientific articles	Electronic	Twelve
Social AND socioecological practices	Scientific articles	Electronic	Ten
Resilience AND community resilience strategies	Scientific articles	Electronic	Ten
Exploratory research	Scientific articles and books	Electronic	Two
	Total …>		**fifty-two**

Source: Own elaboration (2021).

On the other hand, for the in-depth interview technique, a non-probabilistic convenience sampling was used (Otzen & Manterola, 2017) given the attributes of accessibility and proximity of the informants members of three (3) associations attached to Asprocig, (in total there are 13 associations) and that in the opinion of the researcher determined by convenience four selection criteria for data capture, namely; seniority of the member (more than 10 years), community leadership (positions on the board of directors), knowledge of family and collective agroecosystems (proven experience in agroforestry systems) and internal knowledge of the association (decision-making capacity). In this sense, the convenience sample size was thirty informants, distributed ten per association.

Finally, the participant observation technique practiced by the main researcher evidenced the functioning and organization *in situ* of the family and collective agroecosystems, information that allowed validating with the techniques of bibliographic repertoires and in-depth interviews, the level of equivalence of the data obtained through the triangulation process (Okuda & Gómez, 2005), considered appropriate for qualitative research.

2.3. *Information analysis*

Based on Miguel *et al*. (2012) and Fox (2005), the analysis of the information in the bibliographic repertoires was carried out in three sequential stages: 1. documentary analysis of the contents. 2. summary, synthesis and condensation of the information. 3. drafting of the literature review or review article on the study of the interrelationships and structures (Kabalen & Sanchez, 1997) of the conceptual framework socioecological practices and community resilience strategies, as a dynamic process to organize and represent the knowledge patented in the documents (Perelló, 2011), in order to analyze from a historical perspective and critical thinking (Gómez *et al*., 2014) the characteristics of the problematic phenomenon and the solution alternatives presented.

The analysis of the data from the in-depth interviews and participant observation was carried out in two stages: first, the organization and transcription of the narrated and observed data, and second, the coding of recurrent categories of interest to the researcher. The Atlas.ti V.7.0 software used facilitated the structuring of semantic networks of the main categories socioecological practices (presented as an emerging category) and the five resilience strategies implemented by the three Asprocig associations.

3. Results and discussion

3.1. *Association of Producers for Community Development of the Cienaga del Bajo Sinú-Asprocig: Community resilience strategies*

> *Organizations that spend time reflecting on their own practice are learning organizations.*
> (Asociación de Productores para el Desarrollo Comunitario de la Ciénaga del Bajo Sinú [Asprocig], 2006, p. 103)

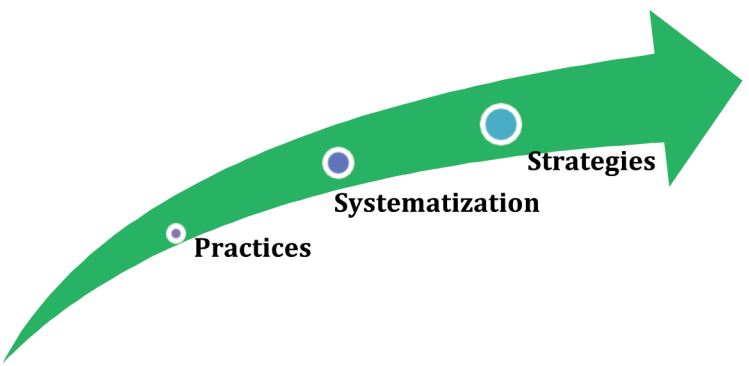
Practice is the most notable source of learning for grassroots organizations working for local development. It makes it possible to achieve a stable and sustained product, from which it is possible to transfer the experience built, check it with others and favor the accumulation of knowledge based on and towards praxis. In this context, this research defines practice as the set of individual or collective daily experiences that are shared within the community to rethink and recognize alternative ways of integrating social-ecological systems (Sepulveda *et al*., 2020)

The practice of each family or collective is the main input to build and systematize the community experiences. From the meetings and debates, the

successful cases of greater contribution in the man-nature relationship are filtered, to then socialize it with all the associates of the organization and its implementation (Asprocig, 2006).

From this perspective, the process of knowledge construction as a factor of social accumulation of power, starts from the systematization of experiments that each member unit tests and knows the benefits, to then spread among all partner units. The teachings are developed in the so-called agroecological schools, which are open training spaces for all affiliated members (Asprocig, 2006). Figure 1 shows the sequential process of creating resilience strategies based on the practices of the agroecological schools.

Figure 1 - Asprocig sequential process of community strategy building

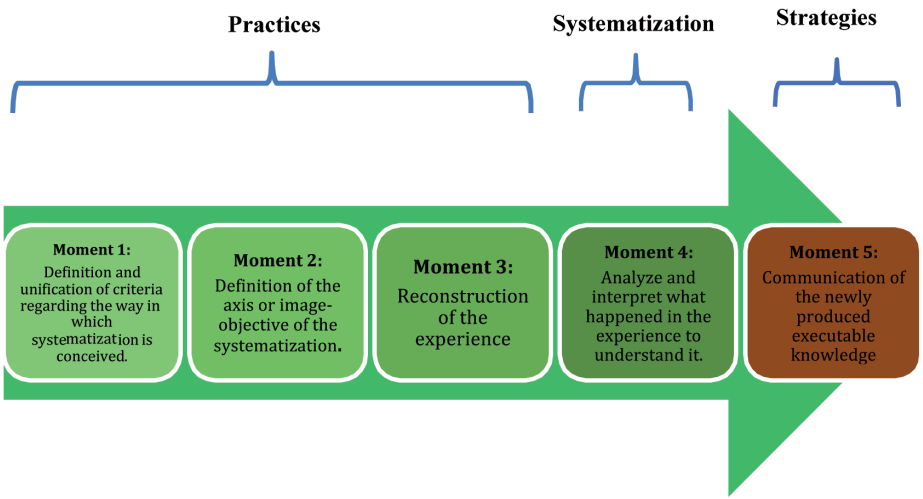


Source: Own elaboration (2022).

The systematization of experiences is a modality of knowledge production born from popular education and incorporated into social practices and community development (Torres, 1998). In this regard, the author states Systematization is understood as a form of collective knowledge on intervention and social action practices, which, based on the recognition and critical interpretation of the meanings and logics that constitute them, seeks to qualify them and contribute to the theorization of the thematic field in which they are inscribed (p. 3).

The process for the production of new knowledge from community practices is developed in five moments, each of which has its own particularities that ultimately allow the design of Asprocig resilience strategies. Figure 2 shows the moments for the generation of new local knowledge.

Figure 2 - Asprocig process for the production of new knowledge



Source: Own elaboration (2022) – adapted from Asprocig (2006).

Moment 1, the participants gather to present their points of view, discuss them and define the agreements that allow the construction of the what, how and for what of the topic in question. In moment 2, what is going to be systematized is specified, i.e., the first ordering of the experience where information is extracted from the experiences in order to place it later in the field of knowledge.

In 3, the process as it was developed is explained in detail, taking into account the diversity of sources of information such as: programming, progress reports and evaluations, records and memories of the participants. The 4th is considered the most complex for understanding what happened, through which the bases for the construction of learning and systematization are acquired. Finally, 5 is the communication and socialization of the new executable knowledge in the community, which are the strategies.

In the development of these five (5) moments, Asprocig has created a methodological approach called "Z" work methodology, which is conceived as a decentralized and pedagogical entity where experience and knowledge are the transverse axes of its actions. It is a teaching-learning strategy that is developed in communities with agroecological work.

Each agroecological community socializes with others, the practices and learning found in the process of knowledge production. The objective is to optimize methods and techniques developed in the experiences, making known the weaknesses and strengths presented in the plots and

yards, through the exchange of learning. These spaces for reflection and construction of new local knowledge are called agroecological spirals (Asprocig, 2006).

To evaluate the performance of the agroecological spirals, a certificate of trust was created (see Figure 3), which recognizes good sustainable and social practices and assesses them through the application of 32 indicators for plots and 28 for yards (Asprocig, 2006). In the research conducted by Ortiz *et al*. (2007) shows some of the results obtained.

For the second half of 2004, 234,419 m^2 of yard areas were evaluated and a total of 190,144 m^2 were certified, equivalent to 63.7% of the total number of members registered in the agroecological spirals. In the first years of operation of the Z methodology, in the case of plots, 1'167,180 m^2 were evaluated and 702,000 m^2 were certified (p. 85).

Figure 3 - Agroecological rice trust certificate

Source: Asprocig (2016).

In this way, the Z methodology represents a working tool for communities to exchange learning and produce new local knowledge in the agroecological spiral meetings (Figure 4).

Figure 4 - Methodology of work Z based on ancestral knowledge and lived community experience

Source: Own elaboration (2022) – adapted from (Asprocig, 2006).

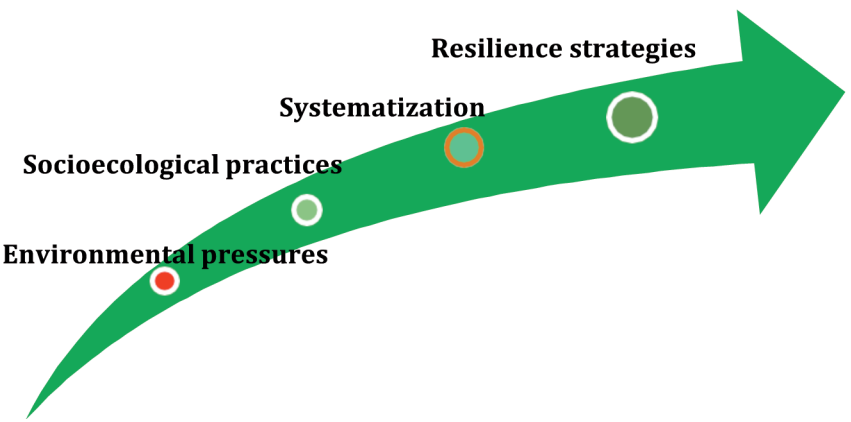
The letter "Z" defines two horizontal categories; ancestral knowledge and community experiences and another transversal one which are traditional and cultural values. All three are the foundations for developing family and collective capacities in the face of adversities that threaten the stability of agroecological communities, hence, the conceptual appropriation of resistance and resilience are the main mission strategies of Asprocig for the management of water and territory.

The first focuses on the defense, rescue and reappropriation of the ancestral knowledge of the Zenú culture, especially in relation to water resource management. The second is oriented to rethink and remake alternative socioeconomic models in order to strengthen the community economy and sustainability.

In this context, the present research defines strategy as the set of actions that aim to strengthen the community economy through the self-management of all its members in order to achieve good management of environmental sustainability. From this point of view, Asprocig resilience tactics are classified into two groups: ecological and socio-cultural. The former are ecosystem and species conservation, while the latter are related to local social knowledge that guarantees quality of life for all associates.

Both are aimed at reducing water conflicts, a process that is achieved with the empowerment and development of particular categories of critical consensus and life expectancy, which allow the construction of a larger category (general), which emerges in this work, as new; *socioecological practices*, and which are the result of a historicity manifested by environmental pressures such as surface water pollution, the drying up of wetland systems, disputes over territorial control, institutional absence, deforestation, erosion and sedimentation. The process of structuring resilient strategies is detailed in Figure 5.

Figure 5 - Structuring of Asprocig resilience strategies



Source: Own elaboration (2022).

Figure 5 shows that there is a logical, coherent and dynamic order in the process of organizing resilience strategies. The triggering elements that incite the structuring of collective actions in the communities are environmental pressures, leading to the creation of socioecological practices. These arise from daily life, subjected to *in situ* experimentation (plots or backyards) and which, after systematization, provide the referential framework for organizing resilience tactics.

3.2. *Socio-ecological practices: an emerging category of analysis*

Socioecological practices are a new category of analysis that arises from the application of qualitative research techniques. It arises from merging community resilience and family and collective agroecological systems

of Asprocig communities, to build collective actions in pursuit of the association's mission purposes and to counteract conflicts over water and territory. In this order of ideas, the resilient strategies that emerge from the emerging category configure Asprocig rural development model.

The conceptual characteristics of socioecological practices are built from the communities' interest in life, biodiversity conservation, family cohesion and defense of water and territory. It is a community paradigm that recovers from Zenú ancestral knowledge the social and economic devices to oppose modern capitalist logics that stimulate capital accumulation with severe environmental damage. From this perspective, the emerging category is related to the solution of environmental problems related to water in the lower Sinú.

Within the emerging category are the subcategories of critical consensus, rural water management, soil management in peasant and indigenous communities, agroecological systems management, ancestral knowledge as a social factor of power, family cohesion, fishing in ponds, ecological and organic agriculture training, and life expectancy. All of them prioritize nature and human existence (and not only markets) as the fundamental.

Asprocig socioecological practices try to transmit to other communities to cooperate and communicate that there are different ways of production such as zero tillage practices, which favors the presence of organic matter and humus necessary for the health and fertility of the soil and therefore to maintain crop productivity (ecological) and income generation (economic). This requires the abandonment of conventional agriculture, which is mechanized, monoculture and short term, for other, conservation and good soil management, such as ecological agriculture, which is alternative, polyculture-oriented and highly productive in the medium and long term.

The need to move from conventional practices to alternatives is based on the urgent need to face the current ecological crisis, understanding the current damages as irreversible. The transition schemes should recover and/or strengthen the epistemological contributions developed by biology in the understanding of the natural world such as biodiversity of species, self-organization; from physics with resilience and entropy; and more recently from the science of complexity with dissipative structures, categories that are read and understood in the daily life of communities and are necessary for the escape from the ecological conflicts that affect them.

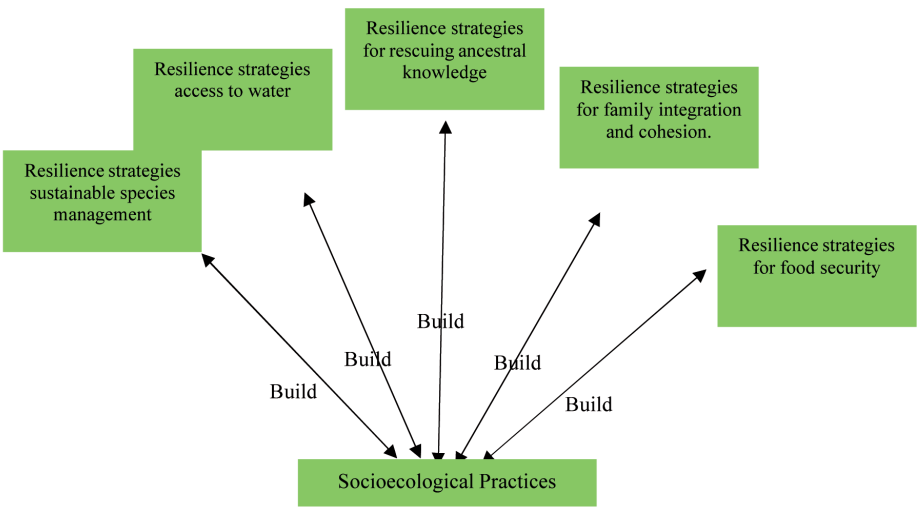
It takes up concepts from agroecology, ecological economics and political ecology to configure, from community practices, a style of production that articulates community work with nature, which leads to guaranteeing the balance of natural functions in order to conserve it in the long term.

The paradigm on which the emerging category of analysis is based recovers the importance of ecology in the economic activities of agricultural

production, considering that the elements of the biosphere, especially water and land, are fundamental to overcome the current ecological crisis with new management approaches.

However, as these contributions of knowledge do not come from the academy or the scientific world, it is necessary to investigate other epistemologies that broaden the radius of understanding in the human-nature relationship, such as those offered by the communities of the lower Sinú. In this sense, the socioecological practices enunciated in this research allow the understanding of Asprocig resilience strategies in the face of socio-environmental conflicts. Figure 6 shows the set of tactics born from the practices after following the described process.

Figure 6 - Social-ecological practices and resilience strategies of Asprocig



Source: Own elaboration (2022).

Each resilience strategy aims at achieving a purpose, which form the essential foundations for the configuration of Asprocig organizational, social and cultural project. In this order of ideas, the proposed category of socioecological practices is understood as the historical-sequential, structured and empirical process that contributes to the construction of new local knowledge (own knowledge) and that, when systematized, allows the configuration of community resilience strategies to face diverse local environmental pressures.

In this sense, the socioecological practices represent the actions that are applied in each family agroecosystem and that are subjected to the Z methodology, to then be socialized in the agroecological training schools or agroecological spirals. From here emerges an own knowledge that allows the configuration of resilience strategies, which is explained below.

3.3. *Asprocig Community Resilience Strategies*

Based on the data and information obtained from the three associations investigated, it was possible to classify Asprocig's community resilience strategies into five groups, which represent collective actions to defend the territory and confront the appropriation and dispossession of water, generators of water conflicts in the last two decades. Each of them is presented below.

The first is the strategy for the *sustainable management of species*, which has two missionary purposes: to increase the sustainable supply of fish resources and the sustainable production of plant and animal species favored by the organization. Priority is given to increasing the supply of bocachico, cachama and tilapia fish for two reasons; first, to conserve the work inherited from the associates with the fishing activity and second because fish is the main source of protein for these communities.

This strategy led to the construction of ponds for fish farming and the adaptation and implementation of agro-ecological systems in all the associations for the production of poultry, pigs and six (6) types of medicinal plants, fundamental for the configuration of Asprocig community development model

Access to water is the second strategy. Its mission purpose is focused on three aspects; the defense of the resource from contamination and wetland drying processes, increase of water harvests through ponds and adaptation to climate change. The achievements are evident as shown in the three associations investigated, in essence each association has a harvesting system that allows facing adversities in periods of drought and giving continuity to the production of plant species within each agroecological system.

In addition, the construction of embankments or high dams based on Zenú hydraulic technology has allowed them to face the frequent floods in the lower Sinú, which have been recurrent in the last decade. Although water contamination and the drying of wetlands is revealed as an external situation not controlled by the communities, self-management actions have allowed them to maintain a cyclical state of equilibrium in the face of the adversities of climate change.

The third resilience strategy is the *rescue of ancestral knowledge* for the implementation of pre-Hispanic technologies related to the management of water, land, crops and political and social organizational systems. It is a philosophy born from the communities that has the firm intention of reestablishing the link between culture and nature, recovering the practices of the Zenúes settled in the Sinú and San Jorge valleys between the 1200 b.d. and 800 a.d.

The achievements attained are shown in Asprocig member associations, with the implementation of agroecological systems that develop sustainable water and soil management. This strategy is transversal and integrative to all the others and sends signals to the associates about the need to work with criteria of productivity, adaptability, resilience, equity and self-management in each agroecosystem.

The fourth strategy is related to *family integration and consolidation*. Its mission is focused on strengthening community management capacity, integrating the family in the development and implementation of family and collective agroecological systems, as well as encouraging the commercialization of products in their own distribution channels. Its main characteristic is the importance given to women and the other members of the family nucleus in cooperating in all economic, social and political activities of the organization.

The central point is to increase family cohesion as a way of conceiving family teamwork, which was fundamental in the Zenú culture. For Asprocig, this tactic allows redefining the concept of agroecology, arguing that it not only refers to processes that make a sustainable management of agrological activities, but also to the form of participation with which the different members of the family are integrated in the different community activities. This indicates a new *community ethos* with the re- emergence of social empowerment in *praxis*.

Finally, there is the strategy for *food security*, which seeks to improve family and collective agroecological production models that minimize threats to community well-being. It is the most significant of all Asprocig resilience strategies, defined as the capacity to take advantage of the flow of matter and energy from natural ecosystems and reduce waste that generates high entropy through the increased reuse of biomass in the agricultural production cycle.

The lower energy dissipated in agroecological systems with good management and conservation practices is a product of rural skills that lead to new forms of rural development. As the capacity to recover, reuse and preserve ecology increases, the high entropy of the economic subsystem decreases and resilience for equitable food access increases.

The strategy defines as a priority the access to food for members and non-members of Asprocig, to realize a fair trade of agroecological products from

the surplus production, which is carried out in the facilities of Asprocig in the city of Lorica, Colombia and improves the income of families and therefore their quality of life.

It is clear that the experience represented by Asprocig is not isolated; the phenomenon under investigation has been studied considerably in recent times in different parts of the world. The concern of organized peasant communities to fight and defend their territories, confront current socio-environmental conflicts and propose alternatives for sustainable local development has intensified since the 1980s (Wolf, 1973; Toledo, 1992,1996; Zemelman, 2000, 2003 Toledo y Barrera-Bassols, 2009; Wlater, 2009; Altieri y Nicholls, 2012a; Swyngedouw, 2013; Batterbury, 2015; Sepulveda, 2015; Sepulveda *et al*., 2020).

The findings coincide with the need to strengthen governance around the relationship between economy and nature (United Nations, 2018), prioritizing efforts to promote sustainable agriculture in order to reduce hunger through food security and improved nutrition (Altieri, 2019). Faced with this global challenge, research has been developed that explores and explains the management and evaluation of agroecosystems with the use of quantitative and qualitative approach methodologies and participatory and cooperative processes, which attempt to measure the agroecological resilience of social-ecological systems through sustainable agricultural practices. The aim is to improve the efficiency of agroecosystems and the well-being of communities (Torre *et al*., 2023; Puech & Stark, 2023; Davis, Huggins & Reganold, 2023; Rice, Einbinder & Calderón, 2023; Benabderrazik *et al*., 2022; Little & Sylvester, 2022; Mudombi-Rusinamhodzi & Rusinamhodzi, 2022; Bartl, 2020).

Research efforts towards sustainable agriculture in the context of the community economy should be strengthened by both local and regional governments in order to promote food sovereignty and security, mitigate socio-ecological vulnerability and consolidate the collective commitment towards sustainable rural development.

4. Conclusions

The exploratory research developed in this work allowed us to verify that Asprocig socioecological practices and resilience strategies promote local socio-environmental sustainability and ensure the adequate management of natural resources to guarantee the use of and access to ecosystem services.

Meaningfully, the experiences, practices and knowledge arising from Asprocig can be safely understood as valuable and successful alternatives to development, one seed of a new civilization. Generally speaking, the agroecological school is a clear-cut example of bioeconomics taken as a critique

of political economy (Maldonado, 2022), i.e., a critique of the production function *après la lettre*.

The central element of this model of community economy is the local knowledge that is built from socioecological practices, which are subjected to a verification process with its own methodological scheme and shared in spaces of reflection with training through the agroecological school created by them. The process of configuring new local knowledge begins with the lived experience and appropriation of ancestral knowledge, which is then systematized to analyze and interpret what was found in the experience and in this way, codify collective actions to establish strategies. The conceptual notions of resistance and resilience are Asprocig main mission strategies for water management and territorial defense. Based on these, community resilience strategies are self-managed, which are essential in the sustainable rural development model: sustainable management of species, access to water, rescue of ancestral knowledge, family integration and consolidation, and food security.

One aspect to highlight is the self-management scheme of the board of directors. It is made up of the members of the association, rotating periodically and all of them must direct their administrative and financial efforts towards the consolidation of the mission and the resilience strategies; in such a way that the social (members of the three associations), economic (development of family and collective agroecosystems that develop farming and fish farming activities) and environmental (biodiversity conservation) dimensions, constitute the epistemological referents to contribute to the achievement of Asprocig's mission purposes.

Finally, local and regional governments are urged to manage environmental public policies that respond to the global call contained in the Sustainable Development Goals and promote alternative models of rural development, such as agroecological markets managed by organized rural community associations with small-scale agricultural production systems

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which are shown as a model of alternative and sustainable rural development in the lower Sinú basin. Thank you very much.

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Qualitative indicators for community water resilience in floodable areas: Agricultural pantry of La Mojana, Colombia

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Abstract

The subregion of La Mojana is a national geostrategic region. It includes the basins of the rivers Magdalena, Cauca, and San Jorge. This location has abundant wetlands, *zapales* (particular marshes from the region), and swamps where there are cyclical floodings and droughts. This region is also considered to be a great reservoir of freshwater, very rich in biodiversity and a place with productive wetlands. It is considered a food reservoir, and despite its cattle-raising tradition, 20% of the rice consumed in Colombia is cultivated here. In addition, it consists of water and land ecosystems that stimulate an agricultural, cattle raising and fishery base: productive fields which generate 90% of the economic productivity of the area.

Between 2021 and 2022, frequent and historical floodings affected 24253 acres of agricultural land, especially the 9633.2 acres of rice crops. There has also been registered some damage to other production units such as corn (645.2 acres), plantain (194.5 acres), cows (6757), pigs (6083), horses (603), poultry (40287), and more than 550000 fish. According to the Register of Victims (*Registro Único de Damnificados,* in Spanish), no less than 45000 people were affected by the winter wave in 2021.

In order to achieve the objectives stated in this article, three phases will be developed: the first one involves the construction

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of the conceptual framework, explaining the nature of the community water resilience category and the pre-identification of the categories and dimensions that are going to be used in the construction of the indicators. In the second phase, a methodological description is established. Finally, in the third phase, an estimation of the qualitative indicators is formulated. The results will help decision makers to generate projects that minimize the damages caused by the flooding.

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Introduction

The groups of natives that populated La Mojana were the Zenúes – gold, water, and ceramic worshipers. They established themselves in three provinces: the first was Finzenú, located near the Sinú River – a place of mysticism and spirituality and a place known for its mysticism and spirituality and, therefore, a place for worship. The second province was Panzenú, located near the San Jorge River – that in those times worked as an economy and trading location. The third was Zenufana, located in the lower valleys of Cauca and Nechí – an area with plenty of minerals and gold production. The feature that these collectives held in common was that they settled in hydrological ecosystems that contributed to the development of different cultural, economic and political practices (Plazas & Falchetti De Saens, 1981).

Geographically, the Momposina Depression subregion (Figure 1) has an edaphic composition of wetlands that belong to the river network of the Colombian Caribbean, such as the Magdalena River, Cauca and San Jorge, which act as water regulators in the municipalities of four regions: Sucre, Córdoba, Antioquia, and Bolívar (CBS & CORPOMOJANA, 2002). To obtain its results, this study was concentrated territorially in the municipalities of San Marcos

Figure 1 - Municipalities that make up La Mojana

Source: MINHACIENDA (2016). Action Plan for Flood Risk Reduction and Climate Change Adaptation in La Mojana (2016).

