

Coca Plantations: Economy and Violence in Municipalities of Colombia  
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**Abstract**

Coca cultivation in Colombia is related to multiple problems that primarily affect the rural areas of the country. This article aims to expose the determining factors that explain the presence of coca plantations in the municipalities of Colombia for the period 2012 - 2019. To do so, a panel data model is developed to obtain results that, although not homogeneous across the territory, indicate that overall, increases in the municipal violence index are positively associated with the growth of coca cultivation hectares in Colombia's municipalities in the short term. The findings suggest that only a quarter of coca cultivation is reduced for every hectare sprayed and increases by 0.22 for every hectare eradicated manually, highlighting the ineffectiveness of anti-drug policy. It is necessary to look for alternatives to try to reduce the supply of the crop, differentiating the needs of each region of the country. In terms of the economy, the only sector that influences the reduction of cultivation is the secondary sector and the fiscal performance index.

**Keywords:** Illicit crops; illegal behaviour; forced eradication; territorial financial management; municipal economic production.

**Resumen**

Los cultivos de coca en Colombia se relacionan con múltiples problemas que afectan primeramente al área rural del país. Este artículo tiene como objetivo exponer factores determinantes que explican la presencia de los cultivos de coca en los municipios de Colombia para el periodo 2012 – 2019. Para ello, se desarrolla un modelo de panel de datos que permite obtener unos resultados que, aunque no son homogéneos en todo el territorio, indican que globalmente los incrementos en el índice de violencia municipal están asociados de manera positiva con el crecimiento de las hectáreas de cultivos de coca en los municipios de Colombia en el corto plazo. Los hallazgos sugieren que se reduce únicamente una cuarta parte del cultivo por cada hectárea asperjada y se incrementa en 0,22 por cada hectárea erradicada manualmente, poniendo en evidencia la ineficacia de la política antidrogas. Es necesario buscar alternativas para tratar de reducir la oferta del cultivo, diferenciando las necesidades por cada región del país. En cuanto a la economía, el único sector que influye en la reducción del cultivo es el sector secundario y el índice de desempeño fiscal.

**Palabras Clave:** Cultivos ilícitos; comportamiento ilegal; erradicación forzosa; gestión financiera territorial; producción económica municipal.

## INTRODUCTION

The economic transformations that have taken place in Colombia have had a significant impact on rural institutions, resulting in crises in the agricultural sector, violence, and marginalisation. Coca crops (*Erythroxylum coca*) in Colombia have been directly related to different scourges that have mainly affected the rural area of the country, linked to the degradation of the economy and health because of the method of eradication by aerial spraying (Camacho & Mejía, 2017), to the environment seen from the perspective of decreased forest cover (Dávalos, Hall, Correa, Corthals, & Espejo, 2011; Morales, 2017; McClanahan, Sánchez, & Brisman, 2019), to pollution caused by the use of chemicals for coca cultivation and processing (Becerra, 2014), to the influence on geographical factors (Rincón-Ruiz, Pascual, & Flantua, 2012), to the armed conflict (Jaramillo, Ocampo, & Osorio, 2019; Lilian, 2011; Diaz & Sanchez, 2004; Bruce-Jones & Smith, 2019), violence (Martínez & Zuleta, 2019) and the beginning of the drug trafficking chain in the country, as stated by (Mejía & Rico, 2010).

Historically, the main producers of the cultivation have been Andean countries such as Peru, Bolivia and Colombia. In the 1990s, Peru and Bolivia intensified their anti-drug policy efforts, which combined to cause drug production in these two countries to decrease in large proportions (Thoumi, 2002). Repression in these countries led Colombia, with a weak strategy aimed at reducing the supply of coca crops, the problems of violence, displacement, guerrilla control and paramilitary organisations in the territory in the 1990s, to begin to experience growth and over time become the country with the largest number of hectares of coca and the largest exporter of cocaine in the world, with the United States of America as the main market.

However, there are different approaches to the growing phenomenon of coca cultivation in Colombia, from the point of view of geography, as identified by Gómez, Sastoque & Mantilla (2019), there are determining factors such as supply and demand, favourable environmental conditions for cultivation, extensions of available land and technological elements that facilitate production. Cocaine is an illicit substance extracted from the leaf of the coca bush, which is a popular and highly addictive stimulant that directly affects the brain (NIDA, 2010).

Despite the efforts made by the national government, there is evidence that municipalities with coca crops are on average poorer than the rest of the country, have low tax revenues, low levels of connectivity and reduced institutional development (Zuleta, 2019). These facts have been an incentive for the sustainable emergence of illicit plantations such as coca, and given the circumstances, it is necessary to stimulate development in the so-called coca-growing municipalities. These institutional loopholes have been exploited by illegally armed groups, which have been involved in cocaine trafficking (Díaz & Sánchez, 2004), and have made their presence felt where there are institutional weaknesses and difficulties of uniform access to the territory (Holmes, Gutiérrez, & Curtin, 2006).

One of the most visible illegally armed groups in the drug trade, the imbalance of Colombian state authority in the administrative and military fields, and the Colombian armed conflict has been the Revolutionary Armed Forces of Colombia (FARC, its acronym in Spanish) (Díaz & Sánchez, 2004; Bruce-Jones & Smith, 2019). After decades of violence, the Colombian government, and the FARC signed a peace agreement in 2016 that has brought opportunities and challenges to the country's social and material ecologies (McClanahan, Sánchez, & Brisman, 2019).

