



## **Coca crops, forests, people and anti-drug policy in Colombia: Towards the understanding of a complex relationship**

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*“Dedicated to my beloved mother Blanquita (R.I.P.), the source of everything beautiful in me. To you I dedicate this and my life, because with love all things are possible, and this thesis was an act of love”.*





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## **Abstract**

The cultivation of coca (*Erythroxylon coca*) by smallholders represents the first step in the largest illegal agribusiness in the world: cocaine. The literature on illicit crops generally considers the global and national factors that influence its expansion but little attention is paid to the local conditions where cultivation takes place. Since 1994, the Colombian state, with the aid of the U.S., has waged a war on drugs based on air fumigation of coca plantations, a policy that has faced questions regarding its ineffectiveness and socio-environmental impacts. This leaves one fundamental question: Is anti-drug policy really based on an accurate diagnosis of the complex reality associated with the expansion of coca crops?

Simple approaches suggest that the problems of the production of the coca crops that have brought serious social and environmental problems to Colombia owe their existence to a demand that, being illegal, generates huge quantities of money. However, this does not explain why just a few countries (Peru, Bolivia and especially Colombia), are the biggest cultivators of coca for the production of cocaine. The existence of a demand that offers such large sums of money should not imply that particular countries should involve themselves in the satisfaction of this demand.

This study analyzes the economic, environmental, institutional and social factors associated with the existence and expansion of coca crops for illicit use. We do this from a regional perspective, by taking into account the particular factors that characterize the areas associated with coca municipalities. For the proposed analysis we use various methodologies, including Exploratory Spatial Data Analysis (ESDA) to visualize and describe the local spatial distributions and clusters, and Local Indicators of Spatial Association (LISA) for the year 2001 and 2008. We also use Geographically Weighted Regression (GWR) models to show that the relationships between the analyzed variables and the coca crops are not constant over space. Similarly, it is demonstrated that the factors commonly associated with the expansion of coca crops are not constant with respect to time, as changes can be seen between the years of the study (2001 and 2008). Our analysis also indicates that the expansion of coca cultivation has led to deforestation, mainly affecting humid tropical forested ecosystems.

Our investigation concludes that analysis including the local reality offers the best way of understanding the factors associated with the expansion of illicit coca crops in Colombia, a fundamental step in the formulation of effective policies regarding the reduction of crops for illicit use (coca). We found that no single factor is exclusively associated with the coca areas, which are in fact characterized by a group of common factors; additionally, we discovered that the factors usually mentioned in the literature are neither spatially nor temporally constant, another explanatory factor in the failure of anti-drug policy to date, which is applied without consideration of the heterogeneous and complex local reality. After determining the aspects associated with the presence of coca cultivation in Colombia, we analyze the anti-drug policy that is currently in place and evaluate the social and environmental aspects of this policy. For the first time, we construct and perform statistical analysis on a spatial database with social, economic, environmental, coca-production and fumigation data for all 1125 municipalities in Colombia over the period from 2001 to 2008. We complement statistical analysis with in-situ observations and a secondary literature review. Our statistical analysis provides quantitative evidence to back up previous claims based on victims' experiences, single case studies and ethnographic observation. We question the effectiveness of the fumigation policy and suggest that what the war on drugs actually succeeds in eradicating is not coca, but humans and the forest. Finally, we show that the expansion of coca crops, with the associated increase in violence and displacement of people, has fragmented collective territories. However, with one case study we show that using another type of anti-drug policy based on encouraging the strengthening of communities, collective territories can succeed in curbing the expansion of coca crops.

**Keywords:** coca crops, socio-environmental conflicts, spatial analysis, tropical deforestation, Colombia, Geographically Weighted Regression, fumigations, collective territories.

## Resumen

El cultivo de la hoja de coca (*Erythroxylon coca*) que es realizado principalmente por pequeños agricultores, es el primer paso y la base de lo que puede ser considerado el agro negocio ilegal más grande en el mundo: la producción de cocaína. La literatura sobre cultivos de uso ilícito considera generalmente los factores globales y nacionales que influyen en la expansión de los cultivos de uso ilícito, sin embargo poca atención se ha puesto en los factores locales asociados a las zonas cocaleras. Desde 1994, el estado colombiano con la ayuda del gobierno de Estados Unidos, ha fomentado una guerra contra las drogas basada principalmente en las fumigaciones aéreas de cultivos de coca, una política que ha sido cuestionada por su ineffectividad y sus impactos socio-ambientales. Esto deja una pregunta de fondo: La política antidrogas realmente se basa en un diagnóstico real de la compleja realidad asociada a la expansión de los cultivos de coca?.

Planteamientos simples sugieren que la problemática de producción de cultivos ilícitos (coca) que ha traído serios problemas sociales y ambientales en Colombia, se debe a la existencia de una demanda que dada su ilegalidad genera grandes sumas de dinero, sin embargo esto no explica por qué solo pocos países (Perú, Bolivia y Colombia) y particularmente Colombia son los mayores cultivadores de coca para producción de cocaína. Independientemente de la existencia de una demanda que ofrece grandes sumas de dinero, esto no explica que solo pocos países como Colombia se dediquen a satisfacer esta demanda. En nuestra investigación se realiza un análisis más profundo de los factores asociados a la existencia de cultivos de coca, específicamente analiza los factores económicos, sociales, ambientales e institucionales asociados a la existencia y expansión de los cultivos de coca para uso ilícito.

Los análisis son realizados desde una perspectiva regional, teniendo en cuenta los factores particulares que están asociados a las zonas cocaleras. En nuestro análisis utilizamos diferentes metodologías, usamos Análisis Exploratorio de Datos Espaciales (ESDA por sus siglas en inglés) para visualizar y describir la distribución local espacial y la existencia de clusters que expliquen la realidad local, específicamente usamos Indicadores Locales de Asociación Espaciales (LISA por sus siglas en inglés). También usamos regresiones geográficamente ponderadas (GWR por sus siglas en Inglés), este tipo de modelos permitió evidenciar si las relaciones analizadas entre las variables de estudio son realmente constantes

en el espacio. Así mismo se demostró que los factores comúnmente asociados a la existencia de cultivos de coca no son constantes sobre el tiempo ya que identificamos cambios entre los dos años de estudio (2001 y 2008). Nuestros análisis también indican que la expansión de cultivos de coca ha producido un proceso de deforestación que ha afectado principalmente ecosistemas naturales de bosque húmedo tropical. La investigación concluye que análisis que tienen en cuenta la realidad local son el mejor camino para entender los verdaderos factores asociados a la expansión de los cultivos de coca para uso ilícito, en Colombia, el cual es un paso fundamental para la formulación de políticas efectivas para la eliminación de los cultivos de uso ilegal. En nuestra investigación encontramos que no existen factores individuales asociados exclusivamente a las zonas cocaleras, sino que es un grupo conjunto de variables las que caracteriza estas áreas. Adicionalmente encontramos que los factores usualmente mencionados en la literatura no son constantes ni espacialmente ni temporalmente, este es otro factor que explica el fracaso de la política antidrogas, pues esta se aplica sin tener en cuenta la compleja realidad local que es heterogénea y compleja. Luego de determinar los aspectos asociados a la existencia de cultivos de coca en Colombia, analizamos la política antidroga existente, particularmente los impactos socio ambientales de esta política, para ello construimos y analizamos por primera vez una base de datos sobre factores sociales, ambientales y económicos, así como lo relacionado a los cultivos de coca y la política de fumigaciones. Realizamos análisis estadísticos para los 1125 municipios de Colombia, durante el periodo 2001 – 2008 y complementamos los análisis estadísticos con observaciones de trabajo de campo, y revisión de literatura. En nuestra investigación cuestionamos la política de fumigaciones y su efectividad y sugerimos que los verdaderos afectados por este tipo de política son la población menos favorecida y el bosque. Finalmente probamos que la expansión de los cultivos de coca ha fragmentado incluso territorios colectivos a través de la expansión de la violencia y el desplazamiento de personas. Sin embargo a través de un caso de estudio probamos que bajo otro esquema de política antidrogas basada en el fomento el fortalecimiento de la comunidad, los territorios colectivos si pueden frenar la expansión de los cultivos de coca.