(El Pital, Cuenca, El Torno, and Las Flores sidewalks), San Benito Abad (Las Chispas, Pasifueres, Chinchorro, Tosnovan), located in the region of Sucre, and Ayapel (Cecilia, Sincelejito, and Seheve), located in the Córdoba region.

In addition to the mercury water pollution developed in La Mojana, rivers have altered their capacity to buffer and regulate water in winter due to the construction of artificial canals of almost 30 meters wide and 5 meters deep, and the engineering works used for the drying of the swamps. In addition, this territory has other problems such as drying out, limitations in the interaction between the river and swamps, sedimentation, and inadequate outflows of sewage. Other socio-environmental problems are tree felling, unsustainable fishing practices, and the exploitation of gold and mercury (CBS & CORPOMOJANA, 2002).

This region has been subjected to the sudden expansion of rivers on a regular basis for the last 30 years. By 2022, for example, the floods had left more than 100000 victims, 35000 damaged goods, and extreme losses in livestock, rice, and other products from small groups of peasants (Díaz, 2022). Looking at the history and evolution of the impact of floods in the region, it can be observed that these data have remained unchanged in history.

After analyzing the rain period between 2010 and 2011, Urquijo and Vergara (2013) stated that it brought 500 deaths and more than 3.6 million victims, being one of the strongest rainy periods, especially if compared with the one between 1998 and 2008: between April 2010 to June 2022 – just in these 14 months – 1734 flooding events were registered, representing the 45% of the total events occurred between 1998 and 2008.

With this information, different international missions and national institutional projects have been studying the region since the 1970's, like the Colombian-Dutch Mission (*Misión Colombo-Holandesa*) which offered recommendations that were overlooked until the present, such as the adequation, connection and periodical cleaning of canals, the building of new roads, the improvement of public services, and hydrological planning alongside community development processes (Himat, 1977; Departamento Nacional de Planeación & FAO, 2003; Aguilera Díaz, 2004; Departamento Nacional de Planeación, 2012; Urquijo & Vergara, 2013; IDEAM, 2017). Finally, in 2022, the National Council of Economic and Social Politics (CONPES, *Consejo Nacional de Política Económica y Social*) is looking forward to fostering climate resilience and sustainability in La Mojana. It can be said that many technical and academic views have been shared regarding what is now an over-diagnosed but little-intervened territory.

Some academic studies have focused on the physical form of the threat in this region and on the value of the physical and social vulnerability, but neither of these two analyses has been integrated into the risk assessment (Villegas, 2020). Other groups of studies refer to an ecological view and the

ecosystem services associated with biodiversity (Caraballo & De la Ossa, 2011; Humboldt, 2018). Another line of research is related to production systems, namely, small rice producers that are part of this farming economy (Cadena Cuello & Romero, 2021). On the other hand, for the last decade, different researches about the need of studying on a regional and local scale have prevailed, aiming to design the intervention and environmentally restauration scenes. Despite this, there are very few works referring to social indicators of qualitative perspective that also contemplate the contribution of the resilient communities that live in hydrological areas, who are prone to experience frequent floods.

In this context, the present study was developed to formulate a group of hydrological qualitative indicators that consider the features of resilient abilities in La Mojana. This was formulated by contemplating the community involvement and the knowledge dialogue, and by considering a phenomenological approach that aims to change the traditional research on which descriptions and data are taken from a distance, from the observer and narrator perspective, with descriptive surveys that are limited to a subject that is alienated to the world, and which captures and materializes this information. It is hoped that this study becomes a useful tool for researchers, entities responsible for managing emergencies, entities that integrally manage water resources, and, in general, for everyone in charge of land planning and management.

Therefore, it's important to move forward with the study of these amphibious communities in regard to their resilient processes, cultural practices, ways of living, governments, and valuable information on territorial ordering processes, as much as it is important to advance with the planning of a public policy approach in diverse orders. In this context, this article will include the results of a rich human and investigative experience considering the population of two regions in the North Colombian Cost (Sucre and Córdoba), three municipalities (San Marcos, San Benito Abad, and Ayapel), and eleven sidewalks.

The configuration of community resilience

The concept of resilience is multivalent in nature, considering the use made by various authors and disciplines. For some, it came about in the 80s within the Social Sciences to explain the positive skills that people developed in complex contexts: shortage, permanent loss, dysfunctional families, and extended stress situations (Arciniega, 2013).

Other authors date the beginning of these studies in observations made since the 70s in the field of child psychology, with children in threatening

and unprotected environments who achieve a positive adaptation thanks to the possibility of interacting early with healthy growing-up environments (Kaplan, 1999; Lynch & Cicchetti, 1998).

Later, studies on resilience in adults resulted in new responses and typologies, especially for the various problems that the category has generated in its multiplicity. That is why Bonanno (2012) identified resilience as a personality trait, as special unattended psychopathology, and as a category that can be considered a psychological and emotional balance.

A meta-analysis study conducted by Lee *et al.* (2013) involving 31 071 participants and 33 studies showed that there are personal factors that preserve and generate resilient processes, namely: confidence, positive affection, self-efficacy, self-esteem, social inclusion, and risk factors such as anxiety, depression, distress, and perceived stress.

However, in terms of environmental studies, resilience has been studied for a longer time and was initially applied in Holling's work (1973), who, through the field of ecology, showed that the concept was meant to understand and manage complex systems linked to people and nature. Later, from the systemic theories, it was defined that the term resilience would be the ability of a system to absorb and recover from a new event (Klein *et al.*, 2003) fully and harmonically.

In the 1980s, when the concept of resilience was consolidated in various disciplines, such as biology, geomorphology and anthropology, its main use was still that of invulnerability. In Rutter (1993), the concept appears as an exclusive, constant, and unalterable format. Vulnerability and resilience were born as general characteristics, not permanent nor inherent to the people or groups, given that they change according to the type of adversities or circumstances in which individuals are found. After many studies, it is still not clear how this concept should be used and what are its determining factors or how they can be measured. Although, recent literature on threats and disasters often refers to the concept of resilience as a guiding principle behind effective threat risk management, making it operational for policy, which poses critical challenges in terms of its evaluation (Gómez & Rivas, 2017).

On the other hand, the concept of community resilience was born mainly in the 1990s, with theories of natural hazards applied to multiple social situations: tremors, floods, hurricanes, hunger, and human displacement (Arciniega, 2013; Brangwym & Hopkins, 2010; Marzana *et al.*, 2013).

In conclusion, resilience is not just the ability to withstand a hostile experience, it also involves actions of greater importance which means detecting and warning of possible misfortunes with the ability to recover after the harm (Uriarte Arciniega, 2010).

Community resilience is the ability that a group of people has to overcome situations of stress and stand above any difficulties. It involves assuming

adversity together, collectively developing the ability to be constantly informed from a wide basis of strengths and opportunities. This dimension has a multiplicity of common practices to perform, like increased confidence and achieving protective and restorative actions; therefore, it is not only necessary to compile information to face difficulties (Acinas, 2007). The community is strengthened through the possibility and ability to build collectively and achieve the required results.

In short, we can define community resilience as a collective dynamic where common goals and shared needs are achieved through collectively overcoming difficulties. It is for this reason that each group, from its social, political, and economic experience, finds a mastery of techniques and skills acquired through common learning. This includes shared emotions, emotional control, and collective memory. It is necessary to emphasize that it is not only a problem of overall aptitude but also of technical and creative knowledge to face the challenges and obtain, from this perspective, a collective integration (Alzugaray, 2019).

Resilience at the community level determines forms of social connection with nature since they are built with collective effectiveness in mind. That is to say, the ability to interact collectively facing human difficulties to reach an expected end. In this way, the collective faces, without major difficulty, the impacts of the disasters attending to aspects of locality, communication, and mutual support, thus creating diverse positive emotions (Fredrickson *et al*., 2003).

The effects of adversities are not only conditioned by individual actions, but they also depend on organized collective motions, such as the help from organized families, the experience of the communities in critical intervention, and the experience in the intergroup emotions (Wlodarczyk *et al*., 2017). However, when negative experiences are constant and handled individually, social isolation, depression and anxiety occur (Rubin *et al*., 2006). Resilience, from a psychological standpoint record how trauma is transformed into growth actions (Bonanno, 2012).

In summary, resilient individuals develop strategies that are appropriate to face problems from a self-efficacy perspective. This way, they recognize the value of emotions and positive affection that comes from taking on traumatic events that are also collective (Fredrickson *et al*., 2003; Fredrickson *et al*., 2008). Community leadership allows individuals to face these problems given that they set, organize, and stimulate collective actions so that organized communities can solve and confront adversity. This organizational dynamic consists of self-efficacy, persistence, creativity, independence, challenge, audacity, and, mostly, of being prepared for adversity.

As Uriarte (2010) points out, several definitions for resilience were brought up in the last decades and can be grouped into three categories: resilience

as systemic stability against the coup, as reparation, and as transformation. The first refers to coping with a difficult situation; the second involves the ability to resist, to protect integrity; and resilience as transformation refers to strengthening people's skills and competencies for adaptation to changes, and to strengthening from weaknesses.

From the above, it can be observed a field of knowledge is being formed: one of resilience as a whole and one of community resilience. These two options are conformed by multiple publications with theoretical bodies and concepts that are still vague, without conceptual and methodological clarity, which lead to difficulties for mediation and proper evaluation (Sharifi *et al.*, 2016). The concept of resilience is increasingly being used in a practical and reflective manner, in academic and political circles where there are a variety of entities, including national and local organizations, and international organizations.

Aguirre and López (2017) point out from the theory of complexity that community resilience is linked to the transcendental biography of individuals, as well as to the particularities of belongingness, the environment, and its context. This perspective suggests that resilience at a collective level is achieved through systematic interrelationships and interactions (more than just individual activities) addressing the social entity. However, despite the attempts by many to characterize and quantify resilience in a socio-ecological context, it has been proven that providing its measurement outside a numerical scale was not possible (Cabell & Oelofse, 2012). Within the qualitative perspective of resilience, traditional knowledge must contribute to scientific research through knowledge dialogue.

Community water resilience to flooding

In relation to resilience and its effects on floods, it's been three decades since a new point of view was developed within the social sciences to study natural disasters, urban and regional planning, as well as the territorial order, in contrast to the naturalistic view of the natural sciences, which considered calamities to be isolated geophysical factors that are not systemic and are considered as disconnected from the most vulnerable communities. In this sense, the experience of going through a disaster doesn't depend on the event as much as it does on the fragility of the society exposed to danger and on the preparation that each community makes to face it (Aversa *et al.*, 2020).

In a study on flooding in the Upper Thames River region in Canada, Peck, Karmakar and Simonovic (2007) consider three components of analysis: threat, exposure, and vulnerability. These factors offer a broad understanding of the manifestation of a flood in specific localities, to the extent that it allows the generators of public policies and territory planners to design new spatial

planning and the configuration of infrastructure with traditional and technical knowledge.

Peck *et al*. (2007) point out that in flood vulnerability there is a need to quantify susceptibility and the attention to the different difficulties generated in a region or population. Balica, Douben and Wright (2009) take a different perspective. They define the vulnerability to floods that manifest in a community as something that is always susceptible to new exposures and permanent threats. For this reason, they combined three categories of water resilience: the ability to resist, recover, and transform. The risk analysis methodology is based on four categories described by Balica *et al.* (2009) and Peck *et al*. (2007): physical, economic, infrastructural, and social.

In general, floods are one of the risks that occur mostly in various ecological landscapes, affecting much of the economy and daily life, this being a feature included in the risk assessment. In addition, this assessment is not purely of parametric nature. Around the world, there is a need to improve the understanding of risk and its vulnerability with new forms of comprehension based on qualitative knowledge. A new variety of theories and concepts in the practical study and experience of risks of and vulnerability to floods should guide the process.

In many countries, the Geographic Information System (GIS) has been able to show the impact of flooding in areas with periodic monitoring of days and months, locating its impact in critical facilities, such as emergency service stations, roads and bridges. These studies accept that land use and soil type are considered the two major mechanisms of flood exposure (Balica *et al*., 2009).

Water resilience emerges as a concept from the contribution of these authors and organizations in the following manners: GOAL (2015) configures resilience as the ability to anticipate an external difficulty capable of resulting in flooding; from natural risk management; Meza (2021) sets this concept as an urban trait that occurs with the strengthening of resilience with socio-natural and political-economic components; the International Federation of the Red Cross, the Mexican Red Cross and the Red Crescent Societies (2016), within the Flood Resilience Program, propose resilience as a recent concept that is dynamic along with psychosocial aspects of individual responses under stress situations; and, finally, the International Federation of the Red Cross (2014) considers resilience as the ability of organizations or nations exposed to natural disasters, crisis, and vulnerabilities to prevent the effects of water environmental disasters and the ability to prepare to affront them.

In recent years, several studies have included the individual perception of risk as another element within the exposure that integrates experiences, cultural knowledge, and relationships between those and nature. Therefore, today we understand the logic of vulnerability to floods, especially from

social perceptions, and their representations since these allow us to adapt and recognize the mechanisms on the way to decrease the exposure of recurrent events with vulnerable populations (Won & Zhao, 2008; López, 2010; Soares *et al*., 2014).

Qualitative indicators for flood events

The indicators generate outstanding, vital, and unique information, and provide conclusive evidence. The information for its construction can be qualitative, quantitative, or mixed, considering a set of objectives. Ideally, these express a relationship between two or more variables and are delimited in time and space. Some features to consider in its design are the accessibility to a region and the perception of a subject as an opinion. Its methodology should explain what and with whom it will be measured, considering clear objectives to establish needs, strengths, and the calculation of their measurement (CNEPDS, 2013).

The various indicators related to floods are more urban than rural (Ferrari, 2007) and have been carried out through surveys that measure the vulnerability to floods of different cities. In Mexico, for example, Hernández and Ramírez (2017) used a methodology of flood risk analysis applicable to urban basins, for which they defined vulnerability rates that consider the degrees of exposure, susceptibility, and resilience throughout the basin. Accompanied by special modelling processes in times of flooding and risk maps, this methodology allows, with a base of information generated by INEGI, from Basic Geostatistics Areas (AGEB), to specialize a group of indicators (Balica *et al*., 2012; Alcocer Yamanaka *et al*., 2013).

On the other hand, indicators for integrated urban planning actions have been organized for intermediate cities that are periodically affected by river floods, an example of which is the one carried out by González *et al*. (2020) in the central valley of Chile. The most used indicators for floods assembled for public policies are defined from three properties: subsystem redundancy, learning time after each event, and localized response capacity (Hong & Liao, 2012; González *et al*., 2020).

Another set of flood indicators was carried out by an international humanitarian organization dedicated to the care of communities (GOAL, 2015). The perspective used covers five key thematic areas, namely:

1. governance;
2. risk assessment;
3. knowledge and education;
4. risk management and vulnerability reduction; and
5. emergency preparedness and response.

On the other hand, the methodology of community-based resilience analysis (CoBRA) is carried out in two stages. Firstly, analyses of the lifestyles or social capital and, secondly, adaptability and strategies. Another of the methodologies suggested by Mayunga (2007) contemplates a comprehensive analysis of resilience from an approach based on human, physical, economic, and social capital. In this study, it was decided to use a more adapted methodology, based on a modification of the CoBRA analysis, among others.

Materials and methods

The research method in this investigation was applied in the municipalities of San Marcos (El Pital, Cuenca, El Torno, and Las Flores), San Benito Abad (Las Chispas, Pasifueres, Chinchorro, and Tosnovan), located in the region of Sucre, and Ayapel (Cecilia, Sincelejito, and Seheve), located in the region of Córdoba. Regarding the population participating in this study, 231 people of different ages and genders were selected.

Following the theories of perception, the following process was used to develop the appropriate methodology:

1. Firstly, strategies were set to describe and interpret the perspectives of the world considering the person living these experiences and not the one observing them. Fewer descriptions of the other person were displayed, and more personal perspectives were included. This means that there was no intervention in the view of the person living these experiences and the graphic, written, verbal and emotional limitations and possibilities were considered and were not modified.
2. Secondly, an ethnographic diary or grid was used, containing notes from researchers in the field. The goal was not to interpret but to contextualize the collective behavior of each community.
3. Finally, the compilation of data was carried out, for which grids were used to note down everything each participant had said, having total respect for the text integrity, to then make a proper reading of the information collected.

The applied methodology is performed from a phenomenological-perceptual approach. The perception here is modified from the traditional perspective, supported by psychological projective techniques, such as mental maps and surveys (Morales, 2012). The perception of flood risk used in this study is subjective. According to García (2012), this perception is formed with the personal history of each participant, and their experience combined with the quantity and quality of information coming from beliefs and attitudes. Therefore, the information obtained here is of personal introspection and intersubjective character. For this, several tools were used, such as the cause-effect tree, the timeline, and the focus groups.

The cause-effect tree. It was applied to one sidewalk by each municipality. Initiated with a brainstorm, the objective was to make a participatory, democratic diagnosis. This methodology allows the community not only to be a source of passive information but to be involved in the formulation of objectives, as well as the diagnosed results, each participant is given a card of different colors to write individually what they think about the strategies used by each person and then by the community to deal with floods and the potential of eco-systemic services in this process.

The timeline. As a methodological option, it was possible to respond to the needs of temporal understanding that allows, for this case, the action of the communities with the eco-systemic services in the floods' real-time and the direct connection. Therefore, the timeline is defined as a participatory research methodology that seeks to relate specific, concrete, determined events and actors chronologically, from the temporal location and the description of events related to a specific theme. These are recorded exactly as described by the participants, taking into account the mode, time and place of the events or events of a community.

For this development, elder participants with a long lifetime in the municipality were chosen. This tool is configured with historical notions, as it seeks to emerge and challenge the memory of floods and their practices resilient to the onslaught of water. The events identified from the community perception will be related and complemented with the journalistic records of the time.

Focus groups. A focus group is the expression of a group-order interview through a topic script or an organized interview with the interaction between participants to produce information.

PHASE 1. Community preparation: Local co-researchers were invited. These people were in charge of dynamizing the exercise with the community, meeting it in a place and facilitating the logistics of the meeting.

PHASE 2. The community was made aware of the methodology and its application.

PHASE 3. Development and socialization: The eco-systemic services, water resilience and floods were explained to each group. For this purpose, the groups were divided according to the defined categories. In addition, a considerable number of participants who could not read and write were assisted in writing. Finally, the experience is socialized and placed in the illustrated tree.

PHASE 4. Conclusion and education: After socialization, the meaning of the results was explained to the community and the process was evaluated.

PHASE 5. The community was consolidated (Leadership): The community ratifies the leaders who will accompany them in the restoration processes and future processes.

PHASE 6. With the systematized results and the appropriation of several methodologies to define vulnerability indicators with floods, the following categories were found: climate, knowledge dialogue, and applied ancestral knowledge.

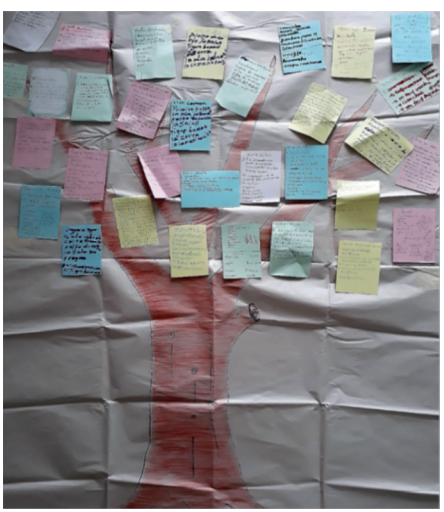
Table 1 - Application of methodology places

Municipality	Sidewalks Centre Population	Place of the activity development	Number of participants	Gender	
				M	F
San Marcos	El pital	Home of Inalides Villadiego (co-investigator)	24	6	18
San Marcos	Cuenca	Home of Robinson Núñez (Legal representative association)	39	15	24
San Benito Abad	Chispas	José Luis Sandoval (co-investigator)	31	5	26
San Benito Abad	Pasifueres	Home of Leticia Zambrano (co-investigator)	18	6	12
San Marcos	El Torno	Communal Space "Morrocoy"	59	16	43
San Marcos	Las flores	Educational Institution "Las Flores"	42	23	19
San Marcos	Tosnován	Home of Liliana Chávez (co-investigator)	6	2	4
San Benito Abad	Chinchorro	Home of Francisco Luna (co-investigator)	12	2	10

Source: UNICORDOBA working group.

The paradigm is phenomenological since the world is observed as something unfinished, so the meaning is given in detail by those who live in it. Within this framework, the researcher self-recognizes as an interpreter of the realities constructed by the study subjects and demands a degree of understanding of the meaning, sense and structure of social participation. Figure 2 shows the written perception of a group of people from the Cuenca sidewalk, about their living and the floods. The essence of the collective action and its realities taken by the subjects of study are therefore sought.

Figure 2 - Example of a problem tree



Source: working group.

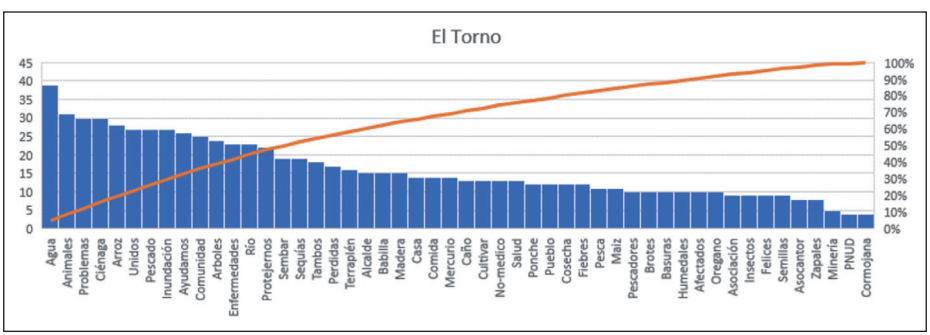
Community perception is the concept that was put into circulation. In the first instance, it considers stimuli as the source of the individual's perception and then integrates group experiences, attitudes, values, needs, social circumstances or expectations. Traditionally, perception is more inspired by psychological projective techniques, such as mental maps and sociological techniques, such as surveys (Morales, 2012). However, the cause-effect problem tree and timeline tools opted for phenomenological theories that involve leading participants to personal introspection encounters.

Results

In San Marcos, Ayapel, and San Benito Abad, the methodological cause-effect problem tree tool was implemented to give an account of the social perception of eco-systemic services, their implications and community resilience concerning floods. Likewise, by using the contributions obtained from the methodological tool of the timeline, it was easier to address the short and long-term memory of people with more years of life in each community.

With this systematized information and a varied selection of data it was possible to study different methodologies to develop qualitative indicators and measure vulnerability in floods such as community-based resilience, lifestyles, social capital in resilience (CoBRA), human and physical capital (Mayunga, 2007) governance and built environment (Jacinto *et al.*, 2020) threat, exposure, and vulnerability (Peck *et al.*, 2007), and infrastructure (Balica *et al.*, 2009 and Peck *et al.*, 2007). Finally, the most used flood indicators are those of Liao (2012) designed to be articulated in public policies and González (2020), which defines three properties: i) redundancy of subsystems; ii) learning time after each event, and iii) localized responsiveness, with which a set of qualitative indicators specific to the floodable region of La Mojana, Colombia was configured.

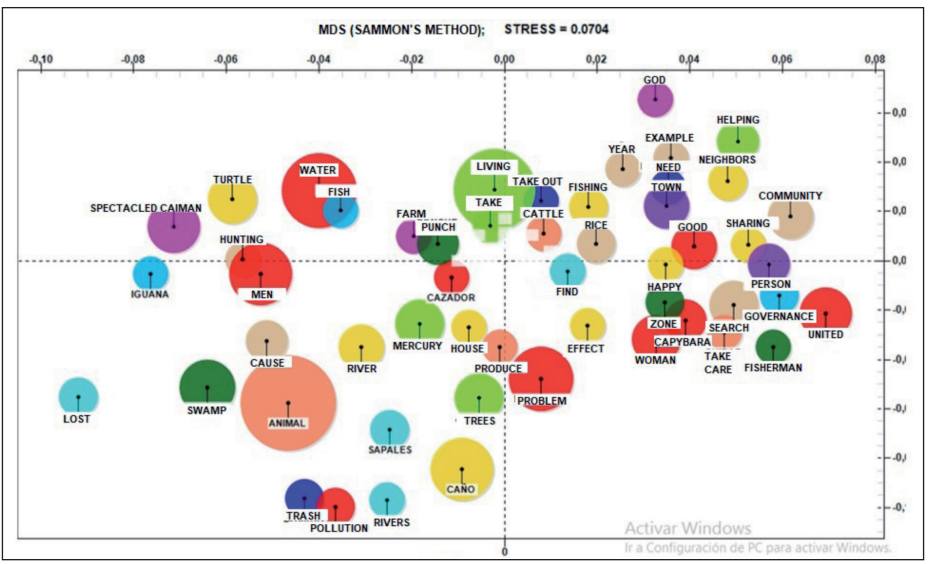
Figure 3 - Word Recurrence in the El Torno Community



Source: working group.

Each participant was given a card of different colors in which words connected with phrases that were written freely and were previously explained and argued. They contained the categories: good living, eco-systemic services and floods, community resilience, and governance. From the above, it was obtained for the analysis a group of information that, in terms of research of perceptions, allowed an objective and systematic description of everything described in this study. Likewise, a graph was made of each sidewalk and each municipality as presented below with the case of the community of El Torno, where the most recurrent names are referred to the "aquatic man" (water, fish, trees), to the dynamics of risk (shortages and destruction), and adaptation (land, affected, adaptation). These results, although they seem obvious, take on meaning and validity in contrast to the other communities of San Marcos, since in terms of environmental rehabilitation, they are indicating a path and sensitivities.

Figure 4 - Sammon's Method Applied to El Torno Sidewalk



Source: Data from Information Analysis Software T-LAB.

The data were also systematized in the Software T-LAB, composed of a set of linguistic and statistical instruments for content analysis, discourse analysis and text mining represented in a graph by a municipality. In this model, the groups of points represent a thematic unit. Meanwhile, the segment located in the lower-left is associated – sometimes more than others

– with the problems that are affecting the area; this is the reason for the identification of words associated with the contamination of the place within the system studied, such as, for example, river, mercury, garbage, swamp, *zapales* (marshes) and house.