When the group that illegally took up arms demobilised, the number of deaths due to confrontations with the security forces was considerably reduced, although this arrangement did not ensure the end of the conflict, as other transcendental and relevant aspects were not taken into account, as shown by Morffe & Albornoz (2018), it is perhaps the weak or non-existent institutional presence and the persistence of several problems

during the conflict that have brought challenges for the Colombian state, related to trust, integral development and violence resulting from the emergence of new criminal structures or the rearrangement of structures already settled in the territory.

Furthermore, the lack of help from the state in certain places is cruel, (Castillo & Cardona, 2019), and for many individuals, there is no alternative but to engage in illegal activities such as coca cultivation, amid a conflict that goes from moral to survival. However, as stated by (Trejos, Badillo, & Irreño, 2019), despite efforts in some of the prioritised regions, expressions of armed violence continue to occur, disrupting the consolidation of territorial harmony.

Following the peace process with the FARC and after the signing of the agreements (2017 - 2018), coca cultivation grew by an average of 7.95%. One possible reason for this growth in cultivation is that the FARC exercised control over the maximum hectares that a farmer could sow (Bengoa, 2018) and with their departure from the territory, the new illegal armed groups that now control the business have not maintained the same method and, conversely, have encouraged the sowing of the crop on a large scale. The new groups, dissidents, or residual armed groups, increase violent disputes due to the lack of capacity to subdue and organise the so-called drug traffickers, who do not have a single reference to defend their interests (Defensoría del Pueblo, 2018).

Security in the coming years is expected to be complex with the departure of the FARC from some territories, the growing problem of illegal economies and coca crops, as the end of the armed conflict does not imply the disappearance of public security issues (Grasa, 2019), it will be time to address a transition in public security and democratic governance, with a readjustment to the new needs arising from the peacebuilding that is underway. As has been identified, the territories that present these problems have low levels of human capital and backwardness in basic infrastructure (López, Guarín, Medina, & Zuleta, 2019). In this regard, peasants have poor access routes to maximise their production, low opportunities to access a fair market and the cost-benefit of production with other agricultural activities, which has influenced their decision to continue planting coca crops (Moreno, Kraybill, & Thompson, 2003).

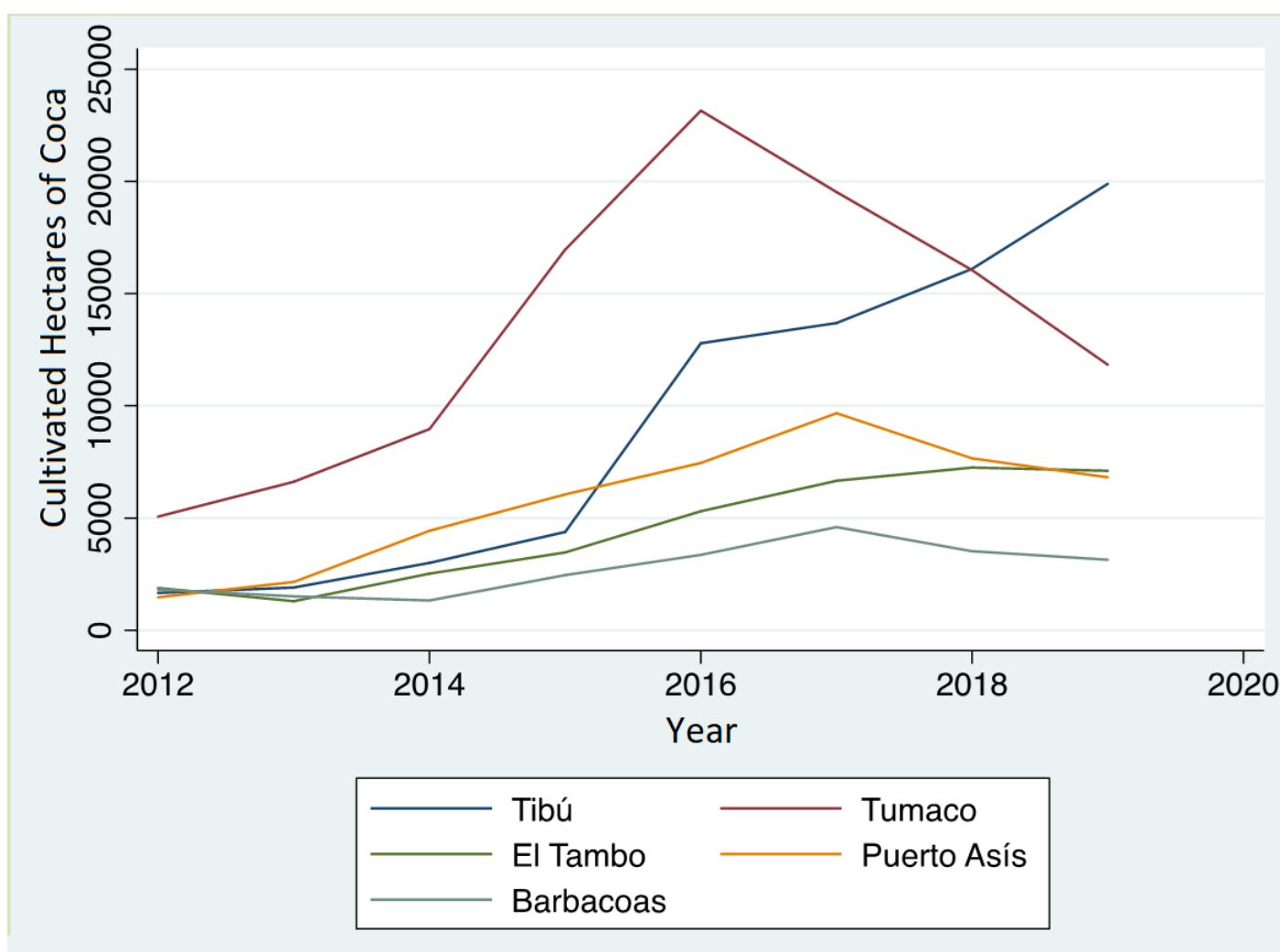
To reduce the supply of illicit crops, the Colombian government has proposed strategies over time consisting mainly of forced eradication of the crop by the manual method, the programme for the Eradication of Illicit Crops through aerial spraying with the herbicide Glyphosate - PECIG and the National Integral Programme for the Substitution of Illicit Crops (PNIS). Forced eradication has a recidivism rate of close to 80%, while the alternative development strategy is only 10% (Bengoa, 2018). However, according to the report on the PNIS for 2019 by the United Nations Office on Drugs and Crime (UNODC), the persistence of 0.4% of the total area voluntarily eradicated is evident, making it clear that the model of transition to alternative development is the most efficient, if it is sustainable and fully financed over the long term.