**Palabras clave:** cultivos de coca, conflictos socio ambientales, análisis espacial, deforestación tropical, Colombia, regresión geográfica ponderada, fumigaciones, territorios colectivos.

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## CHAPTER ONE: INTRODUCTION

The literature concerning socio-environmental conflicts has grown over the last few decades (Avcı et al., 2010; Martinez-Alier, 2001; Martinez-Alier et al., 2010; Wittmer et al., 2006), principally in developing countries where conflict for resources such as petroleum, wood and fisheries is common (Gerber et al., 2009; Martinez-Alier et al., 2010; Orta-Martínez and Finer, 2010; Shmueli, 2008). In the case of the coca crops, the analysis is necessarily more complex because it includes both a violent conflict and natural resources which are analyzed by authors like Bannon and Paul (2003), who argue that conflict is commonly associated with richness in natural resources. Several authors have explained the presence of coca in certain countries (Guridi 2002; Thoumi 2005; Thoumi 2005) and different policies have been drawn up during the last few decades to mitigate its cultivation (Renard 2001; Metaal 2005; Vargas 2005; Ministerio del Interior y de la Justicia 2006; Reuter 2006); however, after more than 20 years of war on drugs, the continuance of illicit crops in countries such as Colombia and the socio-environmental impacts of this war make it necessary to reflect upon the effectiveness of the policies that have been adopted (Moreno-Sanchez, Kraybill et al. 2003; Vargas 2004; Thoumi 2005; Walsh John, Sánchez et al. 2008).

The economic benefits that are generated by the prohibited trafficking of natural resources create an incentive for illegal armed groups to take advantage of the adverse social, economic and institutional conditions which exist in some countries, such as the Republic of Congo (coltan), Sierra Leone (diamonds) and Colombia (coca to produce cocaine). In fact, most cases related to natural resources and violent conflict are found in developing countries and particularly in areas with vulnerable communities, where one can usually find illegal armed groups and a weak presence of government (Le Billon, 2001).

Coca is a traditional crop in many Andean countries (Matteucci & J., 2003; Timothy, 1981). However, since the 1970s the production of coca has been increasingly focused on the manufacture of cocaine, due to the increase in demand, principally from the United States and Europe (Guridi, 2002). In the last few decades, Colombia, Peru and Bolivia have been responsible for most of the production of the coca leaf. Peru was the principal source of the

coca leaf until 1997, when Colombia took over as the world's number one producer (UNODC,2008).

The main motivating factor behind this thesis is that I am one of the Colombians who, for more than 20 years, has been a spectator of a war on drugs that, it can be said without hesitation, nobody has won; in this war, day after day I have seen the forest and the people emerge as the big losers. One of the initial questions I had at the beginning of this investigation was why, after over 20 years of fighting against drugs, Colombia still has this problem; could it be that the diagnosis has been inadequate? Why has anti-drug policy failed to work? Could it be that a more detailed approach to studying the expansion of coca cultivation has been lacking? I grew up under the conventional wisdom that the problem of drugs in Colombia is one of supply and demand, meaning that as suggested by Milton Friedman, cocaine is produced in Colombia as a result of external demand that, due to the drug's illegal status, ensures the payment of huge sums of money. Colombia, as a poor country, meets this demand.

I have always thought of this as a weak thesis, and believed that the causes are deeper than a simple matter of supply and demand. Regardless of the existence of a demand that promises big money, what is the reason for Colombia, specifically, to specialize in this type of production – one which destroys both nature and society? It cannot be simply because of the favorable conditions for growing the crops as they can also be cultivated in other countries. My main hypothesis is that Colombia possesses internal characteristics and regional particularities which make this illicit production possible; perhaps if demand for cocaine didn't exist, the coca regions would continue to partake in other types of illegal activity such the illegal mining that currently takes place. An unquenchable demand for cocaine and the associated material rewards on offer are not, on their own, sufficient reason for Colombia to be a producing country, no more than the demand for underage sex should lead a country to specialize in child prostitution. Coca and cocaine can be supplied by many countries, but what makes Colombia the place for their production and the center of socio-environmental conflict? Only by understanding this can we come up with an appropriate anti-drug policy; first we need to move away from the traditional belief that the problem is merely one of supply and demand.

My angle when writing this thesis was to find the structural factors associated with the expansion of coca cultivation; as only by determining this would it be possible to understand why anti-drug policy that has been implemented in Colombia has not only failed, but actually resulted in hurting the same victims as always: the forest and the most vulnerable people. I selected the first decade of this century firstly because this was the time when anti-drug policy, based on aerial fumigations, intensified and secondly because this is the era with the highest availability of local information on coca cultivation (the coca censuses began in 2000).

From my perspective, the failure of anti-drug policy (particularly the aerial fumigations – see Chapter 4) implies a lack of an adequate diagnosis of the socio-ecological factors associated with the existence of coca crops in Colombia, and an incorrect diagnosis will lead to an inappropriate policy (Chapters 2 and 3 deal with giving a more accurate diagnosis). Finally, thanks to fieldwork carried out in a faraway, forgotten part of Colombia, I successfully show that by breaking away from traditional ways of thinking and anti-drug policy, by considering factors not usually associated with coca cultivation, and by strengthening community development, a reduction in cultivation can be achieved.

This document can be broadly divided into two sections: Chapters 2 and 3 are dedicated to studying the factors associated with coca crops, while 4 and 5 focus more on anti-drug policy, its ineffectiveness and the possibility of more realistic alternatives. In the first section, associated factors at the beginning of the 21st century are studied using different methodologies that allow a better understanding of the relationships between socio-economic, institutional and environmental factors and the expansion of coca cultivation. The innovative methodologies had never been used before in this type of study and make important advances in the understanding of these relationships. In the second chapter we use exploratory spatial data analysis (ESDA), following the methods in Anselin (1994, 1995); Patacchini and Rice (2007). Specifically, we use global and local multivariate spatial correlation analysis to identify local patterns of spatial associations based on the Local Indicator of Spatial Analysis (LISA) approach (Anselin, 1995). The use of this methodology allows us to address the two central themes: (i) a determination of the relationship between illicit crops and the factors generally mentioned in literature and by experts, by assessing the presence and expansion of coca cultivation for illegal use between 2001 and 2008 in Colombia; (ii) determination of the

factors that may be associated with the presence and expansion of coca cultivation between 2001 and 2008 on a local scale and identification of the differences with global analysis.

In the third chapter, we obtain a deeper understanding of the relationships between the expansion of coca crops and several of the factors mentioned in the literature as drivers, incorporating local heterogeneity, an important topic that has been largely overlooked in the literature on illicit crops. The objective of this chapter was to achieve a better understanding of the factors associated with the expansion of coca crops in Colombia between 2001 and 2008, taking into account the various local realities. The paper aims to show that the factors associated with the expansion of the crops have changed geographically over time; they have not been constant over the last decade and so an adjustment of the policies is required to integrate the local realities instead of persevering with the same general policies. In this chapter we use a new methodology: The Geographically Weighted Regression (GWR) models, which are an extension of the Ordinary Least Squares regression model, allowing spatial (local rather than global) parameters to be estimated (Fotheringham, et al., 2002; Fotheringham, Charlton and Brunson, 2001). The OLS models lead to generalized relationships that are not applicable to the whole territory and do not allow for the understanding of local characteristics of certain areas. This becomes an obstacle for the analysis of issues such as the expansion of illicit crops, a topic that requires a better understanding of local realities. GWR follows a local statistics approach, introducing a set of local parameter estimates that show how the relationship varies over space. Subsequently, the spatial patterns of the local variables are assessed to provide an improved understanding of hidden possible causes of patterns (Brunson, Fotheringham, & Charlton, 2002).