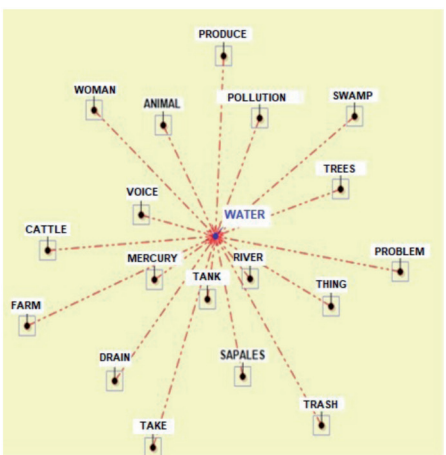
The relationship system of these words shows that the community is being strongly affected by both pollution and mercury. It is important to take into account that its vital system is closely linked with water, since it provides and constitutes, in part, the most important eco-systemic service of supply. Faced with this vulnerability, the community emerges to confront the difficulties of the system, helping itself (a situation that is evident in the graph in the upper-right and the lower-right, although the latter has correspondence with the mechanisms to be resilient, given that expresses actions to be developed).

Also, they show emotional feelings like being happy. There seems to be some tension when this emotionality is presented by environmental problems. What this shows is that the ties with the territory go beyond the border that restricts them. Also, in the upper-left are evidenced some of the main products that may be associated with their diet. Animals, in this case, have higher priority over vegetables. It is interesting to point out that the word animal is found in the lower-left segment, this is because the destabilization of the ecosystem is affecting the presence of fauna.

Characterization of water resilience in the municipalities of San Marcos, San Benito Abad, and Ayapel

San Marcos community water resilience. Embankments (a bank of earth and sand to prevent flooding in an area) have become the mitigation measure for the effects of floods. The medium provides some food sources, such as fish and hunting animals, and rice and subsistence crops are produced. It has good supplies of fish, common caiman, and turtles, and it is also a good environment for planting rice and growing plantain. It also has timber trees for bridges, canoes, and *tambos* (structures to get protected from flooding), among others. To deal with the floods,

Figure 5 - Ayapel's Water (Associations)

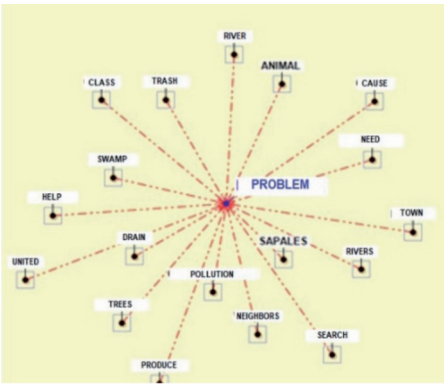


Source: Data from Information Analysis Software - T-LAB

the population from this area built a handmade containment wall, they expanded *cambuches* (huts made of plastic) where food is stored, especially rice, to not suffer from hunger in difficult times. Also, the population of the area fight food shortages through productive courtyards, orchards, and vegetables. As for their well-being, the area is thriving, as it provides food, vegetable, fruits, fish, and others.

Ayapel community water resilience. In this community, the population doesn't take part in local organizations, or boards, and, in general, they have a lack of associations. However, they identify several actors in the area, including the United Nations Development Programme (UNDP), Unicordoba, and Corpoayapel. In adverse times when rains are lurking, each family builds *tambos* and embankments, and in terms of vegetation, the flood-resilient spices are oak and bell rice, corn, and subsistence crops that are produced in the area. There are animals such as turtles and yuyo ducks. Within this ecosystem, the San Matías pipe offers water, and fish, and serves as a waterway. In addition, it is understood that the pipe fulfills a regulatory function since it works for the swamp to discharge its water at times when it is heavily charged. Productive activities of an artisanal type that are transmitted through generations, such as canoe construction, trammel, tying, and farming practices are those that are perceived in this community as important for the development of economic practices. Local knowledge related to productive activities, food and plant-based remedies is still transmitted. The knowledge of fishing and agriculture is also transmitted from generation to generation through oral tradition. Water as presented in the chart of associations is stressed by the presence of mercury, increased litter, and livestock.

Figure 6 - San Benito Abad's Problem (Associations)



Source: Data from Information Analysis Software - T-LAB

San Benito Abad community water resilience. In terms of governance, there is a consolidated community organization, and the role of women has been decisive in the association of farmers and fishermen, as well as the community action boards-JAC and civil associations such as ASOPASFU (Association of Fishermen and Farmers of Pasifueres). In the territory, there

are organizations such as Pastoral Social, UNDP, and CORPOMOJANA. In terms of resilience, some families have implemented climate change mitigating fruit orchards with UNDP. In the face of constant flooding, the houses have been adapted, building for it *tambos* or mounds of earth that prevent the water from the pipe to penetrate the homes. The pipes serve as regulators of the waters of the Cauca River and provide fish for their food. They say that in the *zapales* they obtain different edible species such as punch and turtles and that in the area there is also the presence of timber trees, usually used in the construction of houses. In terms of resilience, the residents claim to build "terrified at home, the construction of dams for summertime", they also plant trees far from the houses, to avoid accidents with falls. This is combined with good relationships between neighbors, "because if I don't have something, someone else has it".

Table 2 - San Marcos Timeline

Source	Before	During	After
Community perception	Memories indicate that the problems in the area have been occurring since the decade of the 50s, with floods that affected crops and animals; they assure they did not receive any humanitarian aid. Since the 50s and 60s, vegetation has been declining, mountains have begun to disappear.	In 1984, large-scale flooding was registered, higher than that of 1950, given that the increasing floods occurred in November, when the rice is harvested, resulting in economic and subsistence consequences. It was pointed out that the greatest flood affection took place between 2010 and 2013, given that the area was flooded for more than two years, forcing the community to live in dairy farms.	During the current year, the floods have left disastrous consequences, several trees have been lost and the health of the residents has been affected (headaches, flu, sickness, etc.); without leaving aside the crop loss due to pests.
Newspaper reports and notes	"In San Marcos, the inhabitants indicate that since 1950 disasters add to the strong rains with an increase of 16.1% in relation to the normal conditions in times of winter" (UNDP, 2012). "The deterioration of the ecosystem continued to increase and the flood of 1950 forced the García Márquez family living in Sucre to move to Cartagena" (El Tiempo, 2012).	"In 2010, winter reached enormous levels of social and economic impact. It can be said that this winter is the worst in the last 30 or 50 years." (El Florano, 2011) "In 2010 came the flood, rivers and streams broke their homes with violence. Plants and animals died. The crops were ruined, and the land was contaminated" (El Espectador, 2016).	"In San Marcos, they decree public calamity due to floods. Although it has stopped raining, the rupture of the Cauca River in Colorado (Antioquia) is jeopardizing La Mojana, among the flooded areas are El Torno, El Pital, Las Flores and others" (El Universal, 2017).

Source: Data from Information Analysis Software – Atlas ti. 7.

Table 3 - Water indicators for the development of community resilience in La Mojana, Colombia

Categories	Subcategories	Unit of measure periodicity indicator	Typology	Instrumental Data source	Conceptual description	Reference
Dialogue of knowledge	Conversation between actors	Number of conversations Number of people with memories	Qualitative biographical	Group interviews Timelines Problem tree	No imposition of arguments from each of the parties, seeking to recognize each individual, and their practices	V.M. (2003). Barrera-Bassols, N. (2008), L. and Olivé, L. (2015)
	Conversations on living experience	Number of people of different ages talking	Qualitative Perceptive	Participant Observation Discussion group Timelines Problem tree	All people of various ages, sexes and trades need to formulate their views. For this, the ability to deal with new agreements and provide dimensions and knowledge is required	Valdez, C.J. (2008) Bohm, David (2001)
	Listening to the lack of knowledge	Number of questions to solve from different actors and levels of knowledge	Qualitative Narrative	Projective techniques Assemblies of feelings Problem tree	Uncertainty and ignorance push people into thinking towards action and memories	Boisier, S. (2003) Fals Borda, O. (1988) Freyre, P. (2005)
Weather-related	Water cycle	Number of creeks Number of types of clouds Number of rains per day-per week Number of wells with drinkable water	Qualitative descriptive	Focus group observation In-depth interviews Timelines	Climate change, deforestation and erosion have strong impacts on the water cycle and increased rainfall	Pidwirny, M. (2006) Dingman, S.L. (1994) US EPA (2015)

Table 3 - continued

Categories	Subcategories	Unit of measure periodicity indicator	Typology	Instrumental Data source	Conceptual description	Reference
	Floodings	Number of days-years flooded Number of houses near the river Number of clean canals Number of alarm systems Number of routes prepared for evacuation Number of native trees planted	Qualitative descriptive	Focus group Participant observation Documentary analysis and press Social mapping	Water always maintains its natural dynamics, its meanders, then its forms and cohesion, as well as its floods in a systemic way, any modification increases the risk of floods	Cruz Vergara y Sánchez, 2011 Hernández, Barrios-, Héctor, & Ramírez (2017) Balica, S. (2012)
Governance-related	Citizen participation	Number of participative diagnostics Number of projects done with the community with local authorities Number of people participating in service areas (education, health) Number of communal and social associations and organizations	Qualitative critical	Social dialogue Document analysis Problem tree Participant observation	Considered as a community becoming aware of the issues that slow their development, their critical thinking and the organization of associative forms that facilitate the common good	Whittingham, M. (2005 Ramos, H. (2015). Revesz, B. (2005). Rhodes, R.A.W. (2005)
Ancestral knowledge applied	Good living	Number of medicinal plants Number of edible plants Number of houses with vegetable gardens Number of preserved species Number of activities with reciprocation	Qualitative descriptive	Critical ethnography Timeline Problem tree Participant observation	To live well is to recover the memory of our peoples, their culture, and their life, in harmony with nature, and the cosmos according to a systemic sense	Gudynas, E. (2011), Alaminos, A., and López, B. (2009), Cubillo, P., Hidalgo, A.L., & Domínguez, A. (2014)

Table 3 - continued

Categories	Subcategories	Unit of measure periodicity indicator	Typology	Instrumental Data source	Conceptual description	Reference
	Ancestral technologies against floodings	Number of embankments Number of built tambos Number of grounded houses Number of dams for summertime	Qualitative interpretative	Critical ethnography Timeline Problem tree Participant observation	From a set of alternative technologies, taken up to face the challenges of climate risk, and floods, multiple and varied technological systems have been generated associated with the management and conservation of water, soils, and vegetation	Ibáñez B. Isch, E. Panario Gutiérrez (2020)
	Learning experiences	Number of people that share their experience with the FVI flooding control.	Qualitative interpretative	Critical ethnography Timeline Problem tree Participant observation	In light of uncertainties and new learning about the future, new strategies are designed to be flexible, resilient, able to adapt to changing conditions, multifaceted and with new options	Torres Guevara, J. (2014)
Socio-environmental conflicts	Assessment languages	Number of actors in conflict	Qualitative descriptive	Actors map and in-depth interview	It refers to the different conceptions of territory, nature, and the environment while establishing a dispute about what is understood by development and, more generally, by democracy	Alier, J.M. (2021). Environmentalism of the poor: environmental conflicts and valuation languages. Icaria

Table 3 - continued

Categories	Subcategories	Unit of measure periodicity indicator	Typology	Instrumental Data source	Conceptual description	Reference
	Impacts of extra-activism	Number of days with a strong smell coming from the water Number of days with changes in the color of the water Number of days with the most presence of material being dragged in the river	Qualitative descriptive	Participant observation Calendar	Ext activism is defined as the exploitation of large volumes of natural resources, which are exported as commodities and generate enclave economies (localized, such as oil wells or mines, or spatially extended, such as soybean or palm monoculture)	Staffolani, Claudio, & Cuesta Ramunno, Estibaliz. (2020). Social representations and risk perception in the relationship between environment and health. Implications for regional development in the province of Santa Fe (Argentina). Social Studies Alimentación contemporánea y desarrollo regional magazine, 30(56) Wagner, LS (2014). The paradoxes of extractivism. *NUEVOS CONTEXTOS DE* , 155

The timeline is usually developed with elderly people who have a broad historical notion of the area. The events identified from the community perception will be related and complemented with the journalistic records of the time. For its development, the following stages were taken into account:

- For the analysis of the human-nature relationship, the socio-ecosystem components of resilience, governance and well-being are taken into account. Based on these, it is possible to understand aspects such as the ability to return to a state of equilibrium in socio-ecosystem systems, the management of the territory and the affective bond that the environment produces in society.
- The study of the SSE will be key to the sustainability of the territory, where a balance is established between environmental and socio-economic development. "Socio-ecological systems are based on the idea that the socioeconomic system cannot grow beyond the biophysical limits established by the ecosphere" (Martin López *et al*., 2012).

It is concluded that the main categories for the elaboration of community water indicators, for the case of La Mojana in Colombia, are a dialogue of knowledge, climate, governance, applied ancestral knowledge and socio-environmental conflicts. The above was developed from a phenomenological qualitative field research triangulated with various flood analysis methodologies of urban rivers.

Conclusions

The three main rivers in Colombia converge in La Mojana (Cauca, San Jorgen, and Magdalena), making this confluence one of the most varied and attractive water systems in the world. Half a million residents out of 11 municipalities from Antioquia, Bolívar, Córdoba, and Sucre live in this complex system. The Adaption Fund demonstrated that between 2008 and 2020, La Mojana has been impacted by 495 hydrometeorological events. Among these, 338 were floodings and flash floods that concluded in thousands of people affected, nearly 76000 deteriorated houses and 1200 destroyed. Studies of this area have a noticeable ecological and environmental trend, but the ones that offer the creation of qualitative indicators are greatly inferior. Regarding community water resilience, this category has been developing in topics related to urban areas, instead of rural lands.

So far, even if there was an increase in the efforts of formulating and implementing public policies, numbers, and data show that there is a need to move forward with articulating solutions with local governments. Regarding qualitative studies that aim to create indicators for cases of community water resilience, this article presents three major scientific advances. Firstly, having

the perception of the residents of the area allows the information collected from the data to move towards the understanding of the collective and individual behaviors, which is essential for the intervention and the forecast of projects that look for the reduction of the damage caused periodically by floods in the region.

Secondly, this article – unlike some qualitative and quantitative studies that result in generalizations – made a thorough effort to collect primary material, in the search of the particularities of each one of the eleven sidewalks, highlighting and strengthening their group identities and their environmental realities.

Finally, a design of indicators was elaborated, aiming to consider the experience of previously successfully applied methodologies about community resilience in vulnerable groups that are permanently exposed to flooding. This design of indicators was also aiming to systematize and apply a variety of qualitative methods, in order to complement and build indicators from a community perception and from a contextual and participatory perspective.

The presented indicators are essentially supported by a knowledge dialogue, applied ancestral wisdom and memory, the socio-environmental conflict, governance and climatology. Each of these categories has a theoretical description and a source of data collection, which combines the collected information by the communities from the communities. In addition, these indicators will provide solutions towards decision-making and the spatial and territorial planning processes.

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Housing vulnerability, agricultural production, and goods lost estimated to floods in Rio Nuevo a rural community in Colombia

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Abstract

Floods affect households, crops, and assets, especially in rural areas in Colombia; due to the lack of risk management plans, settlements without core services and land use planning, atypical natural phenomena, and climate change. The floods recorded since 1964, in the rural community of Rio Nuevo in the department of Córdoba, but there is a lack of estimates of the economic losses and housing vulnerability. The research aim was to determine the degree of physical vulnerability and estimated economic losses in crops and goods due to flooding in the local community of Río Nuevo, Valencia Town. The methodological guide for the elaboration of departmental plans for risk management (known in Spanish as PDGR), and the methodology for the economic valuation of potential direct tangible damages, was selected the variables (age, construction, regulations, soil, walls, floors, goods, and crops), questions, surveys to population, available data, proceed to process the information, elaborate maps and analyze. The results reveal physical vulnerability high in Rio Nuevo, with a value of 0.63 on a scale of 0 to 1. The rural community houses built located

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at a distance of fewer than 30 meters, mainly with wood, the soil of alluvial deposits, faced floods, humidity damages, hardening resistance, and non-quality life. The economic losses estimated between goods and crops were US$174200.22. A poverty condition, poor infrastructure, and unfavorable places, hamper improve the quality of the people. Colombian government need to execute a proper infrastructure investment to reduce persistence vulnerability and relocated this riverside area, according to its culture and traditions, and protect the economy around crops.

1. Introduction

The last 20 years of floods recorded, evidence as the most common disaster by more than 40% around the world, with combined economic losses of US$82 billion in 2021 and affected to 1.6 billion persons worldwide (Human Cost of Natural Disasters, 2021). The Intergovernmental Panel on Climate Change (IPCC) predicted an increased risk of flooding in rural and urban areas worldwide (Connor and Hiroki, 2005; Field *et al.*, 2014). People concentration is not only evident in densely populated urban areas but also in rural areas with non-proper management policies and non-economy, which provides favorable conditions for impacts of climate change to be felt more (IPCC, 2014).

The differently predisposed to the harm of floods and vulnerability to nature is well established in research and practice. The local situation before a flooding disaster as poverty, chronic illness, and appropriate places to live make some social groups more likely to suffer losses. The damage to properties, goods, and crops is directly related to the zone recovery (Gallego, 2018). In addition to the social, demographic, and economic aspects, some communities should face a high risk of natural hazards due to their location, floodplains, or riverside cities. This scenario made especially vulnerable to the rainy season and flooding, and these hazards could be exacerbated by the "La Niña" phenomenon and Climate Change (Chang, 2015).

Although flood risk managers must engage with the extant science to inform decisions, the scholarship on how differences in socio-demographic characteristics influence perceived vulnerability and risk of floods is inconsistent. The ample literature presents that cognitive, affective, social, and cultural factors interact in complex ways to reflect on a household's perception of risk or how vulnerable they think there are to flooding (Van der Linden, 2017). The risk perception allows knowing from the dwelling

knowledge, beliefs, judgments, reactions, and willingness to act, issues which are essential for decision-making, both institutional and in the daily inhabitants' lives of vulnerable territories (Peretti-Watel, 2003). The data collected indicates flooding behavior, mobility difficulties in the towns, and difficulties in accessing core services and products, but, the field of vulnerability perception correlates with pepeople's of crops and goods (IDEAM, 2018).

Between 2010 and 2011, Colombia suffered one of the worst rainy seasons in its history, by 8% of the Colombian population was affected by the flooding, with US$3500 million destined on recovered and reactivated the economy. Some towns were more affected than others, and some received more resources from the central government, which created a source of variation in terms of the affected people and distribution of resources (Gallego, 2018).

Floods have become a global and national problem that leaves millions of people with irreparable damage to their homes every year, causing losses in goods and crops. One of the local communities in rural Colombia is Río Nuevo located in the Córdoba department, the municipality of Valencia, where the last 20 years it has presented flooding problems, as expressed by the risk management plan of the Valencia Mayor office in 2018. The poor territorial planning township, since the location of the houses, is at a critical point in the upper basin of the Sinú River. According to the national statistics department DANE (2018), Río Nuevo has presented population growth in the recent 20 years, a rise in households, and the pursuit of goods and crop production. The Sinú River, at this local community point, evidenced erosion related to deforestation on the riverbank and a vulnerability increase to flooding. This research aim is to analyze the housing vulnerability, crops, and goods due to flooding in Río Nuevo, municipality of Valencia-Córdoba.

Colombia is characterized as a hydrological country because it has considerable tributaries that allow water demand. Becoming, according to the Ministry of the Environment (2018) the 15th country with water availability in the world, it brings agricultural diversity, fauna and flora, however, these tributaries also cause floods throughout the country. According to IDEAM (2018), 17% of the Colombian population suffers a flood, indicating housing vulnerability, goods, and crop loss. One of the studies on the conditions of housings vulnerability developed by Duran, C (2017) highlights that the problems are generally aimed at socioeconomic and environmental contexts, however, it is necessary to approach other scenarios such as territorial fragilities, an established methodology in indeed, which highlights the selection of factors (drainage, population density, seismology, geological faults, roads), which describe physical vulnerability, followed by an exploratory analysis of spatial data, at which stage the description

and visualization of the same, through the construction of vulnerability indices, being represented by color indicators and maps that demonstrate the results obtained, where it is interpreted that the departments with the highest vulnerability index physical are Antioquia, Santander and Meta, while the department of Córdoba and the municipality of Valencia presented a medium vulnerability, highlighting that for the analyses, there are causes that must contemplate a vulnerability evaluation, since these are divided directly and indirectly and, in turn, others are annexed, such as mining extraction, drug trafficking, climate change, and the labor market pointed out that the areas with greatest influence on physical vulnerability are the peripheral area of Colombia.

Floods have become a global and national problem that leaves millions of people with irreparable damage to their homes every year, causing losses in goods and crops. One of the local communities in rural Colombia is Río Nuevo located in the Córdoba department, the municipality of Valencia, where the last 20 years it has presented flooding problems, as expressed by the risk management plan of the Valencia Mayor's office in 2018. The poor territorial planning township, since the location of the houses, is at a critical point in the upper basin of the Sinú River. According to the national statistics department DANE (2018), Río Nuevo has presented population growth in the recent 20 years, a rise in households, and the pursuit of goods and crop production. The Sinú River, at this local community point, evidenced erosion related to deforestation on the riverbank and a vulnerability increase to flooding. This research aim is to analyze the house's vulnerability, crops, and goods due to flooding in Río Nuevo, municipality of Valencia-Córdoba.

2. Methodology

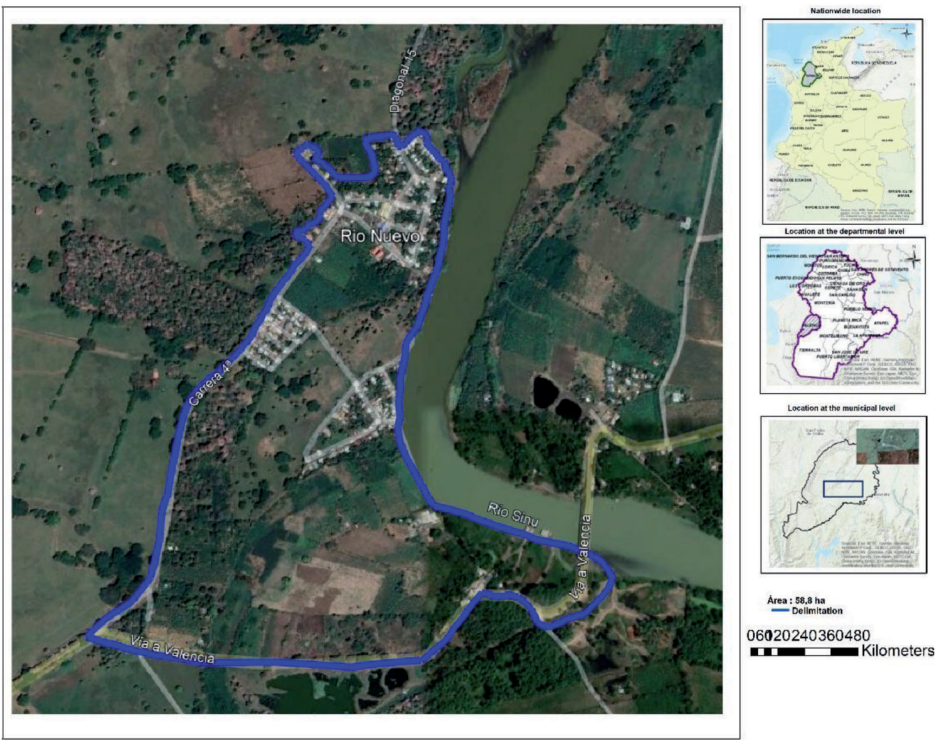
Through the methodological guide for the preparation of departmental plans for risk management (2012); framed in law 1523 of the national risk management system, and the methodology for the economic valuation of potential direct tangible damages due to flooding (Baró, Diaz & Calderon, 2012). Heuristic method to evaluate a problem locally and correctly. Information acquisition data were obtained in the field. The data were collected, processed, and finally analyzed.

2.1. *Study site description*

Río Nuevo, a rural community, Located at 8°15'03" N and 76°03'44" W in the municipality of Valencia-Córdoba, limited to the north by the Villanueva

rural community, to the south by the Manzanares rural community, to the east by the Sinú River, and the west by the Bijagual rural community and the municipal seat (Alcaldía De Valencia & Costa Atlántica Ltda., 2001, p. 40). This region is placed in an upper basin of the Sinú River, has a surface area of 58.8 hectares, and has crops and houses, with a population of 1,297 inhabitants in 187 dwellings. Figure 1 details the location of the district of Río Nuevo, located through the Google Earth program.

Figure 1 - Location of the rural community of Río Nuevo, Cordoba



Source: Authors.

2.2. *Study design and sampling*

These were a population-based cross-sectional study carried out in 2018, embedded in the National Administrative Department of Statistics - DANE (for its acronym in Spanish). Based on demarcated Rio Nuevo, rural

community 2018 census data collection, the sampling frame involved 187 households in location 1 and 178 households. Thus, 144 households reflected a response rate of approximately 99% and 5% correction. A household was considered on the arrangements made by persons, individually or in groups, living together in the same dwelling unit. The questionnaires were filled by one member whose informed consent forms. It was taken into account, that the probability assumed at the time of occurrence of a flood is 50% both for it to occur and for it not to occur. The location of each survey was given randomly, which indicates that each dwelling handles the same degree of importance, regardless of its location.

2.3. *Execution of the experimental*

The executed experimental with surveys and field visits were made were o the corregimiento of Río Nuevo. The survey covered issues of construction materials, floods, distance from the houses concerning the Sinú River, sheets of water, duration, losses in goods and crops, restoration costs, and antiquity, among others, this source of primary information was supported by the Colombian geological service and the study of geology, geomorphology, fluvial dynamics and soils for the design of Valencia bridge foundations by Geosoluciones LTDA (2010-2011), thus allowing the obtaining of the type of soil that is registered in the study area, to this are added the secondary sources, among which are the IDEAM, DANE, municipal mayor's office, periodical sources, and scientific articles.

2.3.1. Housing vulnerability

For the analysis of the physical vulnerability of the rural community of Río Nuevo, the variables proposed by the 2012 Methodology Guide of the risk management plan were taken into account, likewise, variables that are considered essential were annexed, for the determination of the degree of vulnerability. As presented the Table 1.