Overall, the departments of Nariño, Putumayo and Norte de Santander contributed an average of 58.87% of the hectares under coca cultivation to the national total during the period under analysis. According to the Observatorio de Drogas de Colombia (ODC), the municipality of Tumaco, located in the department of Nariño, had the highest number of hectares of coca cultivation in the country from 2012 to 2017, with an average of 13.377 hectares per year, with an average participation of 13.69% at the national level, while for the year 2018 and 2019 it was the municipality of Tibú, located in the department of Norte de Santander, with 16.096 and 19.892 hectares planted respectively, which represented 9.52% and 12.86% of the coca crops planted in Colombia, see Figure 1.

377 hectares per year, with an average participation of 13.69% at the national level,

while for the year 2018 and 2019 it was the municipality of Tibú, located in the department of Norte de Santander, with 16.096 and 19.892 hectares planted respectively, which represented 9.52% and 12.86% of the coca crops planted in Colombia, see Figure 1.

In 2012, the municipality of El Tambo, located in the department of Cauca, was in second place, with 3.93% of national crops, while from 2013 to 2015 it was the municipality of Puerto Asís in the department of Putumayo, with an average share of 5.73%, while in 2016 and 2017 it was the municipality of Tibú, with an average contribution of 8.37%, and in 2018 and 2019, that is, during the period from 2012 to 2018, only two municipalities contributed an average of 19.94% of the total amount of coca cultivation in Colombia, taking into account that an average of 195 municipalities per year have registered coca cultivation in the country, according to ODC data.



**Figure 1.** Hectares under Coca Cultivation by Municipality.

Source: Own Elaboration with ODC Data.

Given the importance of the issue at the national level, several studies have been carried out on coca cultivation in Colombia, such as the work by Rocha (2019), who developed a spatial model of panel data for the period 2012 -2016 and determined that 11% of the variations in coca cultivation are due to municipal contagion, 39% to the method of eradication by aerial spraying, 10% to manual eradication and 9% to alternative development. The study shows that the territorial spread of coca cultivation depends on how vulnerable the conditions of each municipality are, which is why it is suggested that these conditions may be considered when designing, implementing, and evaluating the country's anti-drug policy.

On the other hand, Rozo (2014) studies the effect of anti-drug programmes and

identifies the impact of aerial spraying with herbicides in areas where coca is produced in Colombia. The results indicate that spraying one hectare of coca reduces only a quarter of the hectare sprayed but brings with it negative effects such as increases in poverty, school dropout, infant mortality, and homicide rates. In other words, forced eradication programmes reduce a small amount of crop production, but create serious negative effects that are unintended for the treated population, further fuelling the civil conflict in Colombia, since the treated people may perceive that the negative effects are caused by the government.

The work of Mejía, Retrepo & Rozo (2015) focuses on the effects of implementing a large aerial spraying programme to reduce coca cultivation, using evidence from a quasi-experiment conducted in Colombia. The results of the applied model suggest that spraying one additional hectare reduces coca cultivation by only between 0.022 and 0.03 hectares, arguing that the effects of the eradication policy are too small and not cost-effective for the intended purpose of reducing cocaine production in Colombia.

The relationship between the increase in coca crops and the peace negotiations carried out between the FARC and the Colombian state was considered in the study developed by López, Guarín, Medina and Zuleta (2019). The results of the study suggest that for the period from 2012 to 2016, the municipalities where the armed group was present, experienced a growth of more than 604 hectares of coca, compared to municipalities where the armed group was absent. For the authors, the formalisation of property is a determining factor in discouraging coca cultivation since most of the land that is formalised does not have coca plantations.

The purpose of the work by Ríos, Bula & Morales (2019) is to expose the dynamics of direct and structural violence in seven border departments in Colombia. The study includes the number of guerrilla actions or deaths due to direct violence and coca crops, these researchers determined that before the negotiations of the peace agreement with the FARC, the territories had already been consolidated with the presence of violence derived from the armed conflict and that according to the spatial transformation of the borders, added to the loss of governability and poverty, it ends up favouring the continuity of violence in the territories.

For Martínez & Zuleta (2019), who analyse the impact of coca crops on municipal violence, to achieve long-term peace and generate sustainable development in Colombia, the state should not focus all its attention on reducing the number of hectares of coca, but also on generating well-being for the communities, by being present in the municipalities where there is illegality. Through the models developed, the authors find that coca cultivation increased the municipal violence index by 11.1% for the period 2000 - 2017, being 2.35% more pronounced after 2012, when the FARC talks with the Colombian government began.