After a detailed study of the factors associated with the existence of coca crops in Colombia, in Chapter 4 we evaluate the effectiveness and the social and environmental consequences of aerial fumigation. This is related to the previous chapters in a fundamental way, since part of the ineffectiveness of anti-drug policy has come from an incorrect diagnosis of the factors associated with the expansion of the coca crops, a matter examined in Chapters 2 and 3. In this chapter we make use of new methodologies, such as correlation analysis and fieldwork carried out in an area showing one of the highest levels of growth in coca cultivation during the first decade of the century.

In Chapter 5, we turn our attention to the study of the Afro-Colombian communities of the Colombian Pacific region, whose people were among the most affected by the expansion of coca crops at the beginning of the century. Vélez (2009; 2011) put forth the suggestion that the creation of collective territories in the Pacific region (which started in the 1990s and expanded in the 2000s), considered by Ostrom, (1990; 2005) to be one of the first steps in the establishment of robust, sustainable self-governing bodies, could be a factor in curbing the expansion of coca in these territories, which are of great cultural and environmental importance. In our investigation we show that this is not the case, and that in fact the expansion of coca crops, along with the associated violence and displacement of people, has fragmented the collective territories and impeded their establishment. However, through one case study we show that using another type of anti-drug policy based on encouraging the strengthening of the communities, collective territories can indeed curb the expansion of coca cultivation. In this chapter, as in Chapter 4, our methodologies are correlation analysis and fieldwork in which we conduct interviews in the community and consult experts.

The thesis is built upon four publications and a concluding section that synthesizes and discusses the results of these publications. Chapters 2 and 3 correspond to two publications accepted by the journals *Ecological Indicators* and *Applied Geography* respectively, in which I am the principal author, having been responsible for approximately 90% of the work; the co-authors are Unai Pascual, Suzette Menzel and Milton Romero, who assisted me with technical matters and revision of the paper. Chapter four corresponds to a publication accepted in the journal *Geoforum*, of which I am also the principal author, having been responsible for approximately 80%; the remainder was written by Giorgos Kallis. Chapter five corresponds to a paper submitted to the *Journal of Latin American Studies*, of which I am the sole author.

## **CHAPTER TWO: An exploratory spatial analysis of illegal coca cultivation in Colombia using local indicators of spatial association and socio-ecological variables<sup>1</sup>**

*The cultivation of coca (Erythroxylon coca) by smallholders represents the first step in the world's largest illegal agribusiness: cocaine. The literature on illicit crops generally considers the global and national factors that influence its expansion but little attention is paid to the local conditions where cultivation takes place. This study analyzes the economic, environmental, institutional and social factors associated with the existence of coca crops within municipalities in two different years (2001 and 2008). We do this from a regional perspective, by taking into account the particular factors that characterize the areas associated with coca municipalities and estimating the impacts of coca cultivation on natural ecosystems. For the proposed analysis we use Exploratory Spatial Data Analysis (ESDA) to visualize and describe the local spatial distributions and clusters, implementing the Local Indicators of Spatial Association (LISA) for the year 2001 and 2008. Our results show that no individual factor is exclusively associated with the coca areas; in fact, a group of common factors characterizes these regions. The analysis indicates that the expansion of coca cultivation has produced a process of deforestation mainly affecting humid tropical forested ecosystems.*

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<sup>1</sup> A variant of this chapter has been accepted (Nov 2012) for publication in *Applied Geography*, as: Rincón-Ruiz A., Flantua S., Pascual U., "An exploratory spatial analysis of illegal coca cultivation in Colombia using local indicators of spatial association and socio-ecological variables".

## 2.1 Introduction

Tropical deforestation is a complex social-ecological problem and has been explored from many disciplinary perspectives emphasizing economic, social, institutional and environmental factors (Angelsen, 1999; Deininger and Minten, 2002; Evans et al., 2008; Martinez-Alier et al., 2010; Norgaard, 1994; Scott, 1998; Solomon et al., 2005a; UNODC, 2010a). While most research on tropical deforestation has focused on the agricultural frontier expansion and associated activities such as timber extraction, land conversion to monocultures, little attention has been paid to the deforestation caused by cultivation of illegal crops such as coca for the production of cocaine. This is surprising as the literature has identified this production as a driver of deforestation in tropical regions and particularly in countries like Colombia (Armenteras et al., 2006; Etter et al., 2006; Farrell and Thorne, 2005).

Although coca cultivation is not the main cause of deforestation in Colombia, it is affecting ecosystems through its negative impact on biodiversity especially in forests with suitable environmental conditions for its cultivation (Álvarez, 2007; Dávalos et al., 2009). The displacement of illicit crops to other areas has created a deforestation problem in Colombia as discussed by (Dávalos et al., 2011) using land use coverage maps. There are various underlying factors regarding the location of coca-growing areas in Colombia. Some such factors that have been mentioned in the literature include land tenure insecurity (Fajardo, 2002), the existence of political instability and armed conflicts (Díaz, 2004; Garcés, 2005a; Vargas, 2005), low social and institutional development (Thoumi, 2005a, 2005b, 2005c), high levels of rural poverty (Dion and Russler, 2008), violence and inaccessibility (Álvarez, 2001; Álvarez, 2003; Rincon et al., 2006), forced displacement (CODHES, 2009; Ibañez and Vélez, 2008), income and other economic aspects (Angrist and Kugler, 2008; Ibanez and Carlsson, 2009; Ibañez, 2010; Rocha, 1997, 2000), and environmental aspects (Álvarez, 2003; Dávalos et al., 2011).

Most of the socio-economic and institutional information available for analysis that includes the factors mentioned above is found at the level of the administrative political units in the country: national, departmental and municipal. However, no study has included an in-depth



analysis using disaggregated spatial level data (with data on a municipal level for the whole country) to better understand the regional factors associated with the existence and expansion of coca crops in Colombia. Most statistical analysis are global (do not take into account regional and local particularities and realities), for example Dion and Russler (2008) have attempted to explain the permanence of coca crops in Colombia, providing evidence that poverty has a non-linear effect. However the authors were not able to decipher the local particularities of coca crops areas since their analysis was based on the national and departmental scale rather than a municipal scale. Díaz (2004) used a lower scale (municipal level) but only analyzed the relationship between land use and armed conflict, which although important only offers a partial view of the illegal coca crop growing problem in Colombia.

This paper applies a spatial analysis at the municipality level for the period 2001-2008 with the objectives to: (i) Determine the relationship between illicit crops and the factors generally mentioned in literature and by experts, by assessing the presence and expansion of coca cultivation for illegal use between 2001 and 2008 in Colombia; (ii) Identify the factors that may be associated with the presence and expansion of coca cultivation between 2001 and 2008 at a local scale and to identify the differences with global analysis. To achieve these objectives we carry out an exploratory spatial data analysis – ESDA, using information about social, economic, environmental and institutional factors at the municipal level.