Table 1 - Variables and indicators of physical vulnerability

Questionaries				
Variables	**Question**	**Indicator**		**Vulnerability**
Building materials	**What is the predominant material in the exterior walls of the house?**	Concrete block or brick (good technique)		2
		Concrete block		74
		Wood		261
		Bahareque		3
		Metal Print		0
		Guadua		15
		Vegetable material		15
		Zinc, fabric, cardboard, cans, waste, plastic		21
	What is the predominant material of the floors of the house?	Soil, Sand		291
		cement, gravel		94
		Rough wood, board, plank, other vegetable		52
		polished wood		98
		Tile, brick, vinyl, other synthetic materials		129
		Marble		0
Seniority (Number of Years)	**How old is your home since it was built?**	Less than 5 years		36
		Between 6-20 years		68
		Older than 20 years		90
Compliance with Current Regulations	**Was your home built by?**	It complies with the regulations of the laws (NSR-10)	Professional (civil engineer)	1
		It moderately complies with the regulations of the laws (NSR-10)	Technician (builder)	8
		Does not comply with the laws (NSR-10)	Without academic training (empirical)	114
		Does not comply with the laws (NSR-10)	By your own	303
Location	**How many meters is your House from the Sinú River?**	Far away	>100 m	37
		Medium close	30-100 m	72
		Very close	<30 m	213
Flood	**Does your house have flooding in rainy seasons?**	Presents flood		423
		There is no flood		3
Sheet of Water	**How much is your home flooded? (cm)**			38 cm

Source: Authors.

2.3.2. Agricultural production and goods lost estimated

Recognition of study areas (Topography, Geology, Hydrology). - Number of dwellings and number of crops. - Types of goods and crops. Table 2 correlated the number of people per house. Most of the houses in the township are occupied by three people, highlighting that the inhabitants who live in vulnerable areas with respect to this number of people per house represent 25% of the total, comparing this With the different groups of families, there are other households where the number of people who live in a house is 12, 13 and even 15, and when studying from this perspective it can be considered that depending on the number of people who live in a house, There will be cases where there is a greater impact on the needs, expenses and goods to cover, since many people live in a house, a degree of responsibility is presented to support themselves, so that when interpreting this as an evaluation method, it will serve to define in which dwellings greater damage or economic loss.

Table 2 - Number of people living in a dwelling

Quantity of people	4	13	36	26	25	18	4	11	2	2	1	1	1
Households	1	2	3	4	5	6	7	8	9	10	11	13	15

Source: Authors.

45% of the inhabitants surveyed have hectares, whose source of employment earns daily, although in Table 3. it can be seen that in the rural community of Río Nuevo there is a diversity of crops. The cultivated are corn, rice, plantain, cassava, and vegetables. On the other hand, 77 surveyed do not have crops due to habitants most lost investment previously floods.

Loss of property due to flooding in homes showed that 6% of household goods, 4% of other valuables, 10% of household appliances, 1% of vehicles, 47% of real estate occupying the first place, and 32% of animals taking the second, make up the losses and economic damages that generally affect the inhabitants of Rio Nuevo.

Table 3 - Number of people with crop

Quantity of household	1	2	6	8	14	16	25	29	77
Crop	Watermelon Collard Greens Sapote Avocado Cacao String bean Papoche	Tomato Bell pepper	Ñame	Papaya	Cassava	Plantain	Rice	Corn	Non Crop

Source: Authors.

2.4. *Data processing*

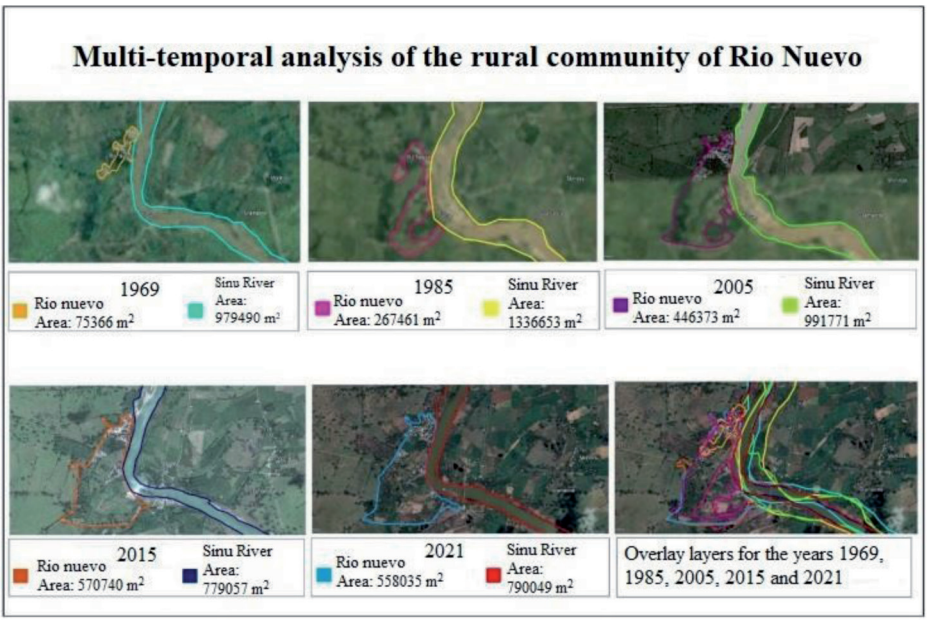
The data processing through the following tools: data software, the weightings were made to determine the graphs of the variables of physical vulnerability and economic losses, thus allowing to know the economic valuation of the corregimiento when a flood occurs; After having the valuations and percentages of the variables, the properties of each survey in the Google Earth Pro software, then in the ArcGIS Pro software, the maps corresponding to the variables of the physical vulnerability and in goods and crops, it was done using the descriptive and observational statistical method.

3. Results and discussion

3.1. *Multi-temporal analysis of the rural community of Rio Nuevo*

Over the years, vegetation cover largely extinguished of the banks of the Sinú River in the last 50 years. Due houses construction, as shown in Figure 2, where it is evident that from 1969 to 2021 the rural community has gone from 75,366 m² to 558.80 m² where the riverbank has been affected, in the same way, it can be seen that the dynamics of the Sinú River in recent years tend to go to the rural community, therefore when an overflow occurs it is more prone to flood.

Figure 2 - Multi-temporal analysis of the rural community of Rio Nuevo



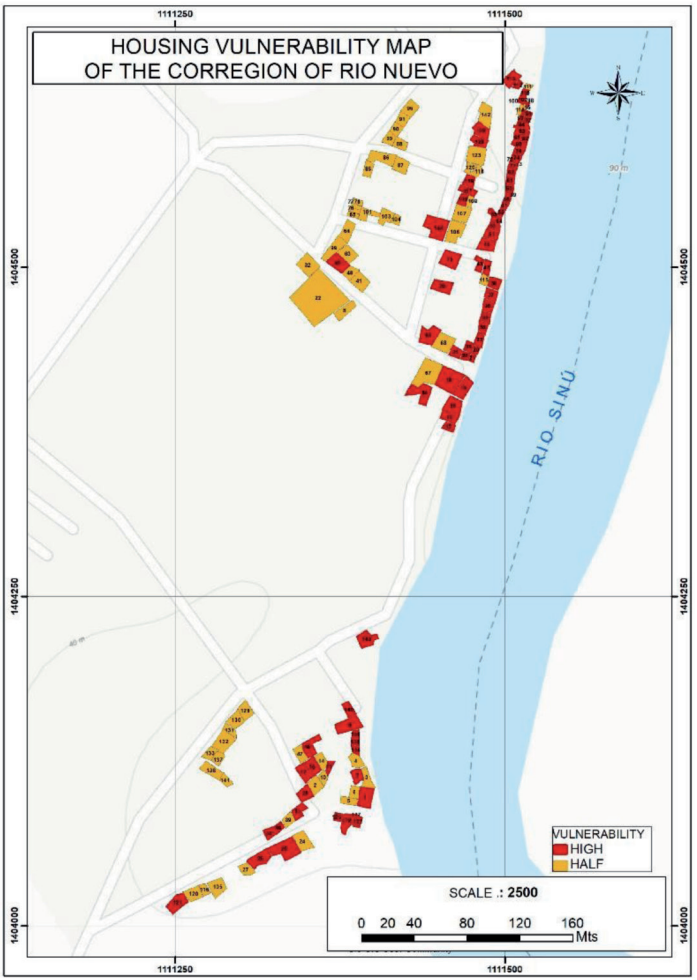
Source: Authors.

3.2. *Housing vulnerability*

The score of housing vulnerability presented by the rural community of Río Nuevo is high, 63.39; indicates that the township shows a probability of 0.63 on a scale of 0 to 1 of presenting physical damage when a flood occurs, as shown in Figure 3. The physical vulnerability that occurs in Río Nuevo is due to the fact that the material of the walls is 60% wood, which, when subjected to weathering processes caused by floods, loses the characteristics of texture, rigidity, resistance and ductility, among others, leading to the generation of instability in the structures. adds that 30% of the homes are more than 20 years old, which indicates that these materials have had interaction with the floods and therefore have low yields, in addition, the professional level variable is 96% corresponding to constructions carried out empirically and masons, who lack construction techniques that allow compliance with the NSR-10 standard, in the same way the houses that are n Less than 30 meters from the Sinú River with a percentage of 49%, they are in a high degree of exposure, indicating that they are more likely to suffer potential damage that leads to generating greater economic losses. On the other hand, according to the environmental regulations of decree 2811 of 1974 where it is specified in article 83 subsection D, the distance parallel to the line of the permanent

channel of rivers and lakes must be 30 meters, an evident situation that they do not comply with. Some houses in the corregimiento as they are built in public spaces destined for the intrinsic tree cover of the Sinú River.

Figure 3 - Housing vulnerability map of Rio Nuevo, Colombia



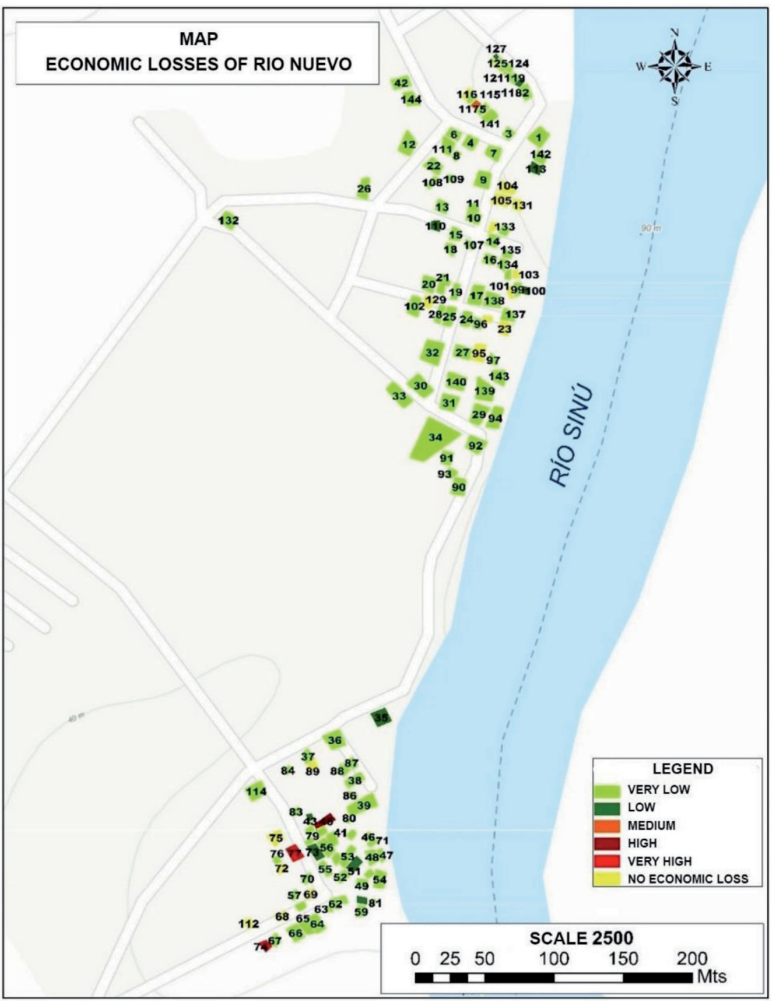
Source: Authors.

3.3. *Agricultural production, and goods lost estimated to floods*

Due to the occurrence of disasters due to floods, the economic losses in goods corresponding to 59% yielded US$103332,92 while in crop losses 41%

of the total lost US$70867,30, taking into account that 45% of the respondents have hectares where they grow corn, vegetables, cocoa, cassava, avocado, yam, tomato, banana, sapote, cabbage, rice, beans, cucumber, watermelon, papaya, chili, eggplant and papoche, where the most frequent are corn, rice, plantain, cassava and vegetables, it was possible to analyze that 62% of the crops are exposed to these events whose damages present partial or total losses in the land, for which many of these people have had to stop cultivating due to the fact that the flood ruins the hectares that were suitable for these activities.

Figure 4 - Agricultural production, and goods lost estimated to floods



Source: Authors.

According to the methodology implemented for the economic valuation of direct tangible potential damages due to flooding (Baró, Díaz & Calderón, 2012), a range identify in which loss each of the inhabitants of the township was located and based on this, obtained: too low 53%, low 23%, medium 3%, high 6% and very high 15%. According to the above, related the nearest the house to the river more losses could occur.

The floods that have brought the most repercussions for the rural community were carried out in the years 1964, 2004 and 2010, the first being the longest lasting with a time of 1 month, since the construction of the Urra hydroelectric was not counted on, followed in early 2010, with a durations between 7 to 15 days and 3 to 5 days occurred, in which all events lost goods and crops, the most representative losses being goods with 59% and crops with 41%, thus achieving a total economic loss of US$174200,22 located within the methodology with a valuation whose majority registered very low losses with 53%.

Conclusions

The rural community of Río Nuevo presents a high degree of housing vulnerability, due the building materials used on houses, wood being the main material because it is acquired low cost in the area, however, the lacks a treatment that helps withstand exposure to floods, to this is added that the inhabitants do not invest in their homes due to fear of the occurrence of the disaster, thus causing the goods and crops that have been acquired to be lost.

On the other hand, the houses that are less than 30 meters do not fulfil with the regulation 2811 of 1974, which states that the distance of 30 meters perpendicular to the tributary is a public space, causing the houses to be exposed to floods and increase the problematic in the loss of goods and crops, when located in spaces destined to the vegetal covers of the rivers or some mitigation work, therefore, it is necessary to relocate them.

Sinú River had too low losses since they are in a high index of marginalization or poverty, which leads to the conditions in which they live presenting material goods of very high quality. Low cost to be in a site of threat susceptible to flooding, in the same way, these losses depend on the level of water and the exposure factor with respect to assets and crops.

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Application of Participatory Methods to Explore Changes in Land Use of a Tropical Dry Forest Basin

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Abstract

Tropical hydrographic basins have undergone significant land use change processes in recent decades and correspond to areas of high population growth and development of economic activities. This article explores the causes of land use change in a tropical dry forest watershed, taking the Canalete river basin as a case study. For this purpose, stakeholder analysis techniques and participatory methods were applied. The results showed that the main causes of land use change in pastures were associated with biophysical factors, while forests-shrubs and crops were associated with direct and subyacents socioeconomics factors respectively. The participatory mapping allowed obtaining a desired land use scenario for the year 2030, observing a decrease of more than 16.2 ha of pasture, compensated by an increase of almost 2.4 thousand ha of crops and 13.8 thousand ha of forests and shrubs. Similarly, the hydrological impact of changes in land use was observed, especially in terms of flooding.

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1. Introduction

Tropical regions experience natural changes in land cover due to varied factors such as growth of forest stands and climatic processes. Nonetheless, anthropogenic disturbances, such as deforestation, are the major alteration factors (Smithsonian Tropical Research Institute, 2015). The favorable climate conditions in these regions have encouraged rapid expansion of human settlements and establishment of economic activities that modify plant cover and land use. Therefore, efforts should be increased towards understanding of drivers of change and processes in tropical ecosystems (Kalácska *et al*., 2005).

According to FAO (FAO (Food and Agriculture Organization), 2016), in the tropical countries there was a net loss of forests of 7 million ha/ year from 2000-2010. Underlying factors affecting forest conversion include population growth and changes in food consumption habits. The expansion and intensification of agricultural production is the immediate cause of 80% of deforestation worldwide (Kissinger *et al*., 2012).

Globalization and increased incomes have created growing demands for products, which, with land availability in the tropics, have boosted cultivation and grazing in rural and forest lands (Lambin & Meyfroidt, 2011). Commercial agriculture, including crops and pastures is the most crucial factor in deforestation of tropical and subtropical countries causing 40% of deforestation, subsistence agriculture, 33%; and the rest is distributed among urban expansion, infrastructure and mining (Hosonuma *et al*., 2012). Overall, cattle farming is the major driver of biodiversity loss (Marques *et al*., 2019).

On the other hand, river basins constitute an area where natural environment and socioeconomic systems interrelate (Garcia, 1998), reason why it becomes a unit of analysis conducive to the identification and analysis of changes in land use. Also considering that basin management is deemed as an integrated system within which multiple decisions are made regarding land and water use (Smithsonian Tropical Research Institute, 2015).

Nevertheless, the Inter-American Development Bank (Banco Interamericano de Desarrollo, 2012) has defined as good practices for

basin management: knowledge of conditions and behavior of natural and socioeconomic resources, active participation of relevant stakeholders and the long-term vision. Participation in basin management is an essential element because social stakeholders are determinants in land uses (Reed, 2008), which becomes even more relevant in tropical basin due to economic development and population growth processes involved, and for the needs of populations (Coxhead & Shively, 2005). For instance, Colombian government authorities have a watershed planning instrument, called POMCA by its acronym in Spanish (Plan de Ordenamiento y Manejo de Cuencas hidrográficas) (Bolaños-Valencia *et al.*, 2019), which includes a participation strategy in its different stages (Aranda Echavarría & Vidal González, 2020).

This article explores change causes in land use in a tropical dry forest basin, taking as a case study the Canalete river basin. Stakeholders' analysis techniques and participation methods were applied to identify the change causes in land use, to build a desired scenario by 2030 and research on the perception of the relationship between hydrology and land uses. The aims of this research are: 1. Identify the set of dominant drivers of land use change processes, 2. Recognize the needs and interests of key stakeholders in a future scenario, 3. Investigate the key stakeholders understanding of a socio-hydrological system.

In the context of a tropical dry forest basin, an ecosystem with strong seasonality and recognized as one of the most threatened by changes in land use, the research questions are: Are the causes of change in land use biophysical or socioeconomic (direct and underlying)? Is it possible for the key actors to jointly express a future scenario and their interests? Do the key stakeholders recognize the relationship between land use and hydrology? We applied participatory methods that represent a novel and applicable research approach to explain complex processes, where there is no universal link between causes and effects.

After this introduction, the second section of this paper presents a Literature review and theoretical framework for causes of land use changes. Section 3 describes the study area and methodology proposed for explore changes in land use of a tropical dry forest basin. Section 4 contains the application to the case study and results and Section 5 concludes.

2. Literature review and theoretical framework

Causes of land use changes can be classified as direct and indirect. According to Lambin *et al.* (Lambin *et al.*, 2003) direct causes are human activities (e.g., commercial reforestation) and indirect or underlying causes that constitute conditions in the human-environment relationship (e.g., population density).

Direct causes generally operate at local level (individual farms, families or communities), in contrast to underlying causes that originate at regional or global levels, with complex interactions at organizational levels. Regarding tropical deforestation, empirical evidence suggests that there is no universal link between causes and effects. Decline in tropical forests is determined by combinations of direct and indirect causes that vary according to geographical and historical context (Geist & Lambin, 2002).

In parallel, Mitsuda & Ito (Mitsuda & Ito, 2011), classify factors affecting land use in: socioeconomic and environmental. Environmental factors are related to topography and land productivity, while socioeconomic factors can be classified in accessibility, local community development, spatial configuration and political restrictions. They explain that accessibility, represented in the construction and improvement of roads, is a critical factor in the deforestation of tropical natural areas.

Hettig, Lay, & Sipangule (Hettig *et al.*, 2016) conducted a systematic review of studies related to causes of land use change in tropical regions, given the complexity of change processes. They suggest classifying these causes into: property rights and institutions, accessibility to markets and infrastructure, domestic characteristics, income and wealth, entry and exit of markets, adoption of agricultural technology, population and migration, and key policies.

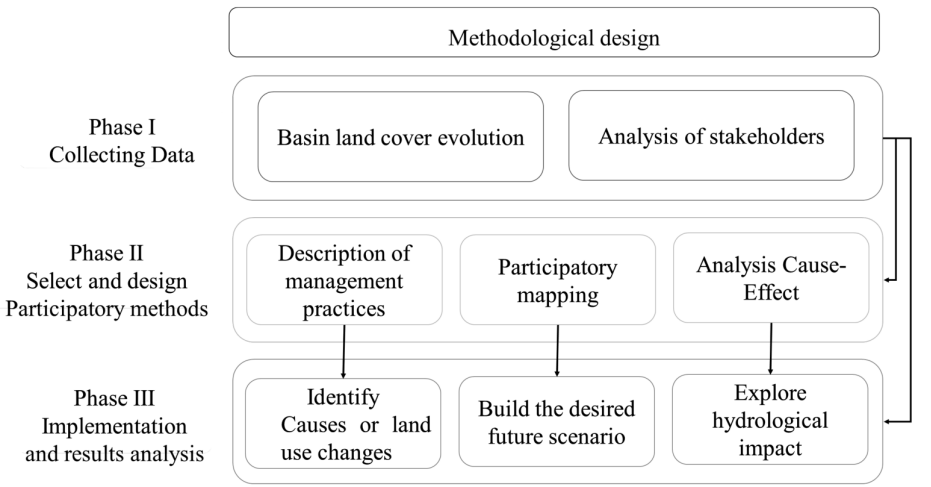
In the other hand, Lovett & Shutidamrong (Lovett & Shutidamrong, 2008) have studied land use and its management in a tropical basin and points out that land use planning requires innovations in analytical techniques in integrating methods of various disciplines. Their research focuses on identifying, applying and evaluating methodologies to facilitate participation of stakeholders in management decisions, and reduce conflicts over land use. Decision-making on basins is most effective when water managers, officials, community members, researchers, professionals and consultants, are included. Their participation allows to understand the underlying problems in the basins, including causes and viable solutions (Robles-Morua *et al.*, 2014).

Recent scientific approaches such as socio-hydrology suggest the joint studly of water and human systems, also recommending public participation (Geilfus, 2008). Some works have explored integrating knowledge and perceptions in a framework of cause-effect links, e.g. in groundwater systems (Guldan *et al.*, 2013), in decision-making in resource water conservation policies (Sanderson *et al.*, 2017), in the identification of socio-environmental effects of land acquisition (Johansson & Isgren, 2017), in the causes of increased cultivated land, settlements and consequences in the water and soil degradation (Wubie *et al.*, 2016).

3. Materials and methods

The methodology has three phases as shown in Figure 1. Phase's I objectives are (i) to build land cover of basin for different periods, (ii) to identify and analyze the stakeholders. The results of first phases are the data to the next phase. Phase II focuses on the selection and design of participatory methods. Finally, phase III focuses on implementing the participatory methods and analyses of results.

Figure 1 - Methodological design



Source: Authors.

3.1. *Study area*

The Canalete river basin, in the northwestern area of the Colombian Caribbean coast, is in an agricultural region and is geographically located in the Cordoba department which includes the territory of the municipalities of Canalete, Puerto Escondido, Los Córdobas and Montería. The basin corresponds to an ecosystem of Tropical Dry Forest and at the beginning of the 20th century most of the coverage was forested (CVS & Universidad Pontifica Bolivariana, 2008).

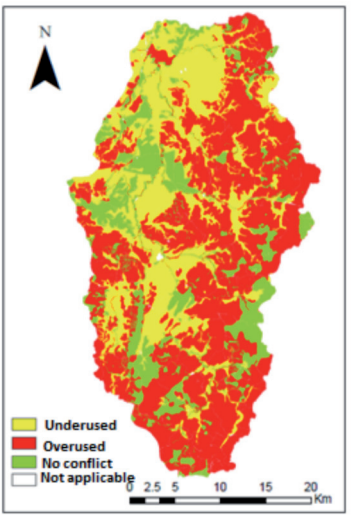
In the environmental diagnosis of the basin, developed by the environmental authority in 2005, it is highlighted that the economy of the Canalete river basin is based mainly on livestock production, including, breeding, fattening, milk production and commercialization of cattle, which is done extensively, and requires large areas planted with pastures.

Agriculture is also a relevant sector, with transient, semi-permanent and permanent crops. Transient crops are represented by corn, rice, cassava, yam and watermelon. Their short cycle makes economic activities dynamic. Semi-permanent crops are mainly bananas, being a product with demand in internal and external markets. Finally, permanent crops are represented by fruit trees such as coconut and cocoa (CVS & FONADE, 2005).

In recent years, forestry has become an important activity in the basin. The most sown forest species is teak (tectona grandis), an exotic species adapted to the region conditions. Other native species planted are oak, mahogany and cedar, all in demand in national markets (Corporación Autónoma de los Valles del Sinú y San Jorge - CVS, 2020; CVS & Universidad Pontifica Bolivariana, 2008).

On the other hand, conflicts over land use in the Canalete river basin include overutilization and underutilization, Figure 2 prepared by the environmental authority, called CVS by its acronym in Spanish (Corporación Autónoma Regional de los Valles del Sinú y del San Jorge), show the conflict map confronting units of vocation for use and current use (CVS *et al*., 2017). 50% of the area of the Canalete river basin, approximately 46 thousand hectares are overused. Overutilization conflicts are related to uses exceeding soil capacity, corresponding especially to agricultural activities on slopes greater than 25%. Underutilized area in the basin reaches 30%, with land used below its capacity for agricultural or forestry production. The areas without conflict correspond to 18%, the remaining 2% includes urban areas and bodies of water, referred to as "not applicable".

Figure 2 - Map of land use conflict



Source: Authors.