In this context, having highlighted the different studies and the variables that influence the variation in the number of hectares under coca cultivation in Colombia's municipalities, a robust database is consolidated containing variables such as hectares under coca cultivation, number of hectares eradicated, violence index and economic productivity by municipalities. The method used for the analysis of the observations includes a panel data model that allows an approximation of the influence of the variables on the number of hectares cultivated in the municipalities of Colombia between 2012 and 2019.

## **METHODOLOGY**

The compliance of the system of variables for the development of this research

comes from the ODC, which provides official information on drugs, as stipulated in Resolution 006 of April 8, 2005, of the National Narcotics Council, the Colombian government's Unit for the Attention and Integral Reparation of Victims, the National Administrative Department of Statistics (DANE, its Spanish acronym) and the National Planning Department (DNP, its Spanish acronym), see table 1.

The variables considered in the research are divided into a dependent variable (the consequence of the combination of effects caused by the independent variables) and independent variables (those that cause changes in the dependent variable). The 1101 municipalities considered by the DNP in the elaboration of the Fiscal Performance Index are taken as a reference.

**Table 1:**

System of Variables

Variable	Concept	Source of Information
Coca Crops	Number of Hectares	ODC
Commuting	Number of Displaced	Victims Unit
Homicide	Number of Homicides	Victims Unit
Kidnapping	Number of Kidnappings	Victims Unit
Threats	Number Threats	Victims Unit
Sexual Assault	Number Sexual Assault	Victims Unit
Enforced Disappearance	Number Enforced Disappearance	Victims Unit
Torture	Number Torture	Victims Unit
Terrorist Act	Terrorist Act Number	Victims Unit
Value Added	Values Added Billions of Pesos	DANE
Fiscal Performance Index	Percentage Value	DNP
Investment Magnitude	Percentage Value	DNP

Source: Own Elaboration.

Several studies analyse violence intending to understand the causes of crime and all that it entails, to make recommendations in terms of public policy, generally using the homicide rate as the indicator that most affects the population; however, other crimes of great implication are not considered. To jointly analyse the relationship between violence and coca cultivation in Colombia, the municipal violence index is calculated, taking as a reference what is proposed by Quintero, Lahuerta, & Moreno (2008) and following the work of Martínez & Zuleta (2019).

The construction of the index is divided into a fixed and a variable component. The first is calculated by taking the average number of years that an individual spends in prison for the crime committed and the weight that each one has compared to the others.

$$Fixed\ component_j = \frac{(Minimum_{Sentence_j} + Maximum_{Sentence_j})/2}{\sum_j^m (Minimum_{Sentence_j} + Maximum_{Sentence_j})/2}$$

The variable component measures the share of the total of each crime compared to all other crimes. With this share, it is possible to identify which are the most recurrent crimes in each municipality and in each given period.

$$Variable\ component_j = \frac{\sum_j Number\ of\ Crimes_j}{\sum_j \sum_i Number\ of\ Crimes_{ij}}$$

The average between the fixed and variable component results in the weighting of the exercise.

$$\text{Weighting}_j = \frac{\text{Fixed Component}_j + \text{Variable Component}_j}{2}$$

Finally, the violence index is constructed by summing each crime by its weighting.

$$\sum_j \ln(\text{Number of Crimes}_{ij})$$

Once the violence index for Colombia's municipalities has been constructed, a panel data regression model is proposed as it allows the inclusion of variables of interest for a period, that is, the structural and temporal dimension is combined based on a general model, as presented in the following equation:

$$y_i = \alpha + \beta_1 X_{1i} + \beta_2 X_{2i} + \dots + \beta_k X_{ki} + u_i; \text{ where } i = 1, \dots, n$$

Where  $y_i$  is defined as the dependent variable of the model,  $X_{ki}$  as the independent or explanatory variables,  $\beta_k$  are the regression coefficients of each variable,  $\alpha$  is the intercept and  $u_i$  is the so-called error term. The above model can be generalised to a panel data model as follows:

$$y_{it} = \alpha + \beta_1 X_{1it} + \beta_2 X_{2it} + \dots + \beta_k X_{kit} + u_{it}; \text{ where } i = 1, \dots, n \text{ y } t = 1, \dots, T$$

The unit of study is represented by  $i$ , the unit of time by  $t$ ,  $X_{it}$  indicates the  $i$ -th observation at time  $t$  for each of the  $K$  variables that explain the variations of the dependent variable, represented by  $X_1, X_2, X_3, \dots, X_K$ . In other words, the variation not only among the number of study cases  $n$ , but also over time, represented by  $t$ , is incorporated into the initial model.

The parameters of the first equation can be estimated by employing ordinary least squares, which allows, under assumptions, to have a better unbiased linear estimator. However, this method is not suitable for estimating the second equation, since there is usually heterogeneity among the cases evaluated:

$$y_{it} = \beta_1 X_{1it} + \beta_2 X_{2it} + \dots + \beta_k X_{kit} + n_{it}$$