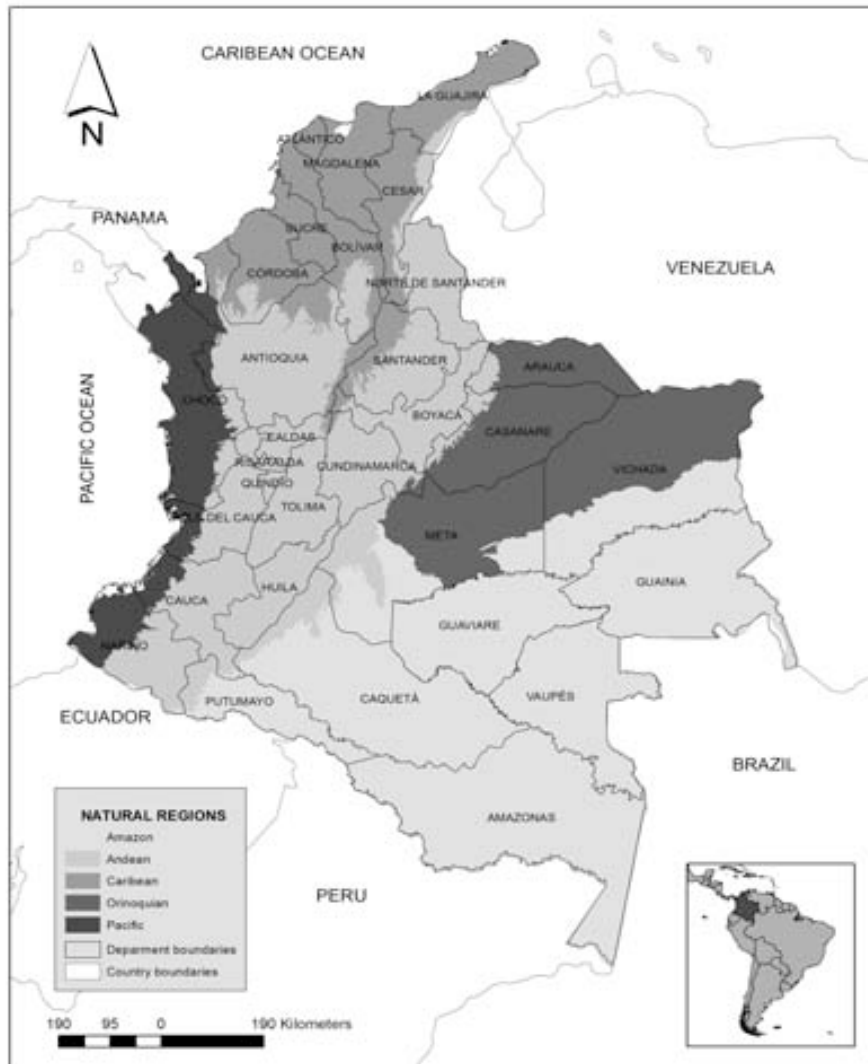
The paper is organized as follows: Section 2 describes the case study area; Section 3 describes the methodological issues relating to data and methods used during the research and Section 4 presents the results obtained, divided into two sections. The first shows a change in the geographical distribution of coca cultivation and estimates the relative proportion of land that was previously forest and woody ecosystems being used for coca cultivation in 2001 and in 2008.

In the second, we analyse the economic, environmental, institutional and social factors associated with the existence of coca crops for two periods of time (2001 and 2008) using ESDA. Section 5 discusses the results and identifies some policy implications regarding the efforts needed to inhibit the expansion of the coca cultivations in Colombia. Finally, Section 6 contains the main conclusions.

## 2.2 Study area

Colombia is located in the northwestern corner of South America and bordered by the Atlantic and Pacific oceans as well as by five other countries (Venezuela, Brazil, Peru, Ecuador and Panama). The climate is tropical hot and humid with two rainy seasons, March to May and September to December. Colombia consists of five continental natural regions, i.e., the Andean (AN), Caribbean (CA), Pacific (PA), Orinoquian (OR) and Amazon (AM) regions. These regions are divided into 32 departments and 1101 municipalities (Map 1). In accordance with our estimations, based on the coca censuses (UNODC, 2006, 2008a, 2008b, 2009, 2009b), 23 departments and 274 municipalities have had a presence of coca for at least one year during the period 2001-2008

Colombia produces more than 50% of coca for cocaine production worldwide, and has an average planting density of 110,000 plants per hectare (UNODC, 2006, 2008b, 2009b). The region with the highest coca yield is the Amazon region, principally in the Meta and Guaviare departments averaging 9,900 kg per ha per year. In 2001 the Amazon region concentrated most of the coca production. The lowest coca yield occurs is the Pacific region (2600 kg per ha per year), but despite its low yield a large part of the coca cultivation has been displaced to the Pacific region in recent years, partly due to the government's eradication policies in the Amazon region (UNODC, 2006, 2008b, 2009b).



Map 1. Continental Natural Regions of Colombia and Departments.

## 2.3 Data and methods

### 2.3.1 Data for the identification of factors associated with coca cultivation

The identification of possible factors associated with coca crops areas (CCAs) included in the analysis was carried out in three ways, (i) a review of the literature, (ii) expert judgement regarding social, economic, environmental and institutional issues related to illicit crops in

Colombia, mainly by researchers and staff from the Colombian Integrated Illicit Crops Monitoring System (SIMCI – acronym in Spanish), the Colombian National Office of Narcotics (DNE – acronym in Spanish), the Ministry of Defense, and various NGOs including: the Transnational Institute (TNI), the Arcoiris Foundation and Acción Andina, as well as researchers from Colombian Universities and (iii) fieldwork in two municipalities, Rosario and Leiva (located in Nariño which have experienced the biggest increase in coca cultivation during the 2001-08). Interviews with public institutions (Health secretary, local government and national policy), and civil society (local population and indigenous communities such as Awá community<sup>2</sup>) were also carried out. These mixed sources of information were instrumental to create a diagnosis of the regional factors associated with coca crops in Colombia. Such diagnosis identified five key factors: (1) poverty, (2) weakness and low presence of the state, (3) violence and armed conflict, (4) inaccessibility and (5) favourable biophysical conditions.

After identifying the possible factors behind the cultivation of coca, spatial and alphanumeric information was collected taking into account two key criteria: (1) available information at the municipal level for the whole country; (2) that the information collected was from an official source. To organize the data, information was classified by social, economic, institutional and environmental factors. Table 1 shows a set of selected variables with information at the municipal level covering the whole country. Some of the key variables identified could not be included because no information was available at municipal level for the whole country as was the case for the following variables: income distribution, land tenure, social capital and state weakness. The number of violent actions and assassinations by illegal armed groups was used as proxy of the weakness of the state. The spatial and alphanumeric information on coca crops was obtained from the Integrated System of Monitoring of Illicit crops of the United Nations on Drugs and Crime (SIMCI acronym in Spanish). We selected the percentage of coca area per municipality as variable “X”, and the

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<sup>2</sup> The Awá Community is an indigenous community that inhabits the southwest of Colombia, in the Departments of Nariño and Putumayo (also found in Ecuador):

rest of the variables as “Y” to analyze their spatial association (in our research the names “X” and “Y” doesn’t imply causality).

The best information available for important spatial and alphanumeric variables on coca crops at the municipality level in Colombia was identified for the years 2001 and 2008. In cases when complete information was not available for a specific year, the existing information from the closest year was used. Additionally, in cases where data were available for one year only, this information was used as a reference for both years. Here we introduce an assumption: Although the variables change with time, we have assumed that these variables maintain their spatial distribution between municipalities in the periods of analysis. We recognize that this may introduce inaccuracies in our analysis and for this reason we have made an appropriate declaration regarding its limitations in the Discussion section.

Table 1 indicates the year for which information can be accessed regarding each of the variables used in the analysis.

*Table 1.* Selected variables at the municipal level.