3.2. *Data*

3.2.1. Basin Land cover for different periods

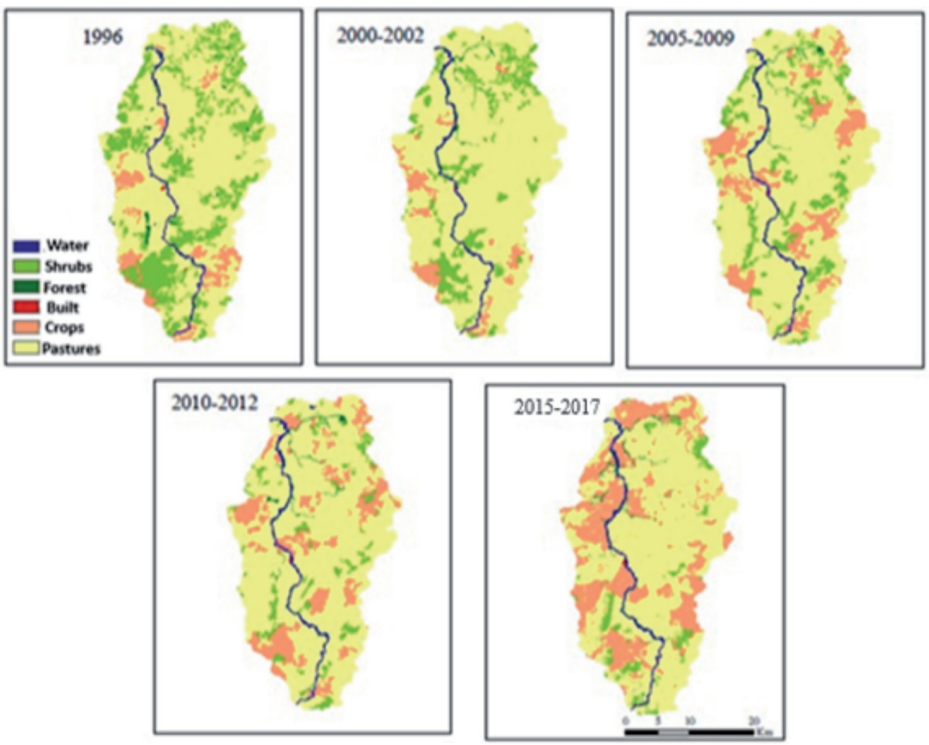
Coverages for different periods of the Canalete river basin are prepared using the Corine (Coordination of Information on the Environment) Land Cover methodology adapted for Colombia. The purpose of this methodology

is to make a homogeneous inventory of the biophysical cover (coverage) of the earth's surface based on visual interpretation of computer-assisted satellite images and generation of a geographical database. The national land cover legend for this methodology, at a scale of 1: 100000, is structured in a hierarchical manner, at levels 1 to 6 in the distinct types of coverage (IDEAM, 2010).

The coverage configuration for year 1996 was developed from LANDSAT satellite image (U.S. Geological Survey, 2017) at a 1:100000 scale. Land cover for three periods 2000-2002, 2005-2009, 2010-2012 were constructed from configurations nationwide, developed from Landsat 1:100000 images and 30-meter resolution. Finally, the 2015-2017 configuration was facilitated by the region's environmental authority and developed from RapidEye satellite images at a scale of 1:25000 and a 5-meter resolution (CVS *et al.*, 2017).

For the coverage of the Canalete river basin, levels 3 and subsequent of the Corine Land Cover methodology adapted for Colombia were used. With this classification, six categories were defined representing the basin coverage.

Figure 3 - Land cover for the Canalete river basin



Source: Authors.

These categories were called: built, pastures, crops, shrubs, water, and forests (the latter includes forest plantations).

Coverages of the Canalete river basin prepared five or different periods: 1996, 2000-2002, 2005-2009, 2010-2012 and 2015, Figure 3 shows how pastures are the predominant coverage in the basin. It is also noted that the areas of forests and shrubs have gradually decreased in the basin, while the cultivation areas have been increasing, especially in recent years.

3.2.2. Identification and analysis of stakeholders

To apply the participatory methods, a stakeholder analysis was previously carried out. The analysis of stakeholders was approached based on the identification of 32 actors described in the current Management Plan of the basin (Corporación Autónoma de los Valles del Sinú y San Jorge - CVS, 2020; CVS & Universidad Pontifica Bolivariana, 2008), including legal or institutional, technical and social stakeholders.

Analysis of stakeholders includes identifying stakeholders and adapting the classification categories for the research purpose (Chevalier & Buckles, 2008). Then, stakeholders were differentiated according to their relationship with the research phenomenon, the change in land use in the Canalete river basin, as follows: i) primary stakeholders: directly related to land use; ii) secondary stakeholders: with participation or influence in the regulation of land use; iii) tertiary stakeholders: with little influence on land use. The result of this initial classification allowed to identify 17 actors between primary and secondary, then these actors were categorized analytically.

Analytical categorizations are a set of methods in which stakeholders are classified based on levels of attributes such as: interest, influence, cooperation, competition, conflict, legitimacy, among others; such methods usually make use of matrices (Reed *et al*., 2009). In this research, three levels (low, high, and medium) were used for two attributes: influence on land use and conflict with other actors over land use. With this classification it was possible to identify key stakeholders, those that have great interest and influence in land use.

Table 1 shows the classification matrix by attributes of stakeholders. Participatory methods were applied by summoning the key stakeholders, in this case, those found in the quadrants: high-high, high-medium, medium-high, and medium-medium.

The analysis of key stakeholders allowed to identify the key stakeholders in the basin, in relation to land uses. These stakeholders were summoned to

Table 1 - Matrix of Classification of Stakeholders

Influence in land use				
	High	Livestock Federation	Agricultural Institute Reforesters	Land Authorities Regional Environmental Authority Cattlemen and Agriculturalists
	Medium	Environment Ministry Highways Institute	Public and Private Universities Agricultural Research Corporation Learning National Service	Non-Govermental Organizations Geographic Institute Institute of Hydrology and Meteorology
	Low	Fishers	Territorial Development Financial Trade Federation	
		Low	**Medium**	**High**

Source: Authors.

the a workshop in December 2017 and with them the participatory methods were developed, in which there were a total of 20 people. Table 2 lists the key stakeholders involved and their action level.

Stakeholder analysis has become increasingly popular among natural resource management policy makers (Reed *et al*., 2009). Stakeholder analysis is also used to understand the wide range of interests (Friedman & Miles, 2006) and to assess viability of future options (Brugha, 2000). In this research, stakeholder analysis was used both to recognize the causes of changes in land use, its hydrological effects and to build a potential future scenario.

Table 2 - Key Stakeholders List

Key Stakeholder	Action Level
Land Authority: Mayor's Office of Montería	Local
Land Authority: Mayor's Office of Canalete	Local
Land Authority: Mayor's Office of Puerto Escondido	Local
Land Authority: Mayor's Office of Los Córdobas	Local
Cattlemen and agriculturalists	Local
Regional Land Authority: Government of Cordoba	Regional
Environmental Authority: Corporación Autónoma CVS	Regional
Corporación de Investigación Agropecuaria [Agricultural Research Corporation] - Corpoica	Regional
Instituto Geográfico Agustín Codazzi [Geographic Institute] – IGAC	Local/Regional
Instituto Colombiano Agropecuario [Colombian Agricultural Institute] – ICA	Local/Regional
Private University: Universidad Pontificia Bolivariana	Local/Regional
Public University: Universidad de Córdoba	Local/Regional
Servicio Nacional de Aprendizaje [National Learning Service] – SENA	Local/Regional
Non-Governmental Organization: GIZ	Local/Regional

Source: Authors.

3.3. *Participatory methods*

Approaches to stakeholder participation are tools or methods facilitate collective knowledge, action and solution, also, allow to recognize and transform the existing environment. The methods are chosen based on the type of participation required and on problems people face and how they will be addressed. Stakeholder participation can enhance the quality of environmental decisions by considering more comprehensive information inputs and exploring complex processes (Bolaños-Valencia *et al.*, 2019). This research applies participatory methods because land use change involves different institutions and economic sectors, also involve multiple and interconnected causes and effects.

With the key stakeholders, a participatory workshop was held in December 2017, at the facilities of Universidad Pontificia Bolivariana Seccional Montería supported by the Environmental Engineering Program. The

participation workshop was carried out emphasized the need to selecting the relevant tools but adjust to the research purpose and the need to a skilled facilitation. The participatory methods selected, adjusted, and applied were:

1. Description of management practices (Geilfus, 2008) to identify Land use change causes.
2. Participatory mapping (Reilly *et al*., 2017) to build the desired future scenario.
3. Analysis Cause-Effect (Johansson & Isgren, 2017) to know the perception about the hydrological impact of land use changes.

The workshop was developed in one day and in three stages: First, a general context of the study area and the research objectives were presented to the key stakeholders. Also, the key stakeholders and facilitators introduced themselves. Second, the participatory method number one was explained in detail, which consisted of a format that contained the list of the causes of land use change identified in the literature review, participants filled out the format individually with the support of facilitators if required. The first two stages were done in the morning hours.

Third, in the afternoon after a break, participatory methods number two and three were developed. For method number two, the participants were divided into 3 groups and each group drew the desired scenario on a sketch map. The facilitators provided coverages map as a guide and handed out colored pencils. Then the three maps of the desired land use scenario to 2030 were consolidated, the participants also declared the reasons of their work. Finally, participatory method number three was developed using a survey in which the key stakeholders individually, wrote down their perception of the hydrological impact of land use in an agreement scale.

All this thanks to facilitators who supported the workshop, they were ten people, including undergraduate students, graduate students, professors, and researchers. Facilitation allows expression of diverse ways of thinking and respect for opinions. Thus, in the workshop, stakeholders were able to express ideas in an atmosphere of trust.

3.3.1. Description of management practices to identify Land use change causes

In the carried-out workshop, each actor was presented a tend graph with evolution of land cover, also provided with a list of 45 causes, variables or change drivers in land use, shown in Table 3 and discriminated in: Biophysical Causes and Socioeconomic Causes, the latter were classified as: demographic, life quality, economic, institutional, infrastructure and security. These causes were selected from review of literature in tropical contexts

(Hettig *et al*., 2016); (Eric F. Lambin *et al*., 2003); Mitsuda & Ito, (Mitsuda & Ito, 2011); (Newman *et al*., 2014) and of the explanatory variables used in the geographical modeling of land use.

Table 3 - List of Change Causes in Land Use

Biophysical		
Hight	Proximity to a village	Soil erosion
Slope	Proximity to a hamlet	Soil Productivity
Proximity to the river	Proximity to the forest	Weather Conditions
Proximity to the coast	Proximity to marshes and wetlands	Natural Threats
Socio-economics		
Demographics	**Life Quality**	**Economics**
Number of children	Life Conditions	Trade and earned Price
Number of Adults	Employment Conditions	Trade and Harvest Price
Number of Elders	Educational Coverage	Sale Price of Harvests
Number of Foreigners	Illnesses in people	Commercial Reforestation
Population Density and Distribution	Debt	Illigal Logging of Natural Forest
Institutional	**Infrastucture**	**Safety**
Public Resources	Aqueduct System	Presence of Armed Groups
Subsidies	Sewerage	Kiddnapings
Taxes	Aqueduct	Displaced people
Intitutional Presence	Technology	Theft or Robbery
Land Ownership	Proximity to Roads	
Govermental Programs	Road Infrastucture Extension	

Source: Author.

Afterwards, stakeholders were requested to register in a survey type instrument, those causes they consider have influenced the evolution of each coverage (pastures, crops and forests-shrubs.

3.3.2. Participatory mapping to build the desired future scenario

In recent years, more attention has been paid to the value of incorporating participatory methods in scenario analysis (Patel *et al*., 2007). Local

stakeholders can develop land use scenarios that consider the environmental and economic impacts of their economic activities (Chantre *et al*., 2016), the above allows developing a scenario as a planning tool.

The desired scenario was constructed through participatory mapping, a technique used to understand future perceptions from the stakeholders. Participatory mapping has been defined as the creation of maps by communities, organizations, governments, universities, and other actors involved in land planning development (Brown & Kyttä, 2018).

In this case, participatory mapping has been used for the communication of preferences on future land use. Year 2030 was selected as the time horizon of the desired scenario, considering that the basin environmental planning in Colombia is carried out at 12 years (Ministerio de Medio Ambiente y Desarrollo, 2014). Figure 4 shows stakeholders building the desired scenario.

Figure 4 - Construction of Desired Scenario

Source: Authors.

In the workshop, actors were divided into three groups, each group was given a map with the sketch of the basin at 1:80,000 scale and a base map corresponding to land uses (pastures, crops, forests and shrubs) for 2015-2017 that included the current of the Canalete River and human settlements.

The objective of this exercise is to produce a map that represents the desirable changes in land use (Geilfus, 2008). The stakeholders expressed on the map the desired land uses for 2030. They were also asked to indicate the reasons for wishing that scenario, to better understand the results. The maps of the three groups were consolidated in a single desired scenario in 1x1 km grids.

3.3.3. Analysis Cause-Effect to know the perception about the hydrological impact of land use changes

The hydrological impact of changes in land use was captured through a participatory analysis Cause-Effect (Johansson & Isgren, 2017) to know the perception about the hydrological impact of land use changes.

A survey was applied to the stakeholders in the workshop about their perception of the impact of changes in land use on the frequency and intensity of floods and droughts. The actors were asked to indicate their agreement, neutrality or disagreement with four questions: Do changes in land use impact the frequency of floods? Do changes in land use impact the intensity of floods? Do changes in land use impact the frequency of droughts? And do changes in land use impact the intensity of droughts?

The actors involved in the participatory workshop replied individually in written form, for each question they chose between five options 1: Strongly disagree; 2: Disagree; 3: Neutral; 4: Agree; 5: Strongly agree. Then the results were consolidated, as explained below.

4. Results and discussion

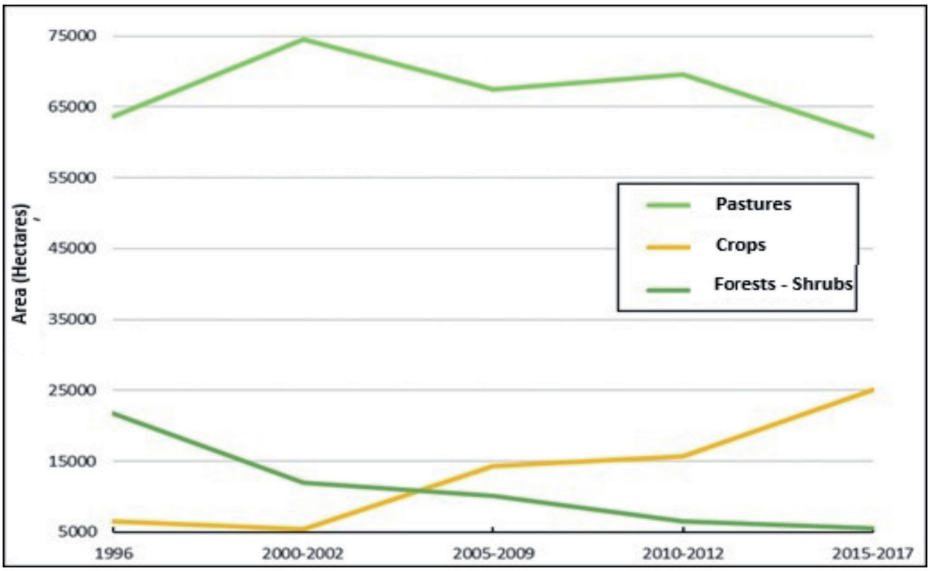
4.1. *Causes of Change in Land Use*

During the workshop, each actor was presented with the evolution of the land covers associated with the land use with the greatest area in the basin: pastures, crops and forests-shrubs. Figure 5 shows evolution of land uses in the basin.

It should be noted that forest and shrub cover were considered as one, given that they are natural or semi-natural cover and that plants in the tropical dry forest ecosystem, present in the basin, are characterized by growth habits of tree and shrub type (IAvH Instituo de Investigaciones de Recursos Biológicos Alexander von Humboldt, 2014). Thus, the characteristic vegetation of the dry forest present in the basin is presented jointly, which also facilitates the identification of change causes in land use by the actors.

Key stakeholders understood the evolution of land cover associated with land use and were able to recognize associated variables. They identified 17 causes of change in land use. These socioeconomic causes were classified as direct and underlying. Direct causes are human activities that operate at a local level and the underlying causes operate at a regional or national level, such as population dynamics and agricultural policies (Geist & Lambin, 2002). In this way it is highlighted that changes in land cover and land use are complex because they are driven by combinations of synergistic factors leading to increased pressure on environmental goods and services (Brugha, 2000).

Figure 5 - Evolution of Land Uses in the Canalete River Basin



Source: Authors.

Identification of change causes by key stakeholders of the Canalete river basin allowed to recognize a set of dominant drivers and a better understanding of crop expansion, deforestation and slight decrease of grasslands in the Canalete river basin. Table 4 shows the number of times each cause was selected, according to land use. It is noted that the biophysical causes were more frequently selected in the pastures. The direct causes were specially selected in the forest-shrubs and finally the underlying causes appear more frequently in the crops. The above shows us the cause types guiding the changes.

On the other hand, causes identified for each land use allow an understanding of factors that interact in this tropical context and how they influence decision making. Thus, the change for pastures originates in part due to natural conditions of the Canalete river basin. The strong seasonality of the rains, characteristic of the tropical dry forest (Dirzo et al., 2011) (Siyum, 2020) and the soil vocation, mainly agricultural, limit the livestock activity associated with pastures. The decrease of pastures is besides fueled by the effect of climatic variability and degradation processes affecting soils and pastures (Barragan, 2013; Garcia *et al.*, 2019).

Livestock is comprised by extensive systems, which in tropical contexts are characterized by low efficiency in soil use and by environmental damage

Table 4 - Identified Change Causes in Land Use

Land Use	Pasture	Crops	Forests-Shrubs
Biophysical Causes			
Soil Productivity	6	1	1
Weather Conditions	8	4	5
Proximity to the River	3	4	–
Soil Erosion	3	–	6
Direct Causes			
Road Infrastructure Expansion	2	-	1
Commercial Reforestation	-	-	2
Illigal logging of Natural Forest	-	-	8
Presence of Armed Groups	5	2	1
Underlying Causes			
Population Density and Distribution	3	6	4
Quality Conditions	2	4	1
Governmental Programs	2	9	3
Institutional Presence	1	4	5
Land Ownership	5	1	–
Land Size and Value	6	–	4
Trade and Price of Harvests	–	12	5
Trade and Price of Livestock	7	–	9
Livestock and Agricultural Techniques	2	1	–

Source: Author.

related to deforestation, burning, erosion, diversity loss, and soil compaction (Mahecha, 2003). Economic causes have also originated a slight decrease in pastures. Distribution inequality of land ownership that for the municipalities of the basin reaches a high Gini index higher than 0.7 (UPRA – Unidad de Planificación Rural Agropecuaria, 2017) and the seasonality, cycles and volatility of land prices cattle (Castillo, 2007), are economic factors that have operated at time scales and that result in individual and social responses to livestock activity and the pasture area.

Crop areas, associated with agricultural activity, have been increasing in the basin, especially due to combination of underlying drivers of change in

the use of demographic, institutional and economic land. Rural population in the municipalities of Canalete, Puerto Escondido and Los Córdobas that are part of the basin is over 80% (DANE – Departamento Administrativo Nacional de Estadística, 2018), making subsistence agriculture relevant, that causes 33% of deforestation in the tropics (FAO – Food and Agriculture Organization, 2016).

To explain changes in land use, it is also important to understand institutions and their interaction with decision (Brugha, 2000). In Colombia, financing the rural sector has shown a favourable evolution in recent years, reflected in indicators of access and deepening; being key products for the dynamism of the agricultural sector: bananas, rice and corn, precisely present in the basin. Other agricultural policy mechanisms in the country have also favoured growth of crop areas in the basin, such as coverage of prices especially important for corn, the exchange hedging program for export products such as bananas and the Incentive of Rural Capitalization – ICR for purchase of machinery in special conditions for the rice sector (Finagro, 2014).

Finally, forest-shrub cover responds to a combination of biophysical and socioeconomic causes. Biophysical drivers can be as important as socio-economic ones in land use. Erosion is a limitation for establishment of commercial forest plantations (CONIF *et al*., 1998) and in the Canalete river basin, 66.29% of the landscape corresponds to erosional structural hills (IGAC, 2009). On the other hand, among the socioeconomic causes prevailing in forest-shrub cover, there is illegal logging of the natural forest, as a direct cause, also identified as one of the main causes of deforestation in tropical dry forest (Addo-Fordjour & Ankomah, 2017). The commercialization and price of livestock is an underlying cause of the shrinking forest-shrubs indicating that in addition to the use of subsistence forest, livestock drives deforestation to access grazing areas.

These results become a contribution that helps decision makers to identify land use policies, which can be command and control interventions affecting direct causes and other public interventions against underlying causes such as macroeconomic, market policies, subsidies, or taxes (Lambin *et al*., 2014). Particularly relevant in tropical contexts where agricultural expansion leads the change in land use and is generally favoured by government policies, coupled with market forces, poverty, and inadequate tenure of the land that drive the agricultural expansion process (Wassenaar *et al*., 2007).

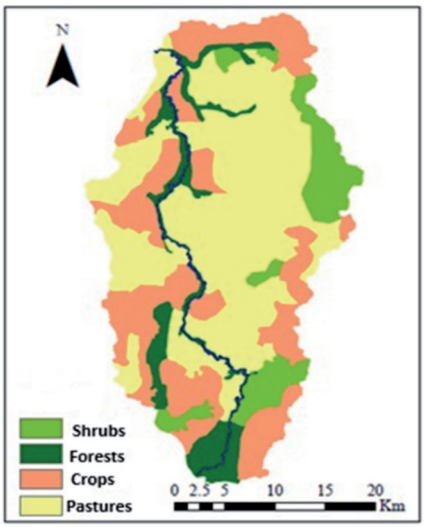
4.2. *Desired Future Scenario*

The participatory mapping allowed to obtain a desired land use scenario by 2030, shown in Figure 6. With respect to the land use configuration 2015-

2017, a decrease of more than 16200 ha of pastures is observed, offset by an approximate increase of 2400 ha of crops and 13800 ha of forests and shrubs. In this participatory exercise, the stakeholders expressed their needs and interests to desire the scenario proposed for the year 2030, presented for each land use in Table 5.

Decrease of pastures in the future scenario, compared to the land cover 2015-2017 is explained by the actors with needs and interests that refer to the improvement of livestock production (such as with silvopastoral systems) and the improvement of social conditions in terms of equality. On the other hand, increase in crops is also related to the improvement of social conditions (income, food, and life quality) and to the use of the land vocation, among other aspects. Finally, stakeholders expressed interest in the increase of forests and shrubs for the recovery of strategic areas and decrease of erosion and floods.

Figure 6 - Scenario for year 2030 built with key actors



Source: Author.

Table 5 - Needs and Interests for the Desired year 2030

Pastures	Crops	Forests and Shrubs
Technified and sustainable livestock	Improve life quality and income of the inhabitants	Water round recovery
Implement silvopastoral systems	Take advantage of the soil agricultural vocation	Recovery of forested areas at the source of the river
Promote land equality	Ensure food security	Maintain wooded areas
Support owners of small farms	Allow crop irrigation	Reduce erosion and floods
Diversify productive activities	Implement agroforestry systems	Connectivity of natural areas with the coastal zone

Source: Author.

Despite the diversity of stakeholders and roles, it was possible to consolidate a single scenario map by 2030 and match areas for different uses, given different interests and needs. Additionally, some actors expressed other interests regarding contextual and cyclical conditions, such as support for ecotourism, articulation with post-conflict conditions in the country and with territorial planning tools of the basin municipalities. The pattern of underlying dimensions and territorial dynamics indicates that important challenges exist for the post-conflict period in Colombia. Relevant political implications for the Canalete river basin include environmental governance, preservation of protected areas, and sustainable agricultural and livestock practices (Garcia *et al*., 2019). The challenge for the agricultural sector is to develop sustainable production strategies that improve the profitability of production (Julio *et al*., 2022).

The desired scenario and land use change causes recognize that changes in land use are the result of a complex interaction between socioeconomic and environmental factors (Demissie *et al*., 2017; Hewitt *et al*., 2014). Stakeholder participation ensures that the analysis and findings of geographic modelling exercises provide correct answers and practical results (Garcia, 2018; Kalra *et al., 2015*).

4.3. *Hydrological Impact of Land Use Changes*

This paper presents an alternative for the study of these water and human systems, using participation tools of key stakeholders, the effects on hydrology of changes in land use in the Canalete river basin. Although, most outstanding feature of the tropical dry forest is the marked seasonality of rainfall (Dirzo *et al*., 2011), research published in hydrology is rare (Farrick, 2014).

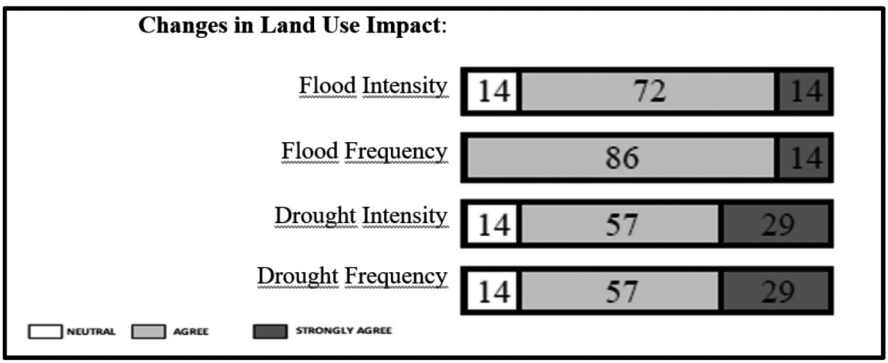
This proposed approach facilitates understanding of socio-hydrological systems and represents an opportunity to identify new data sources, to develop models that include important variables in basin modelling, even in cases where there are data limitations (Mostert, 2018), such as in tropical basins. Some authors indicate limitations in tropical basins due to the available information for example Hydro-meteorological, discharge, infiltration and calibration data (Beskow, 2009; Cornelissen *et al*., 2013; Sierra *et al*., 2017; Viola *et al*., 2014).

The stakeholders revealed their perception of the hydrological impact of changes in land use in the Canalete river basin. Most of the stakeholders reported agreeing that changes in land use modify the intensity of floods, only 14% indicated neutrality in their response. One hundred percent of the stakeholders agreed that changes in land use modify the frequency of flooding.

Regarding drought processes, 57% and 29% of the stakeholders agreed and strongly agreed, respectively, that changes in land use impact the frequency and intensity of events. Only 14% expressed neutrality in their responses.

Results are presented in Figure 7, such as percentage of stakeholders, it is observed that they generally agree on changes in land use impacting basin hydrology, especially in terms of flooding. Hydrological impacts of the different land use changes related above reiterate the importance of including socioeconomic variables within the hydrological analysis of basins. Identifying the causes of land use changes requires an understanding of how people make decisions and how a range of factors, like hydroclimatics, interact in a specific context.