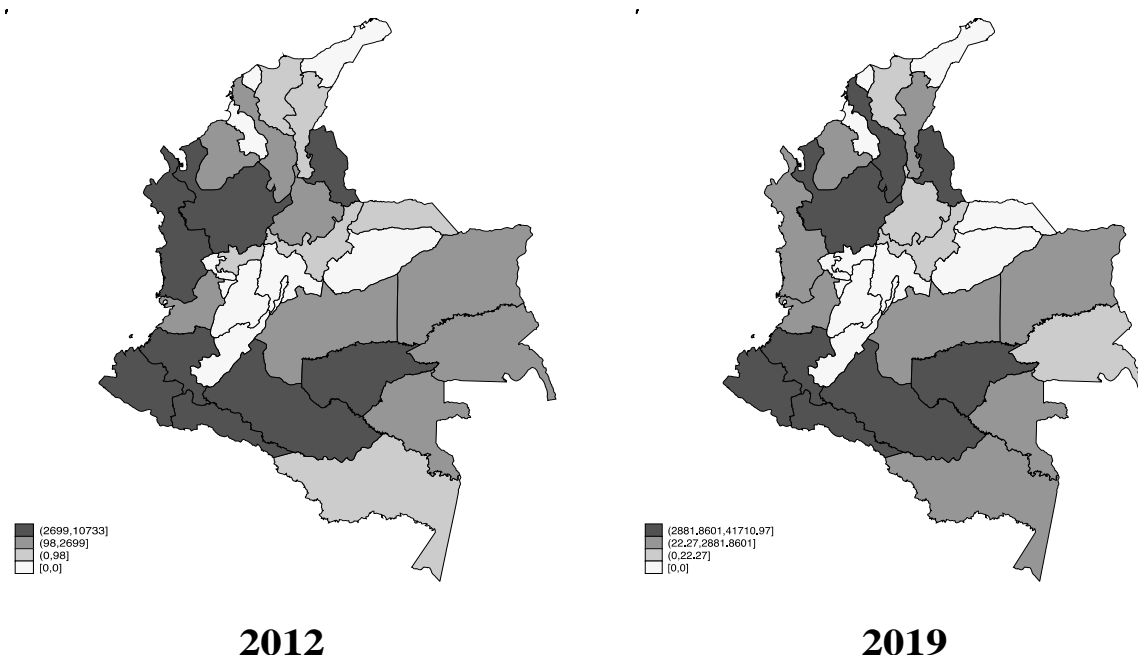
For  $n_{it} = \alpha_i + u_{it}$ , where the intercept  $\alpha_i$  is identically and independently distributed with zero mean and constant variance, being non-error dependent.

## RESULTS

By 2012, Colombia had 47.471 hectares of coca cultivation, with production concentrated in 9 departments: Nariño, Putumayo, Norte de Santander, Cauca, Guaviare, Caquetá, Chocó, Antioquia, and Meta. These departments accounted for 88.13% of the country's cultivation, with the three main growers bordering Ecuador and Venezuela, with a share of 44.77% of the rest of the country. In 2019, the country had 154.476

hectares of coca, with no variation concerning those that contributed most to the area planted in the country, with Nariño, Putumayo and Norte de Santander, as in 2012, being the largest cultivators, but on this occasion with 67.1% participation, with an abysmal difference in the number of cultivated hectares, going from 21.396 in 2012 to 103.648 in 2019, which resulted in 146% the growth in the cultivation of the main producers, comparing only those two years.

Figure 2 shows that the departments of Meta and Chocó dropped out of the 9 departments with the highest cultivation in 2012 compared to 2019, which allowed the departments of Córdoba and Bolívar to be included in the list, with the number of hectares cultivated by these two departments increasing from 3.014 in 2012 to 10.846.95 in 2019, with an average growth of 43.22% over the entire documented period.



**Figure 2.** Comparative Area under Coca Cultivation in Colombia.

Source: Own Elaboration with ODC Data.

During the period under analysis, Tumaco has been the municipality most affected by coca cultivation in Colombia, rebounding in the period 2012 - 2017 and occupying a second place during the years 2018 and 2019, with a difference of only 49.89 hectares from the first in 2018 and 8,062.45 for 2019. The municipality had an average growth rate of 19% during the period 2012 - 2019, with the year 2015 compared to 2014 showing the highest variation, with 89% growth, but with an average decreasing trend of 20% during the last three years analysed.

Historically, the municipality of Tumaco has had little institutional presence, which has allowed illicit activities such as drug trafficking to increase. The geographical location of the municipality has also been a determining factor in the growing appearance of cultivation in the territory. According to Patiño, Santacruz, Urbina & Valencia (2018), the fact that it is a port facilitates the national and international commercialisation of products derived from the crop. Nevertheless, the municipality of Tibú, in the last two reference years, consolidated itself as the first municipality in Colombia with more coca cultivation, with 51% average growth, with no downward trend in the eight years analysed.

The results of the estimation of the model are shown in Table 2. The municipal violence index takes values between 0 and 7.4875, which indicates that the higher the



index, the more violent the municipality is according to the information registered in the Victims Unit, with the municipality of Buenaventura, located in the department of Valle del Cauca, obtaining the highest violence index. As Martínez & Zuleta (2019) refer, a municipality does not necessarily cease to be violent when its index is 0; this establishes the existence of violent municipalities but with no record of their events.

During all the years studied, the municipal violence index decreased on average by 9.11%, with an average index of 1.87 for the period 2012 - 2016, when the dialogues were established and the peace agreement was signed, and 1.24 for the period 2017 - 2019, when the agreement began to be implemented. The average municipal violence index was 3.138 for municipalities with coca cultivation, which was 1.807 higher than the average for municipalities without coca cultivation during the period 2012 - 2019. While the average growth of the violence index for municipalities with registered cultivation decreased by 4.4%, the violence index for municipalities without cultivation also decreased to 10.88%.

In the context of violence in Colombia, the most recurrent crime is displacement, which represents 81.2% of the total crimes registered for the period of analysis. About 1,640,384 people were forcibly displaced within and outside the national territory, as indicated by the National Centre of Historical Memory (2015), displaced persons have been forced to abandon their homes, their lands, territories, their goods, customs, communities, and their ways of life.