Tipo de variable	Sigla	Category	Variable name	Year	Source of data	Unit	Additional explanation
Var X	PCA	Analysis variable	Percentage of the municipal territory in coca area	2001 - 2008	Coca maps (shape) - Integrated Illicit Crops Monitoring System (SIMCI: Spanish acronym for "Sistema Integrado de Cultivos Ilícitos")	Percentage	Percentage of hectares of cultivated coca in comparison to the total area of the municipality. Scale 1:10.000
	GDPC	Economic	Growth Domestic Product per capita	2002 - 2007	National Administrative Department of Statistics - DANE, estimation by the authors	Billions	Annual gross domestic product per person
Var Y	PRD	Economic	Primary roads density	2005	Road map (shape) - Geographic Institute Agustín Codazzi - Estimation by the authors	Mts/roads/ ha	Meters of primary roads per hectare. Scale: 1:500.000
	FDP	Social	Forced displacement of population rate - expulsion	2001 - 2008	Presidency of the Republic of Colombia - Presidential Agency for Social Action and International Cooperation	Number of displaced people per 1000 inhabitants	Number of forced displaced people by violence and conflict. This information is taken from the National System of Integral attention of Displaced People ("Sistema Nacional de Atención Integral a la Población Desplazada")
	RUBN	Social	Rural Unsatisfied Basic Needs Index	2005	National Administrative Department of Statistics - (DANE Spanish acronym for "Departamento Administrativo Nacional de Estadística")	Index from 0 to 100 (From "no basic need satisfied" to completely satisfied, respectively)	The index is determined through 5 indicators to define if the basic needs of the rural population are covered. The selected indicators are: Inadequate housing, Housing with critical overcrowding, housing with inadequate services, housing with high economic dependence, housing with children at school-age but that are not attending school.
	RDP	Social	Rural density population	2005	National Administrative Department of Statistics - (DANE Spanish acronym for "Departamento Administrativo Nacional de Estadística")	Number of persones	Number of persons living in the rural zones of each municipality
	IMD	Institutional	Index of municipal development" (2001 - 2008)	2001 - 2008	National Planning Department of Colombia (DNP - Spanish acronym for "Departamento Nacional de Planeación") - Dirección de Desarrollo Territorial Sostenible DDTs	Index from 0 to 100 (where 0 means low municipal development)	Synthetically measuring the performance of municipalities in social and financial variables. The variables taken are: % of population in header, % of households with water supply, % of households with sewage, % households with energy services, % of people without NBI 2005 per head, % of people without NBI 2005 (rest), % alphabets, % school attendance, tax revenues per capita (current \$), municipal public investment per capita (current \$), % of non-reliance on transfers
	VAIA	Institutional	Number of violent action by illegal armed groups (used as proxy to presence of illegal armed groups)	2001 - 2007	Data Base - Andes University and defense ministry of Colombia	Number of violent action	Number of violent action by illegal armed groups (FARC, AUC, ELN) por municipio. Incluye actos terroristas, asaltos, atentados, Bloques de vías, Emboscadas, hostigamientos, ataques a población
	MR	Institutional	Murder Rate by illegal armed groups (used as proxy to presence of illegal armed groups)	2001 - 2008	Colombian National Police - Estimation by the Authors	Number of homicides per 100.000 inhabitants	Number of homicides per 100,000 inhabitants committed by illegal armed groups (FARC, AUC, ELN). Homicides committed by common crime are not taken into account.
PPF	Environmental	Percentage of the municipal territory in primary forest area (2000)	2000	Colombia Ecosystem map (shape) - Institute of Hydrology, Meteorology and Environmental Studies of Colombia (IDEAM - Spanish acronym for "Instituto de Hidrología, Meteorología y Estudios Ambientales de Colombia") - Estimation by the authors	Percentage	Percentage of hectares of primary forest in comparison to the total area of the municipality. Scale 1:500.000	

### **2.3.2 Coca crops in forest and woody ecosystems**

The analysis of coca crops in forest and woody ecosystems was performed based on information from the ecosystem map for the year 2000 at scale 1:500,000 obtained from manual interpretation of Landsat satellite data (IDEAM et al., 2007). The ecosystem map was overlaid with the coca census data (provided by the SIMCI for this study) for two years, 2001 and 2008, in order to be able to calculate the percentage of coca cultivation in 2001 and 2008 in what had previously been forest and woody ecosystems. These estimations were made from the natural cover in terms of forest, and other woody formations that existed in 2000 (IDEAM et al., 2007). These forests and formations were grouped into 16 different ecosystems types according to the climate and geological position in the landscape.

### **2.3.3 Exploratory spatial analysis of coca cultivation**

Two types of exploratory spatial data analysis (ESDA) were carried out to shed light on the key factors associated with coca cultivation in Colombia following the methods in (Anselin, 1994, 1995; Patacchini and Rice, 2007).

First a global multivariate spatial correlation analysis was applied to calculate a single measure of spatial correlation at the municipal level for Colombia, between the share of land area under coca cultivation and the selected economic, social, institutional and environmental variables. The estimation is based on the multivariate Moran's I coefficient (Anselin et al., 2002), and is referred to as the “global analysis” as it is based on a country-wide analysis without taking into account regional characteristics. This method shows how the analyzed factors are associated to the expansion of illicit crops at the aggregated level.

The second ESDA approach involves a local multivariate spatial correlation analysis to identify local patterns of spatial associations based on the Local Indicator of Spatial Analysis - LISA approach (Anselin, 1995). This approach is used to decompose the Moran's I coefficients by identifying the contribution of each observation at the local level. We used a LISA extension for the multivariate case developed by (Anselin et al., 2002). The multivariate LISA offers an indication of the degree of association between the share of coca area in each municipality and the variables of interest in neighbouring municipalities (Anselin, 1995; Anselin et al., 1996; Anselin et al., 2002).

Both global and local multivariate spatial analyses required constructing a ‘weight matrix’ (Anselin, 2005; Anselin et al., 2007; Anselin et al., 2006), to define a local neighbourhood value around each municipality as a geographical unit. The weight matrix by contiguity was chosen as the best option due to the heterogeneity of the polygons and the wide range of neighbourhoods per municipality.<sup>3</sup>

Both multivariate global and local spatial correlation analyses follows Moran’s I statistic visualized in the four quadrants of the generalized Moran scatter plot (Anselin, 1993; Anselin et al., 2002). This plot represents the analysed variables in a standard form in which the slope of the regression line represents the global Moran’s I statistic. In the present analysis it indicates the spatial association at the global (i.e., national) level. The scatter plot also reflects four types of local spatial correlations between municipalities and their neighbouring areas: the right upper quadrant contains municipalities with high values in the X variable (i.e., percentage of the municipal territory in coca area - PCA) surrounded by municipalities with high values in the chosen Y variable (any of the other key variables selected); we refer to these municipalities having an H-H (High-High) association. The lower quadrant consists of high values of the X variable associated with low or zero values for the Y variable, i.e., High – Low (H-L) association. Low-Low (L-L, lower left) consists of municipalities with low or zero values for the X variable surrounded by municipalities with low or zero values for the Y variable. Finally, the Low-High (L-H, upper left) quadrant contains low or zero values for the X variable with high neighbour values for the Y variable.

A LISA cluster map (Anselin, 1995; Anselin et al., 2006a; Anselin et al., 2002) is used to show the location of observations with significant local Moran statistics, highlighting significant spatial clusters and outliers, as well as showing the centres of the clusters. Hence, the spatial range of the clusters should be seen in the broader context of the region, that is: including the neighbouring regions which are not highlighted in the map. We represent the municipalities associated with H-H, H-L, L-H and L-L values in the LISA cluster map. The statistical significance level of the various correlation coefficients was estimated using 10,000 permutations (Anselin, 2005; Anselin et al., 2002).

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<sup>3</sup> There are three kinds of weight matrices: contiguity (queen, rook), distance, and k-nearest neighbour.