Figure 7 - Percentage of stakeholders



Source: Authors.

Changes in soil characteristics often affect the mechanism of runoff generation (Rodriguez *et al.*, 2010), especially in relation to floods and droughts (Gumindoga *et al.*, 2014). The research of human activities that have a significant impact on hydrology and the factors that can explain these activities, helps a better understanding of how society interacts with the hydrology of a basin (DeFries & Eshleman, 2004).

5. Conclusions

In this article, participatory methods were applied as an alternative to allow exploring changes in land use in the tropical basin of the Canalete River. In this exercise it was possible to reduce from 45 to 17 incident

variables in the change in land use, become a contribution that helps decision makers to identify land use policies. These causes of change in land use included processes related to pastures and crops, in addition to deforestation processes most studied, relevant in tropical contexts where agricultural expansion impacts the environment. Identification of causes of change in land use and construction of a desired scenario, provide important qualitative information, very useful in the parameterization of geographical models of change in land use, which becomes an approach integrating analytical and discursive domains.

It is recognized that changes in land use in tropical basins have had effects on hydrological processes. In this paper, an alternative is presented for the study of these socio-hydrological systems, using participation tools, finding agreement between the stakeholders against the impact of changes in land use on hydrology.

However, this work has some limitations: the coverages for different periods of the Canalete river basin were prepared from different scales and the participatory methods are replicable but adapting to the context and convening capacity of the key actors. Finally, it is important to highlight that the basin is in a tropical dry forest, recognized as one of the most threatened ecosystems hence, participatory methods applied represent a novel and applicable research approach where complex processes are presented and there is no universal link between causes and effects.

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Crop waste management proposal in rice systems at the department of Cordoba, Colombia

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Abstract

The claim for food increases with the waste caused by its production. Rice is appetized but the agro-industrial residue, such as straw and husk, becomes a problem when they're not properly managed. However, renewable source demands grew, indeed, the chains of rice residue as cellulose, lignin, hemicellulose, carbon, and silica could be transformed into: fuel, power generation, gas production, paper manufactory, and fertilizer for the production of fungi and building material. The industrial implementation of rice residue management worldwide has a lack. In this case, it was observed more closely the rice cultivation in a local region of Colombia. The aim of this research was to present the current market, challenges and the proposal of a proper management residue on a circular economy incorporated into Córdoba department rice market. The study was conducted through scientific and comprehensive insights on rice crop waste management options. The selection criteria of the articles were rice production, major components of rice paddy, straw, and husks, and waste disposal in rice systems. Farmers, researchers, federations, administration, and management, need to work on, improving the nutrients of the soil, the quality of the crop, and the management of the residue, the one that remains in the mills and the one that remains in

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the fields. Finally, in all processes, the required investment to obtain a product that meets current market requirements on renewable fuels or raw materials.

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1. Introduction

According to the report of FAO-Food and Agriculture Organization, rice production was 759.6 million tons of paddy in the worldwide production in 2017, Asia is approximately 516 million tons/year, and Latin America is 28 million tons (FAO, 2022). National Federation of Rice Growers (FEDEARROZ by its acronym in Spanish) indicates in the 2018 annual balance, Colombia has an estimated production of 1,904,819 tons, planted on 33,377 hectares; the department of Córdoba, the use of flat areas estimated production of rice 111,687 tons in 2016 and 142,940 tons in 2017 were harvested (DANE, 2022).

Management of rice husk (RH) and rice straw (RS) waste is not adequate in Colombia or worldwide. The RH waste is being disposed of in landfills, the same rice mills, or burnt. Some planters burn RH and RS due to simplicity and to avoid the high costs of managing rice waste. The Open-air burnt process generated problems for rice cultivators and neighbors. Caused by CO_2, CH_4, N_2O, hydrocarbons, dioxins, and other particle emissions and represents a toxicological risk (Ribó, Albiach, Pomares, & Canet, 2017). Rice farmers believe that the direct placement of rice husk and straw in paddy fields would guarantee a cycle of soil nutrients, and organic fertilizer. Moreover, agronomists indicate that this practice could bring problems of air pollution, underground water, and soil, may be as damaging as burning it (Ahmed, Ahmad, & Ahmad, 2015; Colombian Ministry of Agriculture and Rural Development, 2005).

The rice husk is used as fuel for the dried process, industries used the husk in mills to feed the furnace boilers as a substitute for traditional and expensive fuels (gasoline, gas, electricity); for this, mixtures are made with kerosene as an activator in combustion, burning the material. To harness the energy of the rice husk in the rice drying process (Jittin, Bahurudeen, & Ajinkya, 2020). The rice husk used as fuel is due to activated carbon

since it contains around 30% to 50% organic carbon. Rice husk burnt or used as fuel contributes to greenhouse gas emissions (Singh B., 2018). Moreover, rice husk has electrical and thermomechanical properties and as promising electric resistivity (Raheem, Oriola, Kareem, & Abdulwah, 2021; Sanchis, Ferrer, Calvet, Coscollà, & Yusà, 2014). The ash obtained from the calcination of the husk is used in the cement industry, as the production of Supplementary Cementitious Materials (SCMs), the RH can be a cost-effective raw material to produce silicates and silica materials (Bonifacio & Archbold, 2022). Rice husk presents noticeable properties, such as lightweight, and low thermal conductivity, and from the microscopic view is loose and porous (Janbuala & Wasanapiarnpong, 2015). Lately, rice husk has engrossed research in the thermal insulation field (Bahrami, Pech-Canul, Soltani, & Guti, 2017). The husk has been used as a fertilizer, fuel, energy source, building material, and insulation material (Singh, Yadav, Ravisankar, Yadav, & Singh, 2020).

Despite the economic and practical benefits of burning rice straws, it has been environmentally regulated and restricted in many regions worldwide. For example, burning straws has been banned by the common agricultural policy (CAP) of the European Union (Ribó, Albiach, Pomares, & Canet, 2017). In Colombia, the Environment Ministry, with the Colombia Society Farmers-CSF, and Fedearroz, published the Environmental Guide to Rice, here describes laws, restrictions, environmental policies, entire cultivation process and briefly mentions the disposal of waste (Colombian Ministry of Environment and Housing, 2000; Colombian Ministry of Agriculture and Rural Development, 2005). Whereby requirements, terms, conditions and obligations established for controlled open burning in rural areas in agricultural and mining activities (Resolution number 532 of 2005, 2005).

A number of alternatives to the merged entity residue burning, many of which are, theoretically at least, added value to the waste. For growers around the world, there are not many options apart from burning the residue left. At the same level, management proposals that are viable, economically profitable and sustainable are required (Sanchis, Ferrer, Calvet, Coscollà, & Yusà, 2014; Shyamsundar, Springer, Tallis, & *et al.*, 2019). This persistence of residue burning has multiple likely causes: options are often encouraged in isolation and rely on changes in farmer behavior, awareness of the problem, the system of policies, the priority of food security, and water conservation that have gradually forced residue management (Gupta, 2019). Benefits and risks campaigns for moving away from residue burning between farmers that modifications in agricultural performance can indicate and thus incentivize governmental support (Downing, Kumar, Andersson, & *et al.*, 2022). So an improvement in rice production is needed, in addition to rice waste disposal and adequate utilization, due it is not yet efficiently industrialized and

abundantly available. This study aimed to present the different alternatives that rice residue both husk and straw, as a proposal for managing rice crop residues in the department of Córdoba, Colombia.

2. Methodology

Department of Córdoba, located in the north of Colombia, known as the Caribbean region. They have an average annual rainfall of 1,346.1 mm, relative humidity of 84%, average annual temperature of 27.4 ºC and a lifezone called tropical dry forest. Each year there is variation in the production of rice cultivation, in 2017 around 9,198 hectares of mechanized rice were planted, of which a production of 44,404 t was obtained and an average yield of 4.5 t/ha (DANE, 2022). Multiple studies have been carried out to increase productivity and optimize the industrial process, but the elimination of waste currently has a gap.

A comprehensive methodology used in the study is presented in this section. The study was conducted to get scientific and comprehensive insights on rice crop waste management options. The selection criteria of the articles were: a) Rice production at the department of Cordoba, Colombia, b) Major components of rice paddy, straw, and husks, c) Analysis Greenhouse Gases of Rice Crop Cycle, d) Crop residue management options in rice systems (Open Burning and Controlling Burning), and e) Crop waste management proposal in rice systems at the department of Cordoba, Colombia. Scopus, Google School, Science Direct, National Federation of Rice Growers website, institutional statistical data, government sites of Colombia and the department of Córdoba database were consulted. Updated files were selected. The bibliographic search was limited to that period to have documents that are up to date with the advances that have emerged regarding this topic.

3. Rice production at the department of Córdoba, Colombia

Green paddy rice is the grain just after its collection, including its wet husk, and that has not undergone any industrial process (Colombian Ministry of Agriculture and Rural Development, 2005). Later it is cleaned to separate impurities, milled and bleached to obtain white or excelso rice, suitable for human consumption. Rice production in Colombia is separated into five regions, the department of Cordoba belongs to the region known as the lower basin of Cauca, join to the departments of Antioquia, Bolívar, Chocó and

Sucre with 165,808 hectares corresponding to 27.19% of rice plantation of the country. By 2019, the department of Córdoba, had an area of 15,417 hectares of rice cultivation (DANE, 2022).

Rice production slips into mechanized rice, irrigated rice, mechanized rainfed rice, and manual rainfed rice. The department of Córdoba, Colombia, have a number of mechanized rice producers in 2016, which was 724 and the number of Colombian Rice Producing Unit (RPUs) was 826, with an annual planted area of 11,588 ha, harvested area of 10,594 ha, and a production of 47,184 tons (FEDEARROZ, 2016).

Below are the most important data on rice cultivation in the department.

Table 1 - Planted area, production, and yield in rice in the department of Córdoba (FEDEARROZ, 2016)

	Área ha	**Production (t)**	**Performance t/ha**
First semester			
Mechanized rice	327	15.184	4.6
Irrigated rice	2.466	11.980	4.9
Mechanized rainfed rice	811	3.205	5.2
Manual rainfed rice	4	10	2.4
Second semester			
Mechanized rice	7.318	32.000	4.4
Irrigated rice	1.632	8.731	5.4
Mechanized rainfed rice	5.687	23.269	4.1
Manual rainfed rice	225	519	2.3

Table 2 - Planted area and production units of mechanized rice, irrigated rice, mechanized rainfed rice, and manual rainfed rice, in the Department of Córdoba, first and second semester 2016 (FEDEARROZ, 2016)

	Area	**RPUs (1)**	**Area**	**RPUs (1)**	**Anual Area**
Mechanized rice	6.918	641	4.670	434	11.588
Irrigated rice	1.714	81	1.573	135	3.287
Mechanized rainfed rice	5.204	560	3.096	299	8.300
Manual rainfed rice	–	–	–	2.714	2.822

* Colombian Rice Producing Unit (RPUs) – National Agricultural Census in 2016 (DANE by its acronym in Spanish).

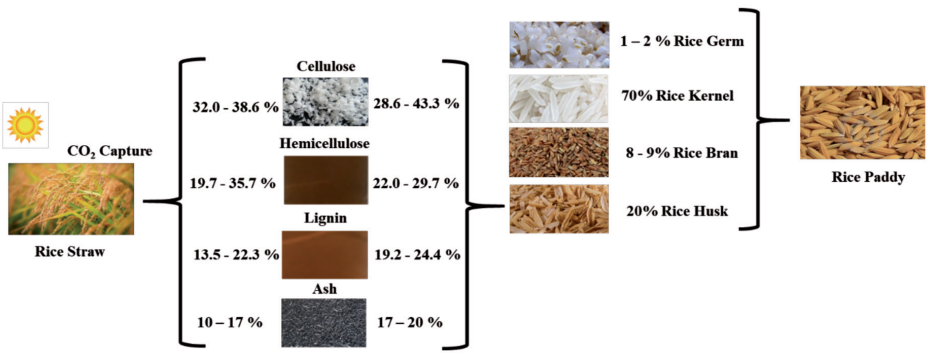
4. Rice crop

The outer hard protective covering of the paddy grain is removed during rice milling and represents 20%-25% of its weight. After the paddy is milled, the husk obtains about 20% of the weight of the paddy (Memon, Shaikh, & Akbar, 2011).

Once the rice kernel and germ are gotten, its two by-products are brown rice and rice husk (RH). Rice straw and husks were formed from hard materials, including cellulose, hemicellulose, and lignin, along with considerable amounts of silica and other minor components, as summarized in (Figure 1). Both are agro-industrial waste.

Though rice is a significant source of food for many people around the world, it produces a lot of straw and husks each year, with an estimated annual production of around 8×10^{11} kg of straw and 1.5×10^{11} kg of husks, respectively (Singh & Arya, 2021).

Figure 1 - Major components of rice paddy, straw, and husks (Dejkriengkraikul, Semmarath, & Mapoung, 2019; Mirmohamadsadeghi & Karimi, Recovery of Silica from Rice Straw and Husk, 2020)



4.1. *Rice Straw*

From the processing and cultivation of rice, the main by-products generated are rice straw from agro-waste; thus, natural fibers from agro-waste (Danish, Naqvi, Farooq, & Naqvi, 2015), this volume of the outgrowth is more than the actual agricultural product (rice), 1.5 tons of RS per 1 ton of rice (Morales, Agudo, & J., 2021). Rice straw's size-specific surface area is large and has beneficial adsorption characteristics for ammonium nitrogen and humidity (Zhang *et al.*, 2016; Guan *et al.*, 2021). Rice straw and rice

husk had a similar chemical composition, with lignocellulosic materials and composed of structural carbohydrates. RS main components are structured as follows: cellulose (30-45%), hemicellulose (20-25%), and 15-20% lignin; silica, inorganic compound (ash) content is relatively high, a minor amount of organic composite and other minor components (Mirmohamadsadeghi & Karimi, 2020; D. Sietske Boschma, 2013).

Cellulose is a linear polymer and crystalline molecular structure; also sets exclusively β-glucose monomers. Hemicellulose´s composition with different carbohydrate polymers and amorphous molecular structure; and holds a polymer that seats sugars (Ibrahim, El-Zawawy, Jüttke, Koschella, & Heinze, 2013). Lignin is an irregular three-dimensional; branched phenolic polymer whose monomeric units' alcohol, and is a polymeric aromatic structure that involves the oxidative coupling (Cao *et al*., 2020).

Appropriate management of the soil, nutrients, fertilizers and water resources, rice crop residues such as RS is considered renewable, abundant and several by-products still require research to be applied to the industry; Cellulose, hemicellulose and lignin extraction processes were suggested (Xiao, Sun, & Sun., 2001). RS is a source of cellulose to obtain pulp and paper manufacturing through chemical pulp due to its organic origin it shares other components such as high silica content, which is optimal to be used in various uses in the construction but it causes scale in the chemical recovery equipment of the pulpers, thus reducing the useful life of the equipment, which makes difficult the production of this material (Leiva-Candia *et al*., 2014; Luo *et al*., 2019; Himmel *et al*., 2007). Cellulose, hemicellulose, and lignin could produce biofuels, biochemicals, and biomaterials. Hemicellulose is less stable than cellulose; hence, easily degraded when exposed to heat temperature (Ma, Gao, Wang, & Liu, 2018).

Hemicellulose removal has numerous techniques such as dilute acid pre-treatments, alkaline extraction, alkaline peroxide extraction, vapor treatment, liquid hot water treatment, ionic extraction, ultrasonication, and microwave treatment is a significant stage in the production of different chemicals (Kaur, Bhardwaj, & Lohchab, 2017). Lignin manifestation and paddy straw's structural complexity are noteworthy obstacles to enzymatic and microbial attacks (Leiva-Candia *et al*., 2014). Rice straw has been used, as support for many polymers matrices and mainly studies, the mechanical properties of these composites were informed (Pandey *et al*., 2000). Nevertheless, pre-treatment exposure helps lingo-cellulosic materials to get a high level of fermentable sugars (Peng, Peng, Xu, & Sun., 2012). The abundant availability of rice straw makes it an interesting lignocellulosic material for bioethanol production; only many difficulties and limitations for the transformation of rice straw into etanol (Malik, S., Kumari, Mehta, & Kumar, 2020). Approachability, low cost, and small-scale energy production from RS have

a potential; still poorly developed a high-value utilization of rice-derived biomass (Swain, Singh, & Sharma, 2019), regardless of their contributions to solving environmental issues due to air pollution or ecosystem degradation (Thabah, Singh, & Bedi, 2021). Mechanic composting and livestock feeds encourage farmers not to practice open field burning (Wi, Choi, Kim, Kim, & Bae, 2013), even though field burning and soil amassing of rice straw persist in collective performance, rice straw has been more improper to burn due to the significant atmosphere pollution caused by greenhouse gas emissions and the smoke that comes with it (Goodman, 2020). Rice crop management policies add value to the feed product, improve the environment, and encourage the paddy-producing countries to adopt a sustainable bio economy.

4.2. *Rice Husk*

Rice plants can captivate the silica content from the soil over the rice growing the silica is absorbed (R.G. Smith and G.A. Kamwanja, 1986). The density of rice husk is low in the range of 90-150 kg/m^3 (Singh B., 2018). Rice husk can absorb water ranging from 5% to 16% of unit weights, and the unit weight of rice husk is 83-125 kg/m^3 (Mansaray & Ghaly, 1998). Rice husk is a lignocellulosic material, which consists of cellulose, hemicellulose, lignin and moisture content. Rice husk is mainly composed of cellulosic sugars and 20% of lignin. The amount of lignin is about 18±4% which makes rice husk unsuitable for the manufacturing of papers and cellulose production. The observed deviation in the composition is due to the type of paddy used, climate and geographical conditions. Most importantly, the ash content in rice husk is 18±2% (Mirmohamadsadeghi & Karimi, 2020; Jittin, Bahurudeen, & Ajinkya, 2020).

Rice husk is produced in large quantities and is an organic waste, promoted by-product of the rice milling and agro-based biomass industry. Rice husk constitutes approximately 23% of the weight of rice (Jittin, Bahurudeen, & Ajinkya, 2020). Also, is a cellulose-based fiber and contains approximately silica, which at the amorphous structures has nutritional value and chemical-physical resistance (Hu *et al.*, 2008; Nair, Fraaij, Klaassen, & Kentgens., 2008; Ndazi, Karlsson, Tesha, & Nyahumwa, 2007). Rice husk also contains volatile matter (60-65%), fixed carbon (10-15%), and 17-23% ash (Karam *et al.*, 2021; Kwong, Christopher, Chao, Wang, & Cheung, 2007).

Organic compounds are main constituents of husk: cellulose (40%-50%), lignin (25%-30%), silica (15%-20%) and humidity (10%-15%) (Bakar, Yahya, & Gan, 2016; Soltani, Bahrami, Pech-Canul, González, & Gurlo, 2017). Rice husk can absorb water ranging from 5% to 16% of unit weights, and the unit weight of rice husk is 83-125 kg/m^3 (Mansaray & Ghaly, 1998).

4.3. *Open Burning*

It has been challenging the threat of residue burning, despite advancements in agricultural sciences and current environmental demand (Bimbraw, 2019; Mondal *et al.*, 2020). The rice straw open burning (RSOB) is unfortunately a very common practice, it is considered as a clean-up method for the next harvest.; also, the farmers believe that rice straw burning has benefits (Singh & Sharma, 2021). With exposure to oxygen, the burning of RH and RS has an incomplete combustion; this releases pollutants into the atmosphere as by-products (G. Tabasso, Cravotto, & van Ree, 2020; Singh, Yadav, Ravisankar, Yadav, & Singh, 2020). Can emit toxic air pollutants such as particulate matter (PM), polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), NO, SO_2, CO_2, and greenhouse gases (J. Chen, 2017; Chi & Oanh, 2021; Pham *et al.*, 2021). One of the main components of the soil is organic carbon, which is regulated through the microbiota, the effects of biochar residues or carbonate. Burning under natural conditions could be affecting the renewal of soil organic carbon, interfering with its reserves (Bi *et al.*, 2020).

Several investigations have been carried out to know the impacts of the RSOB on air quality and human health on a global scale; however, data from some places is still lacking to know its true damage (Pastorello, Caserini, Galante, Dilara, & Galletti, 2011). The investigations carried out show that the activity of burning in the air seriously affects the quality of the air, human health (that is, cancer and bronchial asthma). In addition, the planet has political but not physical borders, so toxic gas emissions can travel between countries, for example the combustion of waste in India affects air quality in Pakistan and vice versa (Ghosh *et al.*, 2016; Conde, Ayala, Afonso, & González, 2005; Torigoe *et al.*, 2000).

In summary, burning in the open causes deterioration of the upper layer of the soil, decrease in the capacity of the crop, health problems, compromise the quality of the air and can influence climate change; which could be improved by efficient recycling of rice straw in a sustainable way (Raheem, Sajid, Iqbal, Bilal, & Rafiq, 2019).

4.4. *Controlled Burning*

With the increased energy demand, cleaner, and more efficient fuels can be obtained in thermochemical. Many technologies like pyrolysis (Ai, Chen, & Fu, 2022), gasification, combustion, etc. are available and applicable. Pyrolysis is an adaptable and appealing technique for producing bio-oil as an alternate transportation hydrocarbon. It is no efficient as natural gas,

but it is correlated with ash and liquid return is achieved (Ai, Chen, & Fu, 2022). The Pyrolysis methods are made by Muffle furnace, gas furnace, fluidized bed reactor, reactor Torbed and fix bed reactor. According to a case study, 4,947 MWh electricity could be produced in a year from 6432 tons of husk through fluidized bed combustion (FBC) technology in which rice husk was taken in a boiler with a capacity of 15 t h^{-1} and a combustion efficiency of 88% and the high pressurized steam generated was applied to the turbine coupled to a shaft that ran the generator (Memon, Harijan, Soomro, Meghwar, & Valasai, 2017).

Gasification is an effective method to transform a wide diversity of biodegradable materials into raw syngas for use immediately as energy, electricity, or transformed into a biological production of gas (oxygen and carbon monoxide) (Vinoth *et al*., 2021; Chi *et al*., 2015).

Combustion systems convert all of the fuel into CO_2, H_2O, and heat, while gasification systems only partially oxidize the fuel, creating intermediate products such as CO_2, H_2, and hydrocarbons. Gasification systems and intermediate products that rarely leave the combustion chamber must be understood (Ai, Chen, & Fu, 2022; Jittin, Bahurudeen, & Ajinkya., 2020).

4.5. *On-field use of crop residues*

The ample disposal of paddy straw can be cost-effectively, and viable employed as a substrate for the crop growing of mushrooms, for converting rice straw into appreciated food rich in protein; straw can smear as the principal substrate for the growth of mushrooms (Bánfi *et al*., 2015). Rice straw does not offer good physical strength to the composted it should be composted and improve its nutrient percent by mixing with a number of materials like gypsum, urea, rice bran, chicken manure, etc., with different ratios will show superior results; one of the simplest rising mushrooms is rice straw mushroom (RSM) (Volvariella volvacea) owing to their short maturing time and have less fat (Zikriyani, Saskiawan, & Mangunwardoyo, 2018).

4.6. *Analysis Greenhouse Gases of Rice Crop Cycle*

Open burning is not the only rice crop factor that emits gases and has an environmental concern. The evaluation of greenhouse gases has been analyzed in the different stages of a rice crop cycle. The first phase analyzed the soil chemistry and land preparation; the second part considered the entire cultivation process, and the last stage attributed to residue management. The main GHGs analyzed were carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). At each stage, emissions were analyzed by various

factors and indicators. For example, in the first stage, CO_2 and CH_4 are the final organic matter decomposition products of these soils and the aeration of the land. In the second phase, consider the following factors: water management, intermittence between dry and flooded soil, inappropriate practices, the high use of nitrogenous fertilizers, and the application of pesticides, and herbicides, lead to higher emissions of CH_4 and N_2O. Finally, the residue management emissions will also depend if it is removed, burned, incorporated by 'fangueo' (mud driving), or deposited on the ground as a cover (Sanchis, Ferrer, Calvet, Coscollà, & Yusà, 2014).

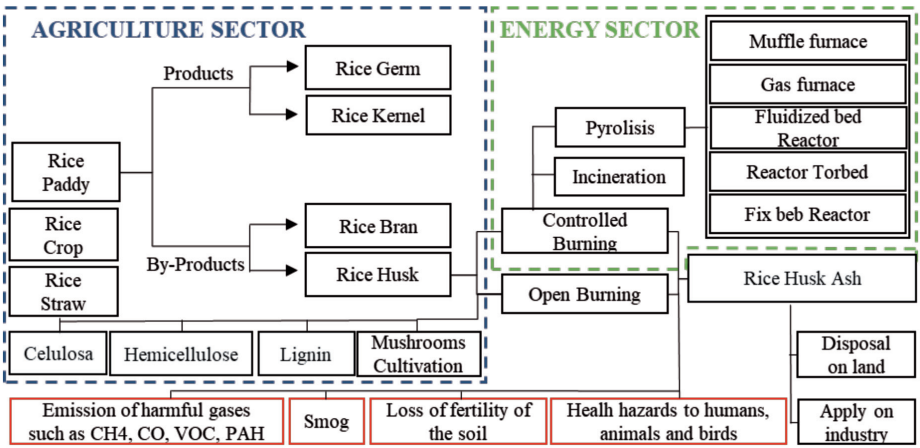
From germination to panicle initiation, it was the stage in which the lowest CH_4 emissions occurred. Within this stage, the incorporated straw alternative achieved the highest CH_4 emissions. The early stage of the development of the plant reflects low emission of pollutants. During the reproductive stage, which spans from panicle initiation to flowering, the highest CH_4 emissions were reached. The straw management alternatives, burning and removal, showed the lowest emissions (Sanchis Jiménez, López Jiménez, & Calvet Sanz, 2014). Worldwide, rice cultivation annually releases around 60-100 million tons of CH_4, contributing substantially to global warming of the atmosphere. This means that 5-19% of anthropogenic (CH_4) emissions are due to rice cultivation (IPCC, 2006; Yusuf, Noor, Abba, Hassan, & Din, 2012). The anaerobic oxidation of the straw inside the paddy field generates a considerable amount of CH_4, which has a global warming potential 21 times higher than CO_2 (Sanchis, Ferrer, Calvet, Coscollà, & Yusà, 2014). The impact measurement methodology will depend on reference functional units: product mass, energy use (Gg CO_2 eq. M $kcal^{-1}$), land area (kg CO_2 eq ha^{-1}), and economic value (Cerutti, Bruun, Beccaro, & Bounous, 2011).