**Table 2.**

Results of the Panel Model for the Municipalities of Colombia

Variables	Coke	Coke	Coke	Coke
Violence Index	41.79*** (6.55)			40.60*** (6.25)
Aerial Spray	-0.258*** (-13.54)			-0.254*** (-13.36)
Manual Eradication	0.223*** (17.61)			0.220*** (17.41)
Logarithm Primary Activities		3.983 (0.42)		26.13*** (3.20)
Logarithm Secondary Activities		-3.998 (-0.27)		-29.89* (-2.19)
Logarithm Tertiary Activities		100.8*** (5.38)		72.06*** (4.41)
Tax Performance			-3.675** (-3.00)	-5.433*** (-4.32)
Investment			1.426* (1.55)	3.789** (4.08)
Saving			2.191*** (4.17)	1.793** (3.31)
<i>Remarks</i>	8808	8808	8808	8808
$R^2$	0.0471	0.0155	0.0023	0.0529

Note: T Statistic in Parentheses. \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001

Source: Own Elaboration.

The war, as stated by Jaramillo, Ocampo, & Osorio (2018), has successfully fulfilled the mission of accelerating the process of displacement of peasants to urban areas and as indicated by Díaz & Sánchez (2004), has helped the expansion of the coca cultivation economy in Colombia. From 2012 to 2014, displacement had an average growth of 5.17% and from 2015 the growth rates decreased to an average of 17.29% until 2019, presenting the highest variation from 2018 to 2019 with 46.11%. 66.59% of

the total number of displacements in the entire period of analysis correspond to municipalities where coca cultivation was present; however, of the total number of displacements registered in these municipalities, 44.05% belong to three border departments: Nariño, Valle del Cauca and Norte de Santander, coinciding in participation with the two departments with the highest number of registered displacements, compared to the rest of the country.

Selective threats have been one of the strategies used to accentuate the Colombian armed conflict. For the total number of crimes under analysis, it occupies second place in occurrence, with 14.28% of participation about the total number of crimes registered in the whole period, with 288,406 cases registered in the municipalities. The trend in the number of related crimes decreases on average by 11.25%, increasing from 2013 to 2014 by 4.35% and 9.82% from 2017 to 2018. Of the total number of threats registered from 2012 to 2019, 54.28% belong to municipalities in Antioquia, Caquetá, and Nariño with coca crops accounting for 48.51%.

Regarding the method used to reduce the supply of coca crops in the municipalities of Colombia, according to the results of the model, in the short term, aerial spraying harms the fluctuations of the crop close to 25% of the hectares sprayed, a result that coincides with the findings of Rozo (2014) and Rocha (2019), i.e. for each hectare that is sprayed, only a quarter of a hectare of the crop is reduced in the short term in the municipality of reference. However, this study assumes only the effect related to variations in the sown area and not on very important aspects documented in previous studies.

According to Observatorio de Drogas Colombiano, during the period 2012 - 2015, 150 municipalities were subject to the implementation of aerial spraying with the herbicide Glyphosate to reduce the supply of coca cultivation; 239.627.04 hectares were intervened, of which 41.96% corresponded to the year 2012 alone. From 2016 to 2019, the aerial spraying eradication programme was not used, given that in October 2015, after evaluating the results of the World Health Organisation (WHO), the herbicide Glyphosate was classified as probably carcinogenic to humans. As Camacho & Mejía (2017) point out, in the short term, exposure to the herbicide increases the number of medical consultations concerning dermatological, respiratory diseases and spontaneous abortions.

On the other hand, eradication by manual method, contrary to what was expected and found in the results obtained in the eradication by an aerial spraying method, is positively associated with variations in coca cultivation in the municipalities of Colombia in the short term. According to ODC data, in the period 2012 - 2019, the number of eradicated hectares had an average growth rate of 34.23%, being higher in the last three years of analysis, with 89.38%.

The 301,616 hectares of coca eradicated manually impacted 369 municipalities, of which 68.47% correspond only to the period 2017 - 2019. The results suggest that the efforts made by the manual eradication method are not obtaining even minimally the expected results; instead, in the short term, the municipalities increase the presence of coca cultivation by about one-fifth for each eradicated hectare. The three economic activities explain 1.55% of the variations in coca cultivation in Colombia's municipalities.

Primary sector activities, which include agriculture, livestock, forestry and fishing, and mining and quarrying are positively related to the growth of coca cultivation in Colombia's municipalities. Therefore, the more this activity grows, the more coca cultivation there will be in the municipality, according to the results of the model's

estimation. The Gross Domestic Product (GDP) of primary activities in municipalities where coca cultivation was present was on average 21.89% higher than the GDP of municipalities where coca cultivation was not reported during the whole period. While the GDP where coca cultivation was present decreased on average by 4.83%, the GDP of the municipalities without coca cultivation showed an average growth of 4.69% during the eight reference years, being 10.87% in the last three reference years.

As for the activities of the secondary sector, which include manufacturing industries and construction, they have a negative relationship with the presence of coca cultivation, indicating that the greater the presence of industry, the lesser the appearance of coca crops in Colombia's municipalities. The GDP of secondary activities in municipalities without coca cultivation is, on average, 315.05% higher than the product of municipalities where coca crops have been present during the period analysed, including the main cities of Colombia, where the greatest industrial participation is registered. The municipalities without coca crops registered an average growth of 4.72% in the GDP of the activities, while the municipalities with coca crops increased their productivity in the sector by 9.87%.

Tertiary activities, which according to DANE, represent electricity, gas and water services, commerce, repair of motor vehicles, transport, accommodation and food service, information and communications, financial and insurance activities, real estate activities, professional, scientific and technical activities, administrative and support service activities, public administration, education, health, artistic, entertainment and recreational activities and activities of individual households are, as in the primary sector, positively related to the variations of coca cultivation in Colombia's municipalities, with an average of 140.61% higher GDP of tertiary activities in municipalities without coca cultivation, compared to municipalities where coca cultivation was recorded. The average municipal GDP growth of tertiary activities without coca cultivation was 8.24%; 1.27% higher than the GDP growth of municipalities where coca cultivation was present.