## 2.4 Results

### 2.4.1 Forest, woody ecosystems and coca crops (2001-08)

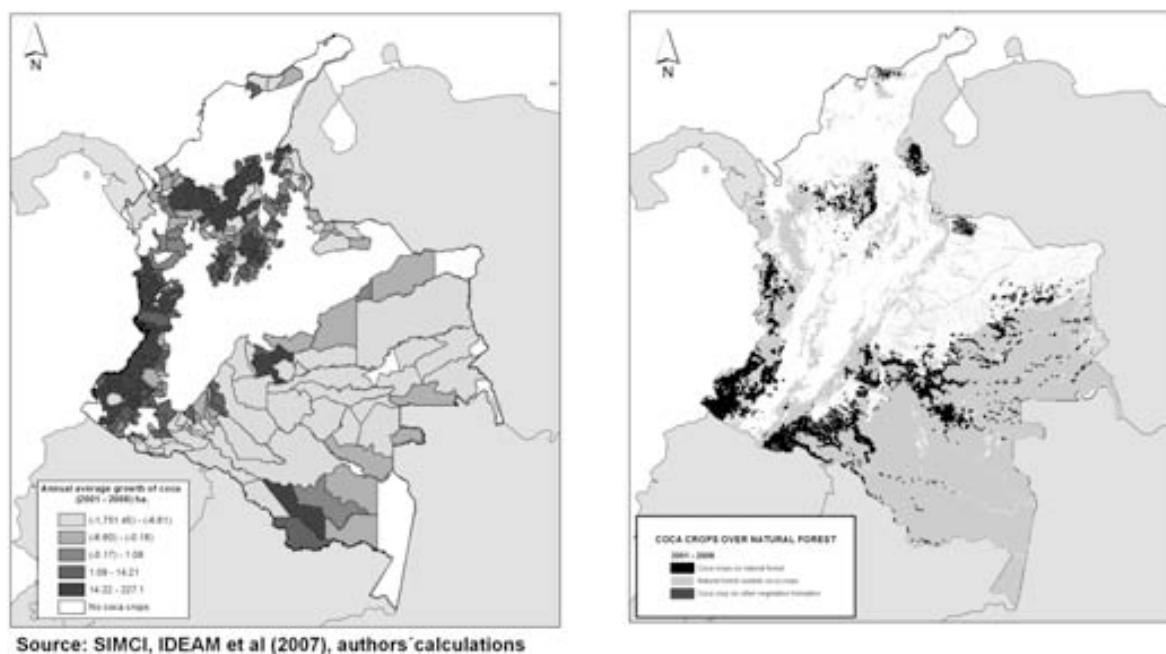
The results show a marked change in the geographical distribution of coca cultivation from 2001 to 2008. Specifically, coca cultivation decreased in the region of the Amazon and the Orinoquia and it increased in the Pacific, Caribbean and the north of the Andean Region (map 2). In addition, during the study period (2001-2008) the expansion of illicit crops in Colombia occurs towards humid tropical forest land (Table 2). Based on the natural cover and ecosystems in the year 2000, it was found that in 2001 the most affected ecosystems by the expansion of coca cultivation were the humid tropical forests specially those in the departments of Orinoco and Amazon. A total of 67,700 ha (40%) of the coca area in 2001 were located in the humid tropical forest and decreased near to 20,500 ha (33%) for 2008. In addition, during the 2000s, coca cultivation expanded to other regions mainly the humid tropical forests of the Pacific. For example the data show that while in 2001, 1,900 ha (2%) of all the coca area was located in the humid tropical forest of the Pacific region, it increased to 8,100 ha (11%) in 2008. Similarly while in 2001, up to 3,400 ha (2%) of the total coca area was located in the humid tropical forests located in the foothills of the Amazon and the Pacific regions, it increased to 5,200 ha (7%) by 2008.

This has caused several important and in many ways irreversible impacts on forested and woody ecosystems, including those that had not been associated with the coca, such as the ecosystems of the Pacific region (see Map 2). We estimate that 58% of the total area cleared for coca cultivation in 2008 (44,600 ha) had been covered by natural forest in 2000.

*Table 2.* Relative proportions of coca crops in 2001 and 2008 in different ecosystems.

Natural Cover	Area (Ha)	
	2001	2008
Tropical humid forest of the Orinoco and Amazon	67.600	20.555
Tropical rainforest in the Pacific	1.982	8.166
Foothills of the Amazon and Pacific	3.442	5.155
Forest in Catatumbo, Caribiam and Andes regions	17.181	9.043





Map 2. Annual average growth of coca and coca crops over natural forest (2001 -2008).

## 2.4.2 Factors associated with coca cultivation (2001-08)

The existence of coca crops in certain regions in Colombia is not only due to favourable environmental conditions for its cultivation but it also depends on some key social, economic and institutional factors. Here we spell out the results of the local and global spatial multivariate analysis where these factors are spatially analyzed at the local scale.

### 2.4.2.1 Multivariate global spatial analysis

A significant global spatial association was identified for the two years (2001 and 2008) between the percentage area under coca cultivation at the municipality level and each one of the variables selected in the analysis (see Table 3). An inverse relationship was found between coca area and the following variables: Rural Population Density (RPD), Growth Domestic Product per Capita (GDPC), Primary Road Density (PRD) and the Index of Municipal Development (IMD). By contrast a positive relationship was found between coca area and the Rural Unsatisfied Basic Needs index (RUBN), Murder Rate by Illegal armed groups (MR), Forced Displacement of Population (FDP), Violent Acts committed by Illegal Armed groups (VAIA) and Percentage of Primary Forest area (PPF).

Table 3. Multivariate Global Spatial Analysis (significant associations with Percentage of coca area 2001 and 2008).

Category	Variable	association coefficient	
		2001*	2008*
Social	Rural Unsatisfied Basic Needs Index (RUBN)	0.035	0.179
Social	Rural Density population (RDP)	-0.008	-0.018
Social	Forced displacement of population rate - expulsion (FDP)	0.125	0.206
Economic	Growth Domestic Product per capita (GDPC)	-0.044	-0.073
Economic	Primary Road Density (PDR)	-0.086	-0.238
Institutional	Index of Municipal development (IMD)	- 0.099	- 0.253
Institutional	Murder Rate by Illegal armed groups (MR) (Proxy for illegal groups presence)	0.017	0.147
Institutional	Number of Violent action (VAIA) (Proxy for illegal groups presence)	0.170	0.180
Environmental	Percentage of primary forest (PPF)	0.125	0.276

\* Significant association (5%)

#### 2.4.2.2 Multivariate local Spatial Analysis:

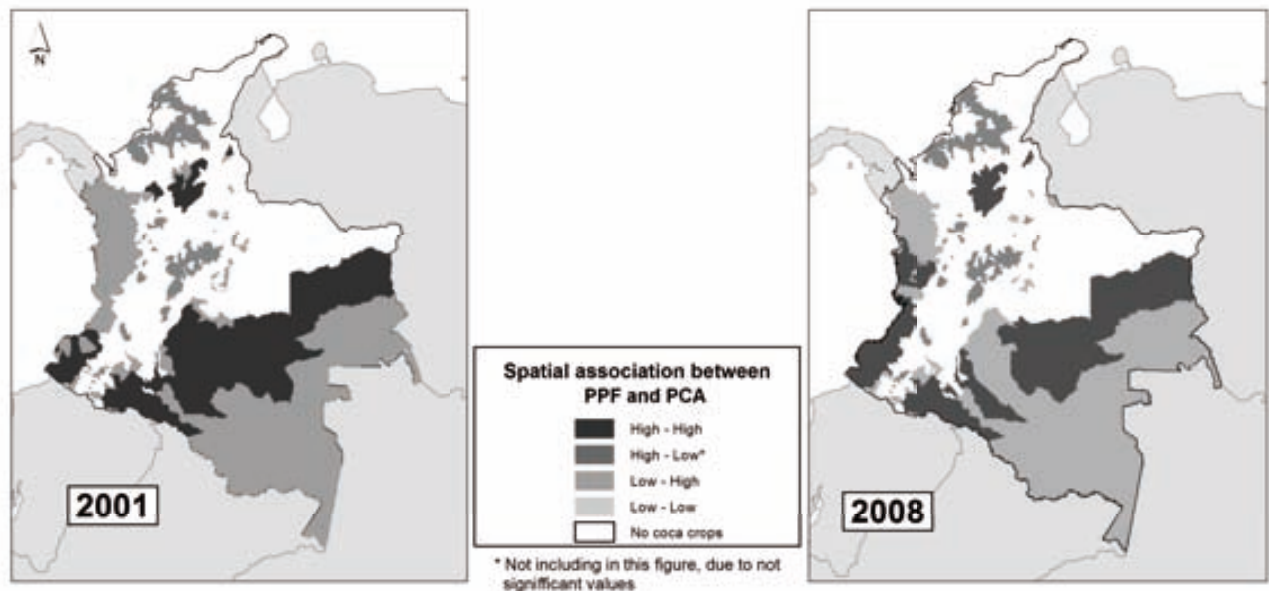
Four key results were obtained based on the multivariate local spatial analysis. First, in 2001 the municipalities where coca was being cultivated had a significant spatial correlation with the variables analyzed in the global analysis, obtaining similar results in signs and significance of the correlations, except for GDPC which was not significant at the local level. Second, none of the analyzed variables was exclusively associated with the CCAs, that is, significant associations were also identified in regions where coca crops were absent. Third, between 2001 and 2008 a displacement of coca growing areas towards the Pacific, the Caribbean and northern area of the Andean region was found. In the new CCAs a similar significant spatial correlation was found regarding the variables analysed in 2001. Between 2001 and 2008 the coca crops were displaced to areas with similar social, economic, institutional and environmental characteristics. Fourth, although there were no individual factors exclusively associated with CCAs, a distinct set of common factors between them could be identified, including low levels of municipal development, low road density, high proportion of primary forest area, high level of forced displacement, significant presence of illegal armed groups and a high 'rural unsatisfied basic needs index' (RUBN).