5. Crop waste management proposal in rice systems at the department of Cordoba, Colombia

Rice cultivation in the department of Córdoba is having several problems: the level of soil nutrients is unknown, the low economic profitability that is causing fewer hectares of rice to be cultivated each year, the yield per hectare of the crop, the management of residues, residue incorporation into another industrial process, reducing the emission of greenhouse gases throughout the rice cultivation cycle, producing rice with less environmental impact among others. Figure 2 presents everything that involves the rice crop cycle, which corresponds to the agricultural sector, components of the husk and straw, the potential energy use of residue, and the pollutants.

The rice waste disposal governance approach starts with a vision and high ambition level, pro transition from open-air burning of rice crop residues to

Figure 2 - Describes the main topics presents in the paper



Source: adaption from (Jittin, Bahurudeen, & Ajinkya, 2020).

an industrial process that will give added value to rice husks and rice straw. This vision should be developed by FEDEARROZ and local government, in co-creation between local government, large or small producers, academic institutes, industrial partners and the Colombia government, in particular the Ministry of Agriculture and Rural Development affairs. The policies have to focus predominantly on high-efficiency, green manures, low-cost, bulk products, such as paper, or biomass co-firing for energy production, while the highest value added in the bioeconomy comes from high quality products. It is actually a combination of a top-down and bottom-up approach, using the principles of transition management.

Green manures are an option that, taking advantage of their ability to fix atmospheric N_2, help recover soil nutrients due to degradation by toxic fertilizers. Instead of emitting polluting gases, green manures increase carbon sequestration. Precision agriculture (using the required fertilizer at the appropriate time) or the use of biofertilizers (compost, etc.) should also be implemented (Gómez, Manrique, Moreno, L, & Torres, junio 2021).

Paddy rice does not undergo 100% transformation to excelso rice. On average, for every 1000 g of rainfed paddy rice, 595 g of excellent rice, 55 g of medium grain or crystal rice, 30 g of industrial broken rice, 100 g of rice flour, 200 g of husk and 20 g of rice impurities are obtained (Gómez, Manrique, Moreno L, & Torres, junio 2021). Few investigations have been carried out in the country to estimate CO_2 emissions, they report emissions of 998.1 ± 365.3 kg CO_2 eq. ha^{-1} per cycle. Nitrogen fertilizers contributed with

the highest emission, with 65% of the total (647.6 ± 19.0 kg CO_2 eq.ha^{-1} per cycle and 106.8 kg CO_2 eq per each ton of rice), due to the use of high doses (Gómez, Manrique, Moreno L, & Torres, junio 2021). The table 4 presents the Emissions in kg CO_2 eq considering rice yield. Table 5 an estimative energy production, if it is consider, rice production and power generation integrated system with rice production capacity of 200 tons per day was found out to generate surplus electricity of 3.4 MW (Darmawan, Biddinika, Huda, Tokimatsu, & Aziz, 2018).

In Colombia, the greatest contribution of irrigated rice crops to global warming is through CH_4 emissions, while in rainfed rice it is N_2O emissions from the application of synthetic fertilizer. Likewise, the reviewed literature confirms that there are mitigation solutions, such as the use of green manures, precision agriculture and the production and consumption of biofertilizers, which allow organic benefits to be obtained in rice production, reducing the emission of toxic gases (Gómez, Manrique, Moreno L., & Torres, junio 2021). According with Sanchis *et al*. (2014) for current waste management, the alternative that produced the lowest greenhouse gas emissions was the removal of straw. The other lower polluting emission is through the burning of rice straw, with an appropriate process of drying the

Table 4 - Emissions intensity in kg CO_2 eq considering rice yield (Gómez, Manrique, Moreno L, & Torres, junio 2021; FEDEARROZ, 2016)

	Yield t/ha	Paddy Rice Yield per hectare Kg.ha. year^{-1}	Excelso Rice Yield per hectare Kg.ha. year^{-1}	Total emission CO_2 eq ha year^{-1}	Husk waste per hectare Kg.ha.	Silice by Husk per hectare Kg.ha.	Straw waste per hectare Kg.ha.	Silice by Straw per hectare Kg.ha.
First semester								
Mechanized rice	4.6	4.600	2.737	4.591	920	184	6.900	1.380
Irrigated rice	4.9	4.900	2.915	4.890	980	196	7.350	1.470
Mechanized rainfed rice	5.2	5.200	3.094	5.190	1.040	208	7.800	1.560
Manual rainfed rice	2.4	2.400	1.428	2.395	480	96	3.600	720
Second semester								
Mechanized rice	4.4	4.400	2.618	4.391	880	176	6.600	1.320
Irrigated rice	5.4	5.400	3.213	5.389	1.080	216	8.100	1.620
Mechanized rainfed rice	4.1	4.100	2.439	4.092	820	164	6.150	1.230
Manual rainfed rice	2.3	2.300	1.368	2.295	460	92	3.450	690

Table 5 - Rice production and power generation integrated system, an estimative for the Department of Cordoba (Darmawan, Biddinika, Huda, Tokimatsu, & Aziz, 2018)

	Production (t)	Husk waste (t)	Husk waste potential (MW)	Straw waste (t)	Straw waste potential (MW)
First semester					
Mechanized rice	15184	3036.8	51.6256	22776	387.192
Irrigated rice	11980	2396	40.732	17970	305.49
Mechanized rainfed rice	3205	641	10.897	4807.5	81.7275
Manual rainfed rice	10	2	0.034	15	0.255
Second semester					
Mechanized rice	32000	6400	108.8	48000	816
Irrigated rice	8731	1746.2	29.6854	13096.5	222.6405
Mechanized rainfed rice	23269	4653.8	79.1146	34903.5	593.3595
Manual rainfed rice	519	103.8	1.7646	778.5	13.2345

straw and in minimum humidity conditions. Nevertheless, further studies are required to improve rice straw management. Appropriate off-site uses of this straw should be investigated and implemented in practice to avoid open-field burning (Sanchis, Ferrer, Calvet, Coscollà, & Yusà, 2014).

Although it is important that rice production increases with demand, the production process must be improved so that it works optimally economically, environmental impact, t/ha yield, pollutant emission, waste disposal and investment is required to give added value to production agriculture as for the residue. However, it is proposed to include in future studies the emissions generated by the machinery used, considering the economic and energy costs that each of them entails.

The hemicellulosic fraction of rice straw can be fermented to ethanol and mycelial biomass, it is able to produce ethanol in anaerobic cultivation on glucose, and aerobic cultivation on xylose and glucose. The production cost of straw-based ethanol is sensitive to key parameters, such as the type, composition, and price of the feedstock, the size of ethanol plant, the conversion efficiency, and the level of investment costs. The net production cost of ethanol is divided into (1) investment costs, (2) fixed operating costs (including salaries, general overhead, insurance, taxes, and maintenance), (3) variable operating costs (including purchase of consumables and sales of excess electricity), and (4) feedstock costs (Swain, Singh, & Sharma, 2019).

Investment is required in managing the crop residue in the department; to develop the fuels obtentions, to later carry out a controlled burning to generate energy or gas obtention, to lastly obtain silica, which, like the silica, is obtained from RH and RS. The high reactivity of amorphous

silica is favorable for many applications such as Supplementary Cementing Materials (SCM). Amorphous silica obtained from RH can chemically react with cement chemicals and increase the strength of cementitious matrices. Furthermore, rice husk silica is used for the immobilization of transition metals and organic fractions, with a high potential to be used as a catalyst (Bakar, Yahya, & Gan, 2016; Mirmohamadsadeghi & Karimi, 2020; Jittin, Bahurudeen, & Ajinkya, 2020). Therefore, future studies on processing methods and their influence on the reactivity of Rice Husk Ash (RHA), which is used up to 20% in brick production, whereas for soil stabilisation, 10 and 20% of RHA is used either as sole material or in combination (with cement or lime) to improve the properties of brick and soil respectively (Jittin, Bahurudeen, & Ajinkya, 2020).

6. Conclusion

Agro-industrial waste has gained value because its composition contains compounds of organic origin that could get into renewable fuels, bio-based chemical products, biofuels, gas, sources of electricity, fertilizers, and raw construction materials. The industrialization of rice residue into Cordoba's economic axe; depends on the analysis proving that it brings benefits to the region in the solvent and energy aspects and is a wise investment. in the mills and the fields.

Cordoba's rural areas demand biomass and energy, especially the ones that are not connected to the system of public services. The agricultural residues will provide economic benefits of improving the quality of life, reducing environmental pollution, and providing employment opportunities to many people in the agro-based power plants established for electricity generation.

The current balance matrix of the entire rice crop cycle is related to the emission of CO_2, CH_4, and N_{2O}, the performance of the rice system t/ha, yield economics, and no proper waste management. It is predicted a non-profitable crop, due to fertilizer-high prices, will also increase the environmental impacts. So, a current solution is organic compost use, which could guarantee CO_2 capture in the cultivation process and mitigate the pollutant emission in the rice cultivation cycle.

The commitment and hard work will come from the farmers, researchers, federations, and administration will be to study the improvement of the soil nutrients, the quality of the crop, and the management of the residue, the one that remains in the mills (husk) and the one that remains in the fields (straw).

The necessary investment to obtain a product that meets current market requirements on renewable fuels or raw materials. Hence, vitality could be suitable pathway that exists between the energy sector and construction sector

with direct benefits, including biomass-based energy, green construction products, and reduction in land pollution.

Depends, on the articulation of the farmers, industry, and local government, together with research, innovation, and feasibility studies, demonstrating that they are sustainable projects, have a point of balance, and cost-analysis proves that it brings benefits to the region in the solvent and energy aspects.

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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.

Diego Alejandro Camargo Trillos
Deivi David Fuentes Doria
Eliecer Miguel Cabrales Herrera
Valeria Borsellino

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

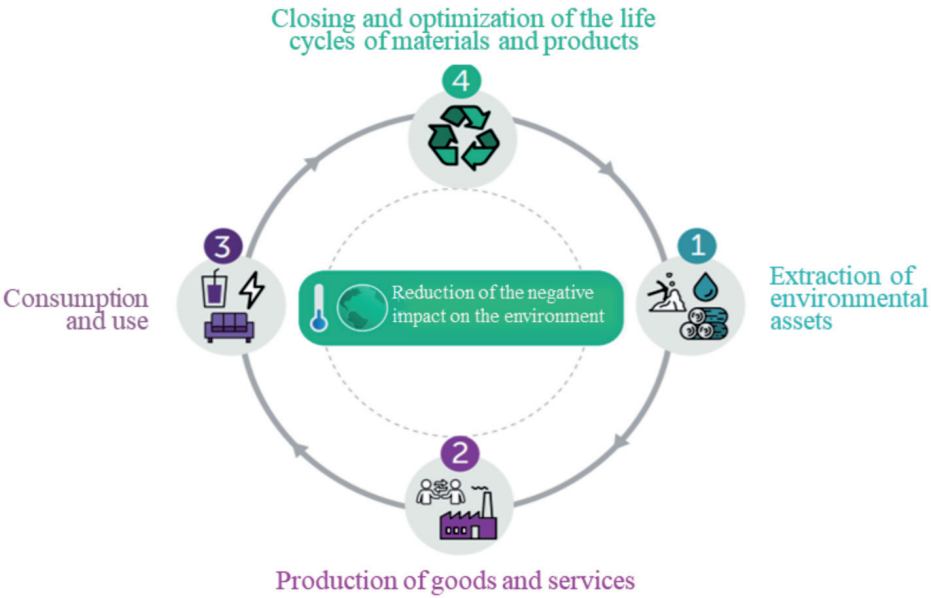
incentives. 5. Access to markets. 6. Coordination and institutional/sectoral articulation. 7. Market information system, monitoring and evaluation. 8. Development and strengthening of the offer. Based on these policies, a general classification of this type of business is established, where according 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.

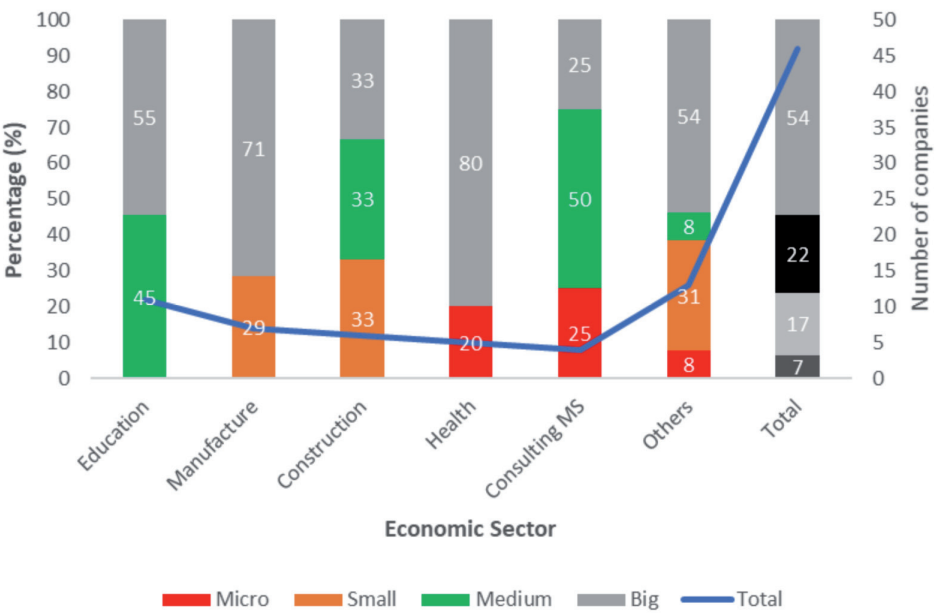
The companies were classified according to the second article of Law 590 of 2000 and Decree 2473 of 2010, which provide regulations to promote the development of micro, small, and medium-sized enterprises. The classification criteria are presented in Table 1 and are based on the number of employees and 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.

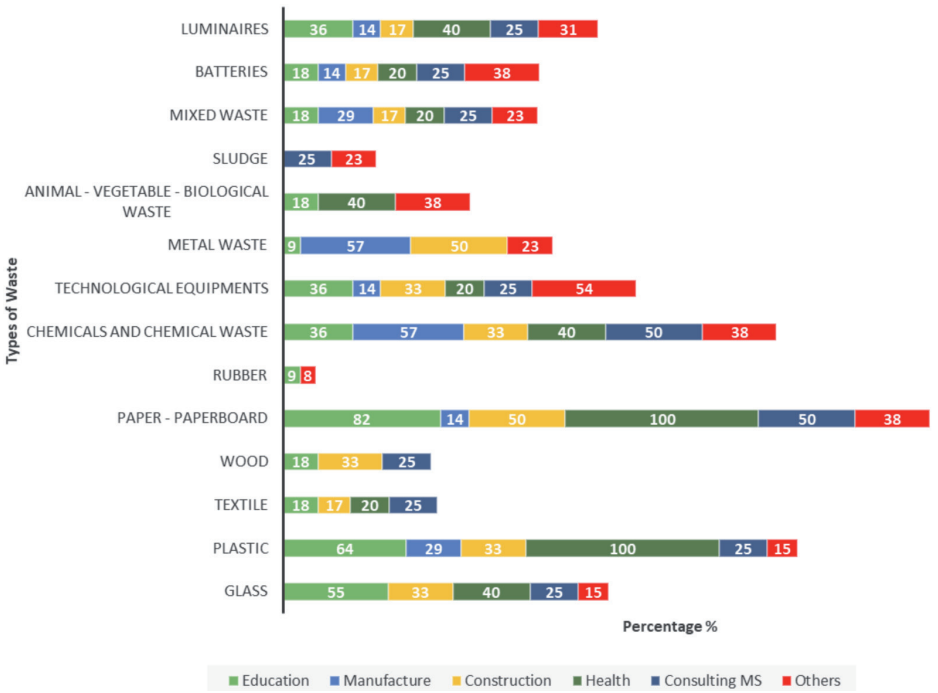
3. Results and discussion

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.

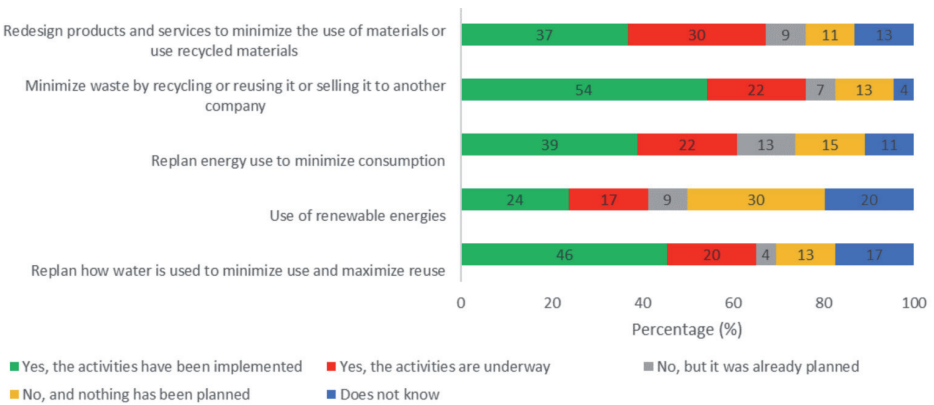
Figure 3 - Types of waste generated by economic sector



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.

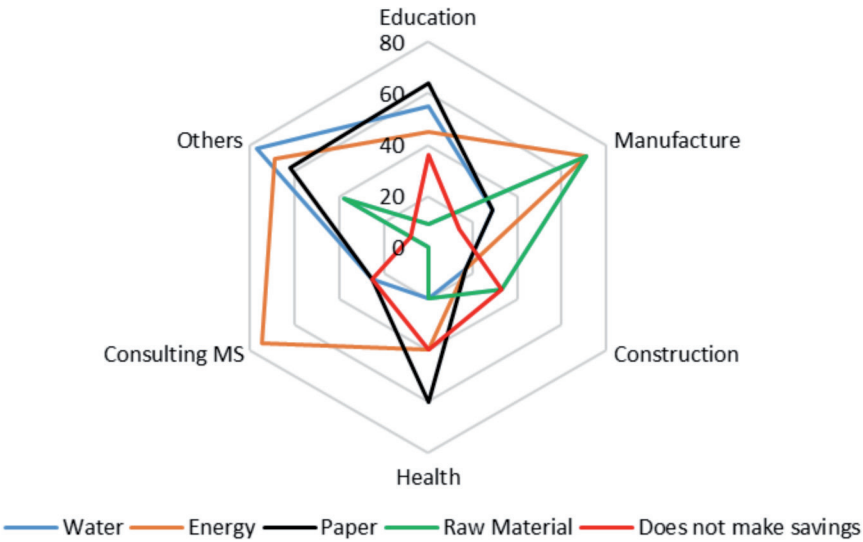
Energy is the most saved supplies by companies (53%); energy is saved by the 75% of consulting MS companies, 71% of manufacture industries and 69% of the set of companies grouped in others. Education (45%), health (40%) and construction (17%) are the economic sectors that less saved energy (Figure 6).

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



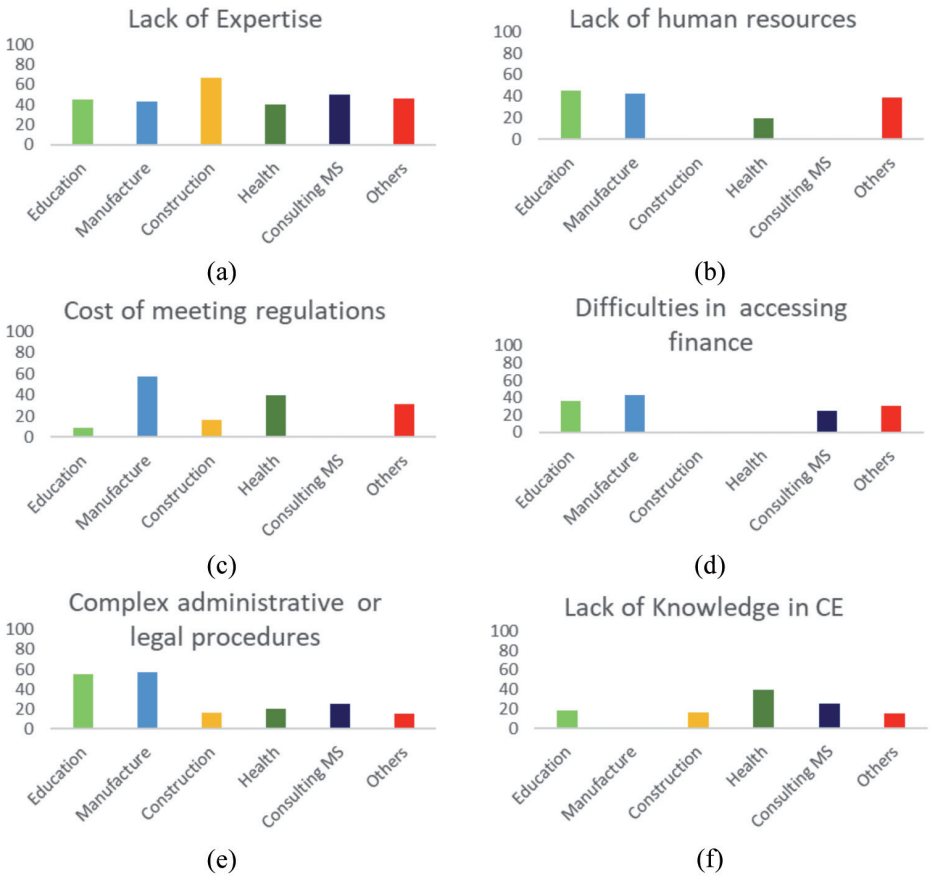
For these reason, systematic process model for Circular Economy business model innovation developed for manufactured companies contains four stages (prepare, sense, seize and transform) with recommendations of institutional, strategic and operational practices (including activities, tools, interdependencies, 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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Occupation Choice in the Rural Labor Market from the Córdoba Department in Colombia

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Abstract

This article aims to establish if the rural labor market of the Department of Córdoba holds structural problems that encourage members of the rural labor force to search for other work alternatives in the urban area, by identifying factors related to supply conditions, such as human capital, age, home location area [dominion], gender, and others that affect the choice of the kind of work. A multinomial *Logit* econometric model was estimated to achieve this purpose, using statistical information from the Great Integrated Household Survey (GIHS) carried out by DANE from the third quarter of 2019, whereby the employment choice of men and women in rural and urban areas was analyzed among four categories, i.e. low manual (1), high manual (2), low non-manual (3), and high non-manual (4). Results reveal that the estimated model shows a good fit and that the education, gender, and domain variables are statistically significant with confidence levels greater than 95%. Similarly, figures of the marginal effects, which reveal changes in probabilities of choosing one job or another, may be evidence of the little consolidation that the rural labor market has to motivate its inhabitants to choose countryside activities, allowing to conclude that the migration phenomenon from the countryside to the city is largely explained by the search for better jobs, thus revealing the

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structural problems of the rural labor market in the Cordoba Department.

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Introduction

The study regarding choice of types of occupation that an individual is able to perform can contribute to understanding the dynamics of labor mobility, particularly in the diverse geographical areas of a region that could show the problems of the labor market in a specific population sector. This is especially relevant in Colombia, where there has been a large migration from rural areas to the cities Norwegian Refugee Council – NRC – (2019) a fact that contradicts the expectations that individuals who reside in rural areas work in the primary sector of the economy and those who live in urban areas occupy themselves in the secondary and tertiary sectors. This article aims to establish if the rural labor market of the Córdoba Department in Colombia, holds structural problems that may affect the desire of the members of the labor force that reside in this geographical area to seek work alternatives in the department urban area, considering factors related to supply conditions, such as human capital, age, home location area [dominion], gender, and others that affect the election of the kind of work.

To reach this goal, a multinomial *Logit* econometric model will be estimated using statistical information from the Great Integrated Household Survey (GIHS) carried out by the National Administrative Department of Statistics of Colombia (*Departamento Administrativo Nacional de Estadísiticas*, DANE), from the third quarter of 2019, giving this work a quantitative and inferential approach, whose conclusions will be supported by the empirical evidence derived from the results of the adjustment (fit) of the indicated model with its respective hypothesis tests. The model to be estimated considers as an explained variable, the election of the labor occupation of men and women in rural and urban areas in the different occupations or jobs identified by the National Classification of Occupation in Colombia (DANE, 2019), which are grouped into four categories, i.e., manual low (1), manual high (2), non-manual low (3), non-manual high (4). Furthermore, the explanatory variables correspond to the supply conditions

of individuals, such as human capital, geographic area of residence and positions within the household (head or marital status), among others.

Results reveal that the estimated model shows a good fit and that all, the model considered globally and the variables education, gender, and domain [urban and rural area] are statistically significant with confidence levels higher than 95%, indicating that they adequately explain the phenomenon under study. Similarly, figures for the marginal effects, which reveal changes in the probabilities of choosing one job or another, confirm the hypotheses proposed by the model.

Based on the obtained results, there is enough empirical evidence about the low consolidation of the rural labor market in the Córdoba Department to encourage its population to choose occupations in the countryside, whereby it can be concluded that the migration phenomenon from the countryside to the city is largely explained by the search for better job conditions, thus revealing the structural problems of the rural labor market in Cordoba.

1. Backgrounds

This first section is made up of three parts, the first of which will be dedicated to making a brief historical account of production and the rural labor market in Colombia, accompanied by a brief review of the government strategies implemented in the last three decades and ending with a description and indicators of the agricultural sector of the Córdoba Department. In the second part, the theoretical framework is presented, and finally, on the third one, a literature review is made on the subject under study from this research.

Rural sector and the strategic framework of agricultural production

The rural sector in Colombia has historically been considered a great source of employment and wealth (Pérez & Pérez, 2002). This favorable consideration is the result of the country's great agricultural vocation that gives it comparative advantages in the production of exportable goods and staples such as tobacco, coffee, flowers, and bananas since the nineteenth century. It is appropriate to point out that, since 2014, the National Planning Department (*Departamento Nacional de Planeación*; DNP) established a new methodology to delimit the concept of rurality in Colombia and define the population that makes it up, in order to reorient agrarian policy. Through this methodology, the Colombian rural population was made up of the inhabitants of the 373 municipalities classified as 'rural' and the 318 municipalities included in the 'dispersed rural' typology, in which both agricultural economic activities and non-agricultural activities are carried out

(DNP, 2015). According to this new method, and the national census carried out in 2018, the rural population is 11,969,822 people, out of which 5,760,524 (48.13%) are women and 6,209,298 (51.87%) are men (DANE, 2020).