The municipal fiscal performance index is a synthetic indicator that measures the overall financial result achieved during a year on a scale of 0 to 100. This suggests that, if the results are close to 100, the municipalities have a good performance, translated into the procurement resources they had in the annual period to sustain their functioning, with high levels of investment and an adequate debt-backed capacity. During the period analysed, on average, municipalities had a fiscal performance of 68.33, which, according to the performance range established by the DNP, municipalities, on average, have been in a vulnerable fiscal situation, with only 6.14% of municipalities in Colombia being solvent, that is, those that had results greater than or equal to 80, with approximately 68 municipalities in this condition for each year evaluated.

The fiscal performance index is negatively related to the growth of coca cultivation, indicating that the higher the performance index, the lower the presence of coca cultivation in Colombia's municipalities, coinciding with the fact that municipalities, where coca cultivation was present, were on average 2.69 points below the average performance indicator of municipalities without coca cultivation during the period 2012 - 2019.

The savings capacity, which determines the degree of liberation of surpluses to finance municipal investment, was on average 44.11% during the whole period. However, there is no major difference between the indicator for municipalities with and without coca cultivation, standing at 73.39%. The relationship of the variable is positive with the variations in coca cultivation in the municipalities of Colombia, which is consistent with the magnitude of the investment, which quantifies the percentage of

investment executed by the territorial entity about total expenditure, with an average of 86.75% for the whole period and no difference between the average for municipalities with or without the presence of coca cultivation.

Analysing by regions of Colombia, for the year 2012, the municipalities of the Amazon region obtained the highest average violence index for the entire period analysed, compared to the other regions of the country with an average of 3.55. The municipalities located in the Amazon region had a decreasing annual index of violence during the period 2012 to 2017 with an average of 8.77%, increasing from 2017 to 2018 with 5.33% and decreasing from 2018 to 2019 with a 15.83% variation.

This region is the only one that presents a negative relationship between the violence index and coca cultivation. The violence index of the municipalities located in the Amazon region registers an average of 3.21 in the period 2012 - 2016 when the dialogues were established and the peace agreement was signed and the average was reduced by 1.04 during the period 2017 - 2019 when the implementation of the agreement signed between the Colombian State and the FARC began, Nevertheless, the violence index registered in the Amazonian municipalities with coca cultivation is 2.81, which is 1.41 points higher than the index in the Amazonian municipalities, where coca cultivation registers were absent during the entire reference period.

**Table 3.**

Results of the Panel Model by Region of Colombia

Variables	Caribe	Pacífica	Andina	Orinoquía	Amazonas
Violence Index	15.17** (2.77)	108.8*** (4.31)	33.34*** (4.11)	32.21** (2.75)	-63.05 (-0.83)
Aerial Spray	-0.887*** (-11.10)	-0.214*** (-5.57)	-0.727*** (-5.50)	0.243*** (5.76)	-0.0364 (-0.41)
Manual Eradication	0.186*** (5.18)	0.326*** (12.80)	0.150*** (5.21)	0.365*** (10.28)	0.201** (2.77)
Logarithm Primary Activities	16.97** (3.07)	108.3*** (3.43)	15.40 (1.44)	-8.521 (-0.83)	134.0* (1.77)
Logarithm Secondary Activities	-5.855 (-0.53)	-55.24 (-1.08)	-27.78* (-1.70)	-1.753 (-0.10)	-2.411 (-0.01)
Logarithm Tertiary Activities	17.93 (1.38)	187.3** (2.97)	50.94* (2.55)	5.959 (0.30)	345.7 (1.76)
Tax Performance	-0.587 (-0.67)	-23.02*** (-4.44)	-2.366 (-1.43)	-0.120 (-0.08)	-26.87* (-2.43)
Investment	0.0141 (0.02)	16.72*** (4.19)	2.438* (2.01)	1.641 (1.38)	16.45* (2.20)
Saving	-0.00311 (-0.01)	6.417** (2.94)	1.161 (1.74)	-0.479 (-0.57)	11.13* (2.03)
Remarks	1560	1424	5032	472	312
R <sup>2</sup>	0.1606	0.0726	0.018	0.147	0.070

Note: T statistic in parentheses. \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001

Source: Own elaboration

In the case of the municipalities in the Caribe region, the violence index is positively related to variations in coca cultivation, as found in the global model. From 2012 to 2014, the violence index had an average annual growth of 2.30% and decreased by 11.67% for the rest of the period, being 3.03 for municipalities where coca crops

were registered and 1.67 for municipalities without coca crops, located in the Caribbean region. The municipalities in the Pacífico region obtained the greatest variation in the results of the regional model, and the average violence index is the highest in municipalities with coca cultivation and municipalities without coca cultivation, compared with the other regions of Colombia, at 3.37 and 2.12 respectively.

The municipalities located in the Andina region had an average decrease of 11.48% in the violence index during the eight years analysed, with an average violence index of 1.14, the lowest of all regions. For the period 2012 - 2016, the index was decreasing by 6.38% and during the period from 2017 to 2019 the variation was the highest, with an average negative variation of 18.27%, with the violence index of municipalities with coca crops being higher by 1.9 compared to municipalities without coca plantations.

In the case of the municipalities located in the Orinoco region, the violence index positively affects the variations in coca cultivation, and the average index for the period is 2.02, being 1.70 in the period of the dialogues and the signing of the peace agreement and 0.61 for the period 2017 - 2019, being 2.91 the index registered for the municipalities with coca cultivation and 1.82 for the municipalities without coca cultivation in the Orinoco region.