The results of the LISA analyses are presented below with accompanying maps. Although we generated LISA maps for all the variables, we have only included those which are significant

in most of the municipalities, as we did not wish to overload the document with maps. We found that the variables that showed significance in most of the territory were RUBN, IMD and PPF. The variable FDP, despite its high significance in the global correlations, was not very representative in the territory in the LISA analyses carried out in the year 2001.

### Environmental factors

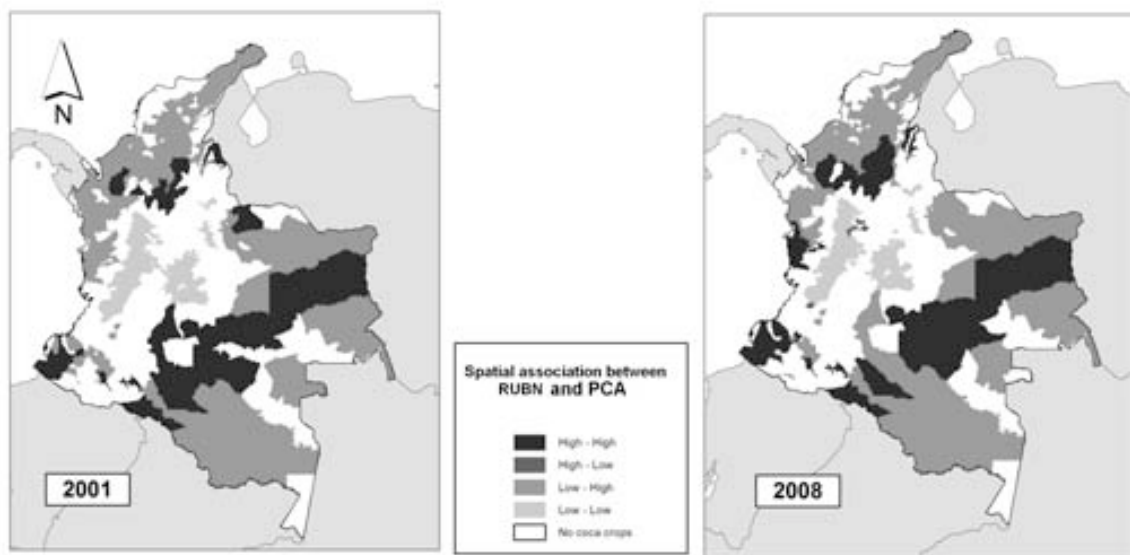
While a positive association between CCAs and areas with a large PPF (H-H clusters) was found for 2001, areas with a high PPF were also associated with municipalities that had a low presence of coca crops (L-H cluster). However, in 2008, an expansion of the H-H cluster was found towards the Pacific and the Caribbean regions, implying that coca crops were displaced to areas with a relatively high PPF.



Map 3. LISA map for PPF (2001 – 200) and PCA (2001 - 2008) by municipality (significant clusters Social Factors)

In 2001 the coca growing municipalities were associated with high levels of RUBN (H-H cluster). This cluster was mainly found in the Amazon and Orinoquia regions, where the coca crops were mainly concentrated (map 4). Nevertheless a L-H cluster could also be identified, which indicates municipalities with low or null coca levels associated with zones of high RUBN (i.e., the Pacific and the Caribbean regions). By 2008 an expansion of the H-H cluster could be seen in the Pacific, Caribbean and northern areas of the Andean region, while a

decrease of the H-H cluster was observed in the Amazon region. In the Andean region, a L-L cluster could also be identified. In 2008, the variable FDP showed similar behavior to the RUBN variable. However, for the year 2001 there was a difference: H-H clusters were only found in some municipalities in Amazonas.



Map 4. LISA map for RUBN (2005) and PCA (2001-2008) by municipality (significant clusters at 0.05 sig. level).

Additionally, in 2001 there was a significant spatial association between coca growing municipalities and a low RPD (H-L cluster). But clusters showing statistically significant spatial relationship between areas without coca (or with low coca levels) and low RPD (L-L cluster) in other regions could also be found. In the year 2008 an expansion of the CCAs associated significantly with low RPD (H-L clusters) was found towards the Pacific and the north of the Andean region.

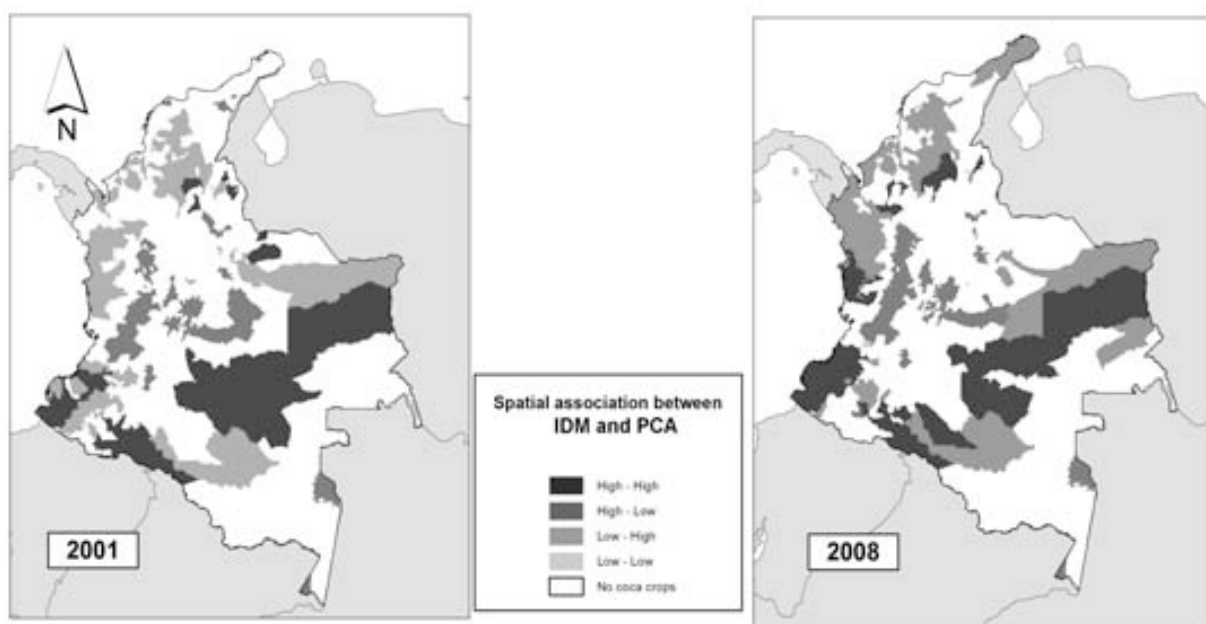
### **Economic factors**

Compared to the global multivariate analysis (Table 3), different results were found at the local level regarding the local association between levels of GDPC and coca cultivation. While there was an inverse significant association at the global level in 2001 and 2008, there

was no statistically significant association between them at the local level. In addition, PRD, (which is a factor that facilitates market development), shows a significant negative spatial association with the relatively more intense coca municipalities (H-L cluster), implying that CCAs that are isolated by road transport have a higher presence of coca cultivation. The H-L cluster in the traditional coca regions in 2001 and the expansion of the H-L cluster in 2008 towards the Pacific, Caribbean and the northern region of the Andes confirms this finding.

### **Institutional factors**

Using the index of municipal development (IMD), the local spatial association analysis showed the presence of an H-L cluster in the CCAs (map 5), implying that coca growing municipalities were associated with municipalities which had relatively low levels of IMD in 2001. However, areas with low levels of IMD could also be found to be associated with municipalities with low or absence of coca area. In 2008 the H-L clusters shifted towards the Pacific and Caribbean regions from the Amazon region. Additionally, variables linked with violent acts and assassinations by illegal armed groups (VAIA and MR, respectively), both resulting from institutional weakness of the state, showed the following results. In 2001, H-H clusters were identified in the CCAs (municipalities with high percentage levels of coca area associated with zones with high levels of VAIA and MR). However, L-H clusters were also found, indicating that in areas with a low to null presence of coca, illegal armed groups were also present. Similar results were obtained between 2001 and 2008, in relation to the significant variables. The only difference was that the significant H-H clusters had been displaced to the southwest and the north of the country.