Nonetheless, the Colombian rural labor market has shown significant dynamics since the first decades of the twentieth century as a result of these comparative advantages, the distribution of its population in rural areas, and the notable participation of the agricultural sector in the Gross Domestic Product (GDP), especially in the 1960s, with average contributions of 31% and an annual growth of over 5% in the years 1960, 1964, 1967 and 1968 (DNP, 1969). This dynamic in the agricultural sector was widely supported by State institutions such as the Colombian Institute of Agrarian Reform, Colombian Agricultural Institute, Institute of Agricultural Marketing, Caja Agraria, Banco Ganadero, National Institute of Renewable Natural Resources and the Environment, Banco Cafetero, Instituto Agrario, Colombian Veterinary Products Company, the Agricultural Development Finance Corporation, and others (DNP, 1972).

In this dynamism, the Integrated Rural Development program was also important as well, which included significant investments in physical and social infrastructure in the countryside (DNP, 1975). The program contributed to the increase in basic food production in the 1970s, when the peasant economy subsector produced 65% of mass consumption products (rice, beans, corn, wheat, yams, bananas, cassava, and vegetables) and generated 831,000 jobs; i.e., 55.3% of the people employed in the rural sector (DNP, 1979).

The agricultural research development, which began in 1915 with the creation of several experimental stations such as the first national research center in *Tibaitatá* and the farm research division from the Ministry of Agriculture, had an important contribution to these data on rural employment and the share of the agricultural sector in GDP, making it possible to deliver the first improved versions of beans, corn, barley, and potatoes (DNP, 1979).

Nevertheless, with the subsequent restructuring, liquidation, and privatization of the aforementioned institutions, the sector dynamism began to diminish in the subsequent decades, affecting the rural labor market and the conditions of workers in the Colombian countryside. Other causes of the decreasing trend in the contribution of the primary sector are related to the rise in the manufacturing industry in the main cities of the country and the increase in investment in the energy mining sector, which received between 1980 and 1989 investments of 5,400 million dollars for Carbocol in Cerrejón and Ecopetrol (DNP, 1979). These two aspects stimulated migration from the countryside to the city and had a notable impact on the Colombian rural labor market.

The Córdoba department is located in the Colombian Caribbean region and has a population of 1.8 million inhabitants (2019), out of which 53% dwells

in rural areas according to (DANE, 2021). It has 25,020 square kilometers of surface, out of which 19% are suitable for agricultural uses and 60% has a vocation for livestock, overlapped with transitory and semi-permanent crops. According to (Viloria, 2004), in 2003 the Córdoba Department made a global contribution of 2.3% to the national GDP with approximately 200,000 rural jobs, which included 100,000 in livestock activity, while in 2019 its contribution reached 1.8% of the national GDP, while the employed population was 795,000, out of which 375,000 [47%] worked in rural areas and 226,000 [28%] were employed by the primary sector of the departmental economy (DANE, 2021). These two subsectors, livestock and agriculture, maintain a significant contribution to the departmental GDP of 24.7% and 10% (Government of Córdoba, 2020).

The department of Córdoba as well as Colombia, had a very dynamic agricultural sector in the last decades of the last century, especially in the production of cattle, mechanized rice, technified corn, wheat, sorghum, banana, cassava, and cotton, as the main generator sources of rural employment and income in each of the subregions that comprise it. However, production of these foods and their profitability have been affected by imports from more competitive countries since the 1990s, when the country replaced the import substitution model with that of economic and commercial openness. Evidence of this effect is indicated by Viloria (2004) who finds a decrease in the participation of the agricultural sector in the departmental GDP, which went from 35% to 31% between 1994 and 2004, with a downward trend since, for 2019, the participation of the primary sector (made up of four branches of activities: agriculture, livestock, forestry and fishing) only reached 11.9% of Cordoba's GDP (DANE, 2021).

Theoretical framework

This article belongs to the theory of labor supply proposed by the neoclassical school, based on the decision of each individual in terms of work, guided by their desire to maximize their benefit (utility) or satisfaction, which in turn, leads them to determine the amount of time that will be dedicated to work to obtain the necessary income to satisfy their needs, in addition to the time allocation that can be assigned for leisure, corresponding to those resting activities that are outside the labor market, but within the established 24 hour-day (Nicholson, 2004).

This can be compactly expressed as follows: If $U(D, C)$ is considered as the individual's utility function, where D is leisure and C is consumption, then the individual will want to maximize it under the constraint of the 24 hours a day limit, as indicated by equation [1].

$$MAX: U(D, C), \text{sujeto a}, w * (24 - D) + Yn = C \quad [1]$$

Where, w is the wage per hour worked and Yn, the non-labor income. To use the *Lagrangian* method with the objective of maximizing the utility function, the Lagrangian expression is initially formalized and equation [2] is obtained, which, when partially derived with respect to each of its variables and set equal to zero, equation [3] is obtained.

$$L = U(D, C) + \lambda(w * (24 - D) + Yn - C) \quad [2]$$

$$\frac{\partial L}{\partial D} = \frac{\partial U}{\partial D} - w\lambda = 0 \quad \text{y} \quad \frac{\partial L}{\partial C} = \frac{\partial U}{\partial C} - \lambda = 0 \quad [3]$$

By solving for l and equating the two results, equation [4] is estimated

$$TMS_{DC} = \frac{\frac{\partial U}{\partial D}}{\frac{\partial U}{\partial C}} = w \quad [4]$$

This expression [4], in the words of McConnell *et al*. (2014) establishes that "the optimal work position is reached at the point where the marginal rate of substitution of income for leisure is equal to the wage", criteria under which individuals make the decision about the number of 'hours' to offer to work. Subsequently, varying w and keeping Yn fixed, the labor supply is obtained as a function of wage $q^w = f(w, Yn)$ (Nicholson, 2004).

Bearing in mind these results, authors such as Olivera Martínez (2012) assure that the neoclassical school justifiably maintains the assumption of choice and flexibility of the labor market, since individuals choose where to work considering their own characteristics such as educational level, experience, and others. Therefore, such characteristics stand as the explanatory variables of that choice.

Literature review

Rural labor market has been the object of analysis in different geographical contexts in recent years. The interest in analyzing, establishing, and describing its characteristics is reflected in a significant number of publications, some of which are reviewed below, in which situations are

confirmed and specific characteristics are described related to activities, income, level of schooling, gender, hiring and conditions of rural workers.

In the international context, some studies focus on analyzing the incidence of gender, age, and level of schooling in the choice of occupation in rural areas, as well as salary differences and gender gaps. Among these studies, Mwabu & Evenson (1997) analyzed occupational patterns in rural Kenya, using cross-sectional data collected from agricultural households, finding that 74% of households were engaged in agriculture compared to 26% employed in non-agricultural activities. They identified back then, that education and proximity to markets are key factors in the transformation of the rural occupational structure of that country.

On his part, Kumar (2016) explores the determinants of the structure of the labor force, using a multinomial regression model to identify and analyze the factors that impede the choice of employment of workers in rural areas of Uttar Pradesh in India. He incorporates variables such as property dimension, social groups, religion, educational level, and age. He considers that the relative influence of educational levels, physical capital and the socioeconomic background of workers, i.e., human capital and physical capital, rather than caste and religion, influence the occupation choice. He finds that workers with better educational levels are employed in the non-agricultural sector, while those who did not attend school depend on the agricultural sector.

In that same geographical context, Agrawal (2021) argues that segregation in rural labor markets in India stems from educational outcomes. In the same manner, he warns that education explains a considerable part of the gender wage gap in rural areas. Nonetheless, they identify that the degree of gender segregation in rural areas of this country is lower than in urban areas. On the other hand, Balsadi & del Grossi (2018) show a continuous decrease in the economically active population employed in rural agriculture and the majority abandonment of women and young people from agricultural activities in the northeast of Brazil. Conversely, they evidenced the increase in the schooling of the employed rural population, especially of those who are integrated into non-agricultural activities.

In the Colombian context, Tenjo Galarza & Jaimes (2018) in their work called 'income and education in the Colombian rural sector', ratify that education contributes more to the increase in labor income in the case of women than in that of men, and note women's preferences for jobs outside of agriculture. Likewise, they point out significant differences (26%-29%) between the hourly income of men and women, although they warn that these differences are smaller in the income obtained in agriculture. They argue that: "perhaps education is not reducing social differences in the rural sector, but quite the opposite: it accentuates the differences" (p. 232). Finally,

they verify that salaried rural workers have higher incomes than non-salaried workers, especially in non-agricultural activities where incomes are higher.

On his part, Otero-Cortés (2019) in his analysis of the rural labor market in Colombia between 2010-2019, highlights the following characteristics: high rural labor informality, low and unstable income, an average employment rate of 55.5%, and a rural retirement coverage of less than 15% during the analyzed period. Informality and retirement coverage had been evidenced on a regional scale a few years earlier by Ortega *et al*. (2014) who, when analyzing the working conditions of agricultural workers in rural areas of the Montería municipality, confirmed an informality of 95%, lower incomes 50% of the legal minimum wage in force and a reduced affiliation of 1% to professional risk management and retirement contribution.

These negative retirement data are well above those evidenced by DANE for the employed population in rural areas throughout the country in 2019. Said data shows that 85.3% of women and 81.9% of men do not contribute to a retirement fund, with the aggravating circumstance that social security coverage is lower for women than for men, since only 12.3% of employed women are affiliated with both health and retirement fund, compared to 15.6% of men, which in any case is very low (DANE, 2020).

Similar problems were identified by Triviño *et al*. (2020) when they analyzed the living conditions of rural workers and the production relationships between them and landowners in the rural area of the Marulanda municipality in the Caldas Department. They specifically evidenced the predominance of the figure of sharecropping, land concentration, and low wages, which discourage the incorporation of young workers and their migration to urban areas.

An important fact about the rural labor market is the notable participation of women in unpaid agricultural work in peasant economies and in the production of exportable agricultural goods, specifically in flower cultivation and in coffee harvesting, in which they participate with 70% and 40%, respectively (Pérez & Pérez, 2002). Female participation in the rural market continues to be important in recent years, nonetheless, in agricultural and livestock activities they only represent 17.9% out of 2,884,385 employed in the agricultural sector and 29.7% out of the 4,757,555 rural workers in Colombia (DANE, 2020). In other words, according to this information from DANE, the employment rate of men is much higher than that of women, with 71.9% and 34.6%, respectively.

These characteristics of the rural labor market in the international and national scenario show common aspects and evidence similar problems that affect in one way or another the level of income and the life quality of workers in rural areas. The analysis of these aspects and problems can

contribute when analyzing aspects that affect the rural labor market in the department of Córdoba and the occupation choice by workers in this region of Colombia.

2. Materials and methods

This section is divided into two segments, the first is dedicated to exposing the source of statistical information, as well as identifying the variables that will be considered to propose the generic model and indicate the statistical program to be used for the purpose of estimating a *Logit* multinomial econometric type model, while in the second part a presentation of the Logit multinomial model is made that will make it possible to understand the results obtained.

The variables, model and data

To determine if the socioeconomic conditions of rural workers, which characterize their labor supply conditions, affect the decision to seek jobs in the urban area of the of Córdoba Department, as stated at the beginning, a Multinomial Logit probabilistic econometric model will be estimated, using the Stata program with statistical information from the GIHS applied by DANE and corresponding to the third quarter of 2019.

To construct the qualitative dependent variable of this model, called 'job', with four categories of possible results or values, the answers provided to the question included in the survey form, literally states: what do you do in this job?, which allow to catalog the occupations of individuals according to their degree of manual and non-manual skills and their high and low qualification levels in the different areas of performance provided for in the National Occupation Classification (DANE, 2019). Following, Jiménez & Restrepo (2011) the different occupations of the workers are grouped, as stated before, into four categories, i.e., Low Manual [LM=1], which includes primary and extractive exploitation, laborers, High Manual [HM=2] in which equipment operation, transport and trades, processing, manufacturing and assembly are considered, Low Non-Manual [LNM=3] which contains occupations in sales and services, auxiliary and technical, and High Non-Manual [HNM=4] where occupations of direction and management, finance, administration, science, technology, and innovation are incorporated.

On their part, the independent variables of the model are: education level [years of study completed], age [years], marital status [married or not], gender [male, female], household domain [urban, rural], relationship with the

head of household [head or not], which are the result of the corresponding questions that are also included in the GEIH form and that are paired with the dependent variable occupation already constructed to form the database with 3,190 observations in total, used to fit the model.

Now, it is important to clarify that the model that will be estimated here will have as regressors the variables mentioned above and that correspond to characteristics of the individuals, i.e., the regressors are those characteristics of the individuals that are invariant between alternatives and that are considered determinants of labor choice in the framework of the neoclassical economic hypothesis. Both the returned variable and the regressors are described in Table 1.

Thus, the model to be estimated is a categorical or qualitative response model in which its dependent variable has four response options with the same number of categories, so it is a multiple choice or multinomial

Table 1 - Description of Model Variables

Variable Name	**Model Name**	**Description**
Job	Job	Categorical dependent variable that takes values 1, 2, 3 and 4
Education Level	EL	Discrete variable that takes values of the years of education of the individual
Age	Age	Discrete variable that takes values of the life years of the individual
Age^2	Age^2	Discrete variable that takes the value of the square of the age of the individual
Married	Married	Dummy variable that takes the value 1 if the individual is married and zero otherwise
Boss	Boss	Dummy variable that takes the value 1 if the individual is the head of the household and zero otherwise
Woman	Woman	Dummy variable that takes the value 1 if the individual is female [woman] and zero otherwise
Rural	Rural	Dummy variable that takes the value 1 if the individual lives in the rural area and zero otherwise [lives in the urban area]
Rural Woman	Rural Woman	Dummy variable of interaction between women and rural [result of multiplying the values of the two variables involved]

Source: Author's own elaboration based on GEIH (DANE, 2019).

probabilistic model that, in the case of this study, the *Logit* was used, instead of the *Probit*, due to its simplicity, Cabrer *et al.* (2001) which can be stated generically as in [5].

$$Job = \beta_0 + \beta_1 Esc + \beta_2 age + \beta_3 age2 + \beta_4 Married + \beta_5 Boss + \beta_6 Woman + \beta_7 Rural + \beta_8 RuralWoman + \varepsilon \quad [5]$$

The Multinomial Logit Model

The multinomial Logit model is an extension of its binary counterpart (in which the dependent variable takes only two values), estimated with the Maximum Likelihood [MV] method instead of the Ordinary Least Squares [OLS] (McFadden, 1984). To establish the multinomial *Logit* model, the linear model given in [6] was initially considered.

$$Y = C + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots + \beta_n X_n + \varepsilon \quad [6]$$

Which can be presented in a compact way as in [7]

$$Y = \beta \boldsymbol{X} + \varepsilon \quad [7]$$

Thus, the response probabilities, i.e., of choosing each category, are given by [8]

$$P_{ij} = Prob(Y_i = j) = F(\boldsymbol{X}_i, \beta_j) = \left(\frac{e^{\beta_j \boldsymbol{X}_i}}{1 + \sum_{h=1}^{J} e^{\beta_h \boldsymbol{X}_i}} \right) \quad [8]$$

That in the specific case of this research work, J=4=LM, HM, LNM and HNM.

Equation [4] corresponds to a multinomial Logit model proposed by Greene (1997) which, as noted above, is a generalization of the binomial Logit, where P_{ij} is the probability that individual i chooses the **j**-th option. Since $\sum^{J} \quad P_{ij} = 1$, the model must be normalized by taking a base category to guarantee the identification of the estimators, which for this case, by default, the Stata program takes the LNM option, so the vector of coefficients associated with this choice will be equal to zero, i.e., $\mathrm{Q}_{LNM} = 0$.

Conversely, in nonlinear models, particularly multinomial, care must be taken with the interpretation of the signs of the coefficients, because there is not necessarily a direct relationship between them and the probability coefficient. Considering this, from [4], the marginal effects can be calculated using equation [9].

$$\frac{\partial P_{ij}}{\partial X_i} = \frac{e^{X_i\beta_j}}{1+\sum_{h=1}^{J} e^{X_i\beta_h}}\beta_j - \frac{e^{X_i\beta_j}}{\left(1+\sum_{h=1}^{J} e^{X_i\beta_h}\right)^2}\left(\sum_{h=1}^{J} e^{X_i\beta_h}\right)\beta_h \qquad [9]$$

Simplifying the second term of [9] and replacing [8] in [9] we get [10]

$$\frac{\partial P_{ij}}{\partial X_i} = P_{ij}\beta_j - P_{ij}\sum_{h=1}^{J} P_{ij}\beta_h \qquad [10]$$

Factoring P_{ij} into [10] we get [11]

$$\frac{\partial P_{ij}}{\partial X_i} = P_{ij}\left(\beta_j - \bar{\beta}_i\right) \qquad [11]$$

Where $\bar{\beta}_i = \sum_{h=1}^{J} P_{ij}\beta_h$ is the average probability of β. Equation [11] allows a simpler explanation of the marginal effects, given that an increase in the independent variable increases (or decreases) the probability of selecting the *j*-th alternative, expressed as a percentage. Thus, two considerations must be made regarding the estimation of the coefficients and the marginal effects. First, there are *j*-1 sets of estimated coefficients, but *j* sets of marginal effects. Second, while the coefficients of the multinomial model and their corresponding signs, according to Gujarati & Porter (2010) cannot be interpreted directly [since they do not depend solely on β_j as in binomial models] and only allow comparison of the probability of being employed in a job is greater [or less] than the probability of being employed in the base job category [LNM for this specific case], the marginal effects indicate the change in the probability of choosing a job caused by the change in the regressor [ceteris paribus], both conditional on the characteristics of the individual (Schmidt & Strauss, 1975).

Finally, it is important to point out that the results of qualitative or probabilistic response models, such as the one presented in this research study, can be evaluated, globally considered, using Wald statistics and/or Likelihood Ratio [LR], while the significance of the coefficients, individually considered, with the Z statistic, and the goodness of fit, with the Pseudo R^2.

3. Results

The obtained results in this work are divided into descriptive and inferential and are presented in the same order below.

Descriptive results

Table 2 shows some indicators of the labor market and characteristics of the individuals differentiated by gender and area of residence in the Córdoba Department. Large gender gaps are observed, specifically in terms of income and occupation, despite the fact that women have higher levels of education on average.

Table 2 - Descriptive statistics and labor market indicators

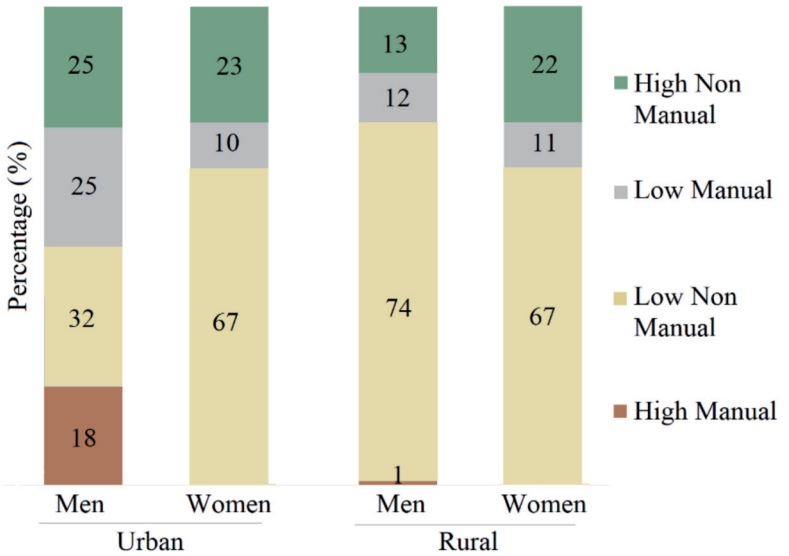
	Urban		Rural	
	Men	**Women**	**Men**	**Women**
GPR	69.8%	53.8%	68.7%	46.3%
OR	62.5%	42.9%	56.3%	39.9%
UR	10.3%	20.2%	18.1%	13.7%
Mean Income ($)	902,011	695,515	583,051	427,431
Mean age (Years)	31.6	31.9	31.5	35.0
Mean Years of Education	7.8	8.1	5.8	6.8

GPR: Global Participation Rate; OR: Occupation Rate; UR: Unemployment Rate.
Source: Own Elaboration based on GEIH (DANE, 2019).

Regarding the distribution of occupations by sex and area, Figure 1 shows that most of the employed women (67%) have occupations predominantly in the service sector [NMB] in both areas. Another result that stands out is that both men and women in rural areas show greater participation in jobs other than those of the countryside, which accounts for the little motivation that this population has to be employed in them.

Table 3 shows the regression results using *Stata*, with the Huber-White option to obtain robust standard errors, in which the coefficients of the estimated multinomial model are shown, marked with their corresponding significance level, where of course those of the HNM base category are not shown because of the explanation above.

Figure 1 - Distribution of Occupations According to Gender and Area



Source: Author's own elaboration based on GEIH (DANE, 2019).

Table 3 - Regression Results

Variables	**(1) LM**	**(2) HM**	**(3) LNM**	**(4) HNM**
	-0.035**	-0.094***		0.422***
Age	0.001+	0.060**		-0.009+
Age 2	0.000+	-0.001**		0.000+
Married	-0.045+	0.196+		-0.054+
Boss	-0.381***	-0.388**		-0.102+
Woman	-1.736***	-4.441***		-1.122***
Rural	-1.761***	-3.707***		-0.701***
Rural Woman	1.668***	-8.837***		1.071***
Constant	0.144+	-0.717+		-5.223***
Wald chi^2	15157.79	Pseudo R^2	0.2145	0.2145
p-value	0.0000			

*** $p<0.01$; ** $p<0.05$; * $p<0.1$; + Not significant.

Source: Own elaboration based on *Stata* (2022).

The results confirm that the model is highly significant at a global level, since the *p*-value of the Wald chi-square test was practically equal to zero, i.e., that the variables together, with more than 99% confidence, manage to explain the probability of choosing the specified job categories. On the other hand, the variables education, sex, area of residence and kinship with the head of household are significant with confidence levels higher than 95%, which allows us to reject the hypothesis that they do not contribute to the explanation of the phenomenon under study and finally, a Pseudo R^2 of 0.21 is revealed, i.e., in non-linear models, the explanatory variables included increase the likelihood by 21%, revealing a good fit of the model (McFadden, 1984).

Table 4 shows the estimation of the marginal effects, indicating the change in the probability of being employed in one job or another. It is observed that characteristics such as education, age, or being head of household are important when explaining the job choice in which an individual is going to work. Particularly, the estimation indicates that individuals with a higher accumulation of human capital tend to value less the LM (occupations in primary and extractive exploitation, laborers), HM (operation of equipment, transport and chores, processing, manufacturing, and assembly) and LNM jobs (occupations in sales and services, assistants and technicians), on the other hand, they value HNM jobs more (direction and management, finance, administration, science, technology and innovation occupations). Marginal effects reveal that one more year of education significantly reduces the probability of choosing LM, HM, and LNM jobs by 1.4%, 1.2%, and 3% respectively, while significantly increasing the probability of choosing HNM in 5.5%, which suggests that investing in education is a way to scale productively.

Table 4 - Marginal effects estimate

Variables	**(1)** **LM**	**(2)** **HM**	**(3)** **LNM**	**(4)** **HNM**
Education Level	-0.0141***	-0.0117***	-0.0294***	0.0552***
Age	-0.00120+	0.00455**	-0.00133+	-0.00202+
Age 2	1.97e-05+	-6.12e-05**	-5.49e-06+	4.70e-05+
Married	-0.00985+	0.0165+	0.00149+	-0.00811+
Boss	-0.0382**	-0.0172+	0.0522***	0.00317+
Woman	-0.0838***	-0.267***	0.383***	-0.0318**
Rural	-0.119***	-0.218***	0.325***	0.0118+
Rural Woman	0.432***	-0.714***	0.0756+	0.207***

*** $p<0.01$; ** $p<0.05$; * $p<0.1$; + Not significant.

Source: Own elaboration based on *Stata* (2022).

Regarding the variables of interest in this research, corresponding to the rural area and the gender of the individual [woman], the estimation results allow us to infer the following: On the one hand, that individuals in rural areas value jobs less associated with the countryside, in particular, the fact of being from the rural area reduces the probability that an individual chooses high manual and low manual jobs, in this case, by 12% and 22% respectively, while, on another hand, they are preferring occupation in the sector of sales and services [predominantly urban], since the probability of choosing them increases by 33%.

Lastly, the results differentiated by gender show evidence in favor of the type of occupation carried out by women, indicating that they are more prone to low non-manual jobs offered in the service sector [occupations in sales and services, auxiliary and technical]. Interestingly, however, rural women are more likely than men to work in primary sector jobs, and therefore men may be more likely to seek job opportunities in urban areas.

4. Conclusions

Among the obtained results, gender gaps were observed in terms of income and occupations, wherewith it can be established that the household roles of women, apparently, condition their participation in the labor market and therefore the structure of the market demand punishes such conditions.

On the other hand, it was observed that both men and women in rural areas are likely to be employed in occupations other than those in the countryside, which accounts for the little appetite that this population has for jobs in this area and that probably, for being a poorly structured labor market, with few opportunities, these people have to move to the urban area in search of better opportunities and labor conditions.

The foregoing is confirmed by the low assessment of jobs associated with the countryside by residents of the rural area of the Cordoba Department, especially by the male population, which highlights the low consolidation of the rural labor market to encourage its inhabitants to choose countryside activities, which is largely explained by the migratory phenomenon from the countryside to the city in search of better jobs, a situation that makes evident the structural problems of the rural labor market.

It is important to point out that the migratory phenomenon in Colombia, differentiated between economic migrants and displaced persons, is present in all regions of the country, especially affecting intermediate cities such as Montería, capital of the department of Córdoba. In relation to economic migrants, the object of study of this research, it can be affirmed that they encounter barriers mainly when moving, as well as generating a change in

the labor supply of the receiving labor markets that has not been possible to estimate quantitatively due to lack of data, among other reasons (Valencia-Agudelo ***et al.***, 2019)

To conclude, it is recommended that complementary studies be carried out to deepen the economic migration phenomenon, particularly in its effects on the receiving labor market in the department of Córdoba.

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