The method for reducing the supply of coca crops is differential between regions. Regarding aerial spraying with Glyphosate, the results suggest that the municipalities in the regions where the policy affects the most are the Caribe region and the Andina region, where coca cultivation is reduced by 0.89 and 0.72 hectares respectively for each hectare sprayed, while coca cultivation in the municipalities of the Amazonas region is reduced by only 0.04 for each hectare sprayed.

As for manual eradication, the differences between regions are reduced, but the ratio remains positive for all cases. Contrary to expectations, as mentioned in the global model, increases in hectares eradicated by the manual method augment coca cultivation in the municipalities of Colombia's regions, most accentuated in the Pacífico and Orinoco regions, where one eradicated hectare increases coca cultivation by 0.37 and 0.33 hectares in their municipalities, where coca cultivation increased annually, with an average of 32.57% in municipalities where manual eradication of coca cultivation was implemented.

In terms of economic activities, during the period under analysis, the Pacífico region had an average growth of 6.75% in primary activities, where the GDP of primary activities in municipalities without coca cultivation is higher on average at 12.68%, in contrast to the municipalities where coca cultivation was registered. Thus, the changes registered in the variable under analysis have a positive influence.

The opposite is true for secondary activities, where increases in GDP contribute negatively to changes in coca cultivation, which means that the higher the GDP in secondary activities, the lower the presence of coca cultivation in the region's municipalities, with an average 79.57% higher GDP in secondary activities without coca cultivation. On the other hand, the variable that contains the tertiary sector activities presents the greatest variation in the model and is positively related to variations in the number of hectares of coca crops in the Pacífico region.

Relating the results obtained in the economy of the municipalities of the Colombian Orinoco region, the higher the GDP in the primary sector, the lower the presence of coca crops in their municipalities, contrary to what was found in the other regions. During the period 2012 - 2019, the productivity of the sector decreased by an

average of 1.15% and was 25.04% higher on average than the GDP of the municipalities where coca cultivation was absent, comparing the production of the sector with the municipalities where there was coca cultivation.

However, the GDP of the secondary and tertiary sectors behaved in the same way as in the other regions, but with the lowest variation. For the municipalities located in the Amazon region, the variations in the GDP of the primary and tertiary sectors affect the variations in coca cultivation to a greater extent than in the rest of the regions, with an increase of 25.6% and 158.4% respectively compared to the Pacífico region and 117.03% and 327.3% of the results for the Caribe region.

For all the regions analysed, the fiscal performance results are consistent with those found in the general model; however, the Pacífico and Amazonas regions show greater variation. The municipalities in the Pacífico region that registered coca cultivation have a fiscal performance index of 64.31; 2.43 lower than the average recorded for coca crops-free municipalities. The results for investment and savings suggest that their increases are globally and positively related to the growth of coca cultivation in Colombia's municipalities, therefore, the result achieved in the regions is not homogeneous; the municipalities located in the Caribe and Orinoco regions present a negative incidence.

## CONCLUSIONS

This article presents the results that relate to the influence of the economy and violence on coca cultivation in the municipalities of Colombia during the period 2012 - 2019. The estimates of the econometric model suggest that overall, violence is positively associated with the increase in the number of hectares planted with coca crops, although the results are not homogeneous when comparing the different regions of Colombia, where municipalities located in the Pacífico region are the most affected by an increase in violence, whilst municipalities in the Amazonas region show the opposite effect to that expected, as increases in the level of violence reduce the number of hectares planted with coca crops.

Considering the limitations of the model developed, the policy adopted to control coca crops in Colombian municipalities has undoubtedly not been efficient. On the one hand, globally, aerial spraying of one hectare of coca in the short term only reduces coca cultivation by a quarter of a hectare in Colombian municipalities, but when analysed by region, the opposite effect is evident for municipalities located in the Orinoco region, where spraying of one hectare increases coca cultivation by almost a quarter of a hectare.

The problem of crop control is even greater regarding the policy of manual eradication, given that in the short term its application is not yielding even the minimum expected results, given that the eradication of one hectare increases the hectare under coca cultivation in Colombia's municipalities by 22%. The picture is even more discouraging when analysing the municipalities located in each region of Colombia, with the Pacífico and Andina regions being the most affected with an increase of 0.89 and 0.72 hectares for each eradicated hectare, respectively. These results invite the search for urgent alternatives to address the control of coca cultivation, differentiating the needs of each region of the country.

By including variables that have not been considered in recent literature, the debate on the determinants of coca cultivation growth in Colombian municipalities is broadened. In terms of the economy, municipalities with coca crops are more productive in the primary and tertiary sectors, compared with the activities of coca-free municipalities, while secondary sector activities are greater in municipalities without

coca crops. The results coincide with what has been established, although they are not homogeneous for the case of the municipalities located in the regions of Colombia. This indicates that the higher the GDP in the primary and tertiary sectors, the greater the presence of coca cultivation and that an increase in the GDP of the secondary sector does decrease the hectares of coca cultivation in the municipalities of Colombia.

The governmental management analysis instrument shows that municipalities that obtain on average a better result in the municipal fiscal performance index decrease the number of hectares of coca crops in their municipalities. Nonetheless, the magnitude of public investment, which measures the degree of investment made by the municipal entity in relation to total expenditure, and the savings capacity, which in turn measures the solvency to generate own resources to be used for investment, have the opposite effect to that expected, indicating that the increase in these indicators augment the presence of coca cultivation in the municipalities. Such a finding opens the possibility for future research to identify the reason for this result.

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