Map 5. LISA map for IMD (2001 – 2008) and PCA (2001 - 2008) by municipality (significant clusters at 0.05 sig. level)

## 2.4 Discussion

One of the most important points for discussion is the limitations caused by using a single year for some variables in the LISA analysis for both periods of study. In this paper, we have been interested in identifying the factors associated with the existence of illicit crops for two years, corresponding to the beginning (2001) and the end (2008) of the first decade of this century. However, for four of the variables considered fundamental to the analysis, information for both these years could not be found; only one datum was available in each case. With regard to the variables RPD and RUBN, based on the data from previous years we found that although there had been temporal changes, the spatial distribution was broadly maintained, meaning that using the year 2005 to analyze the associations with PCA for the years 2001 and 2008, despite the inaccuracy that this may have introduced in the correlations, was reasonable given the assumption that the spatial distribution was constant during the study period. In the case of the variable PRD, according to dialogue with experts on road development in Colombia, there have not been big changes to the proportions of roads

between municipalities; we have therefore made the assumption that although the PRD has indeed changed, the distribution between municipalities has stayed constant. With respect to PPF, given that Colombia has only produced one ecosystem map (in the year 2000) and that we consider it fundamental to our analysis to include one variable of this type, we decided to use it despite the inaccuracies that would be introduced, applying the same assumption with respect to the spatial distribution as we introduced above. In conclusion, we are using an underlying assumption: Although we accept that there will have been temporal changes in these variables, their distribution would have been maintained constant throughout the country. Nevertheless, we recognize that our analysis may be inaccurate, but invite anyone to undertake further study regarding the validity of our assumption. For the moment, we believe that the analytical value gained by including the variables outweighs any inaccuracies that could be introduced in the results by doing so.

Considering the more general results found in the analysis we concur with (Thoumi, 2005a, 2005b, 2005c) that particular variables such as the economic profitability generated by the illegality and the high global demand for cocaine cannot in its own explain why coca cultivation and cocaine production is concentrated in countries like Colombia. In fact, the analysis shows that there is no single regional factor associated exclusively with the presence of coca in certain areas in Colombia. For example, factors such as armed violence and conflict and the high levels of unsatisfied basic need in rural areas and the prevalence of poverty often cited as variables associated with the expansion of the cultivation of coca (Angrist and Kugler, 2008; Departamento Nacional de Planeación (DNP), 2003; Dion and Russler, 2008) are not exclusively associated to the coca growing areas in Colombia. This finding also concurs with the view that illegal groups have existed and developed in Colombia independently from coca cultivation (Díaz, 2004; Klein, 2007) and with the view that illicit crops do not seem to be linked directly to the initiation of armed conflicts and hence the presence of illegal armed groups, even if they seem to elongate pre-existing armed conflicts (Ross, 2004).

Regarding the comparison between coca cultivation in 2001 and 2008 and their location in what had been forest or woody ecosystems in 2000, our results might represent an overestimation because part of the natural forest in 2000 may have been transformed first to agriculture or another type of land use and only after that been used for coca cultivation, rather than having been a direct result of transformation of natural forest to coca crops.

Nevertheless, the results clearly show the increase in coca cultivation in areas of humid tropical forest, which is of great environmental importance.

When more specific results are taken into account we would like to point out that forest cover in isolated areas provides suitable conditions for concealing coca cultivation. But while the literature tends to find a positive relationship between road density and deforestation (Ali et al., 2005; Perez-Verdin et al., 2009; Vance and Geoghegan, 2002), in the case of CCAs, a low road density, in turn associated with low accessibility, is linked to the maintenance of coca cultivation. This implies that coca cultivation can remain in the area and refrain from expanding to other forested areas. Nevertheless, once land under coca cultivation expands, it is a major driver of deforestation due to the establishment of roads and tracks (Rincon et al., 2006)

While the global spatial analysis indicates an inverse correlation between GDPC and CCAs, the association is not statistically significant when the analysis is carried out at the local level. In the latter case, coca crops can be found in both high and low GDPC areas, which is explained by the fact that some coca municipalities are also important in terms of extractive natural resources such as gold mining, oil and palm oil plantations. In future research it is necessary to analyze the relationship between coca municipalities and the distribution of wealth, as currently no data are available at the municipal level.

It is often suggested in the policy arena that in order to solve the expansion of illicit coca in Colombia, CCAs need to be transformed into economically productive zones based on legal commodity productive activities, such as palm oil plantations (Departamento Nacional de Planeación (DNP), 2007; FEDEPALMA, 2006, 2007). We posit, based on the data analysed, that this is an over-simplification of the problem because the expansion of coca crops is not exclusively associated with poverty and low levels of GDPC. If CCAs continue to exhibit characteristics such as low state presence and low levels of municipal development, it is most probable that even with crops as palm oil, deforestation and the social conflicts associated with it will remain (Aristizabal, 2009; Goebertus, 2008). New productive projects such as oil palm and other crops might replace illicit crops, though it is more likely that coca will be displaced to other municipalities that share the right conditions, as identified in the analysis.



We would like to stress as well that some of the current mitigation policies such as aerial aspersion of illicit crops might just create a temporary effect (Walsh et al., 2008a), since favourable characteristics for coca expansion would still be present in other regions of Colombia.

## **2.5 Conclusion**

Based an exploratory spatial data analysis (ESDA), we have identified correlation patterns of coca growing regions associated with a diverse set of characteristics (social, economic and environmental) between 2001 and 2008. The analysis has also proved useful in showing that illicit crops in Colombia between 2001 and 2008 were principally located in areas that in 2000 consisted of forest and woody ecosystems, this mainly affecting the humid tropical forests of the Pacific region. This has caused several important and in many ways irreversible impacts on forest ecosystems. We estimate that 58% of the total area cleared for coca cultivation in 2008 (44,600 ha) was previously natural forests in 2000.

The analysis has allowed to find a significant global spatial association in the two years of analysis (2001 and 2008) between the percentage area under coca cultivation at the municipality level and each one of the chosen variables depicting the environmental, social and economic context Colombia. When the analysis focuses at a local level the results appear in a new light and various key messages need to be flagged: First, none of those variables can be considered to be exclusively associated with the coca growing areas since significant associations were also identified in regions without coca., Second, although there are no individual regional factors exclusively associated with the coca growing areas, there is a set of common factors that are characteristics of these areas, including low levels of municipal development, low road density, high presence of primary forest, high presence of forced displacement, the presence of illegal armed groups and a a high prevalence of unsatisfied basic needs. Third, a spatial displacement of the coca crops towards the Pacific, the Caribbean and northern area of the Andean region are observed between 2001 and 2008. In the new coca growing areas a similar set of significant spatial correlation were found regarding the variables analyzed in 2001. This implies that between 2001 and 2008 the coca crops were displaced to areas with similar social, economic, institutional and environmental characteristics.

The analysis shows that coca growing areas in Colombia have particular regional characteristics that create favourable conditions for loss of forest and woody ecosystem. Despite CCAs being mostly those areas that maintain a large share of primary forests and having favourable environmental conditions for coca production, these areas remain not only physically isolated (low road density), but also socially deprived as reflected by their high index of unsatisfied basic needs index, as well institutionally impaired as reflected by their low indices of municipal development. These characteristics together create a favourable context for the existence of illegal armed groups to enforce control over the territory and its population through violence and forced displacement. Under these circumstances the forests and the local population become easily exploitable for illegal activities. Through violence, a new structure of rules are created in these regions, in which the forest is considered as an easily and freely utilizable resource. This in combination with the rural population remaining in deprived social conditions create the favourable scenery for deforestation by coca crops for illegal use.

If the root causes for the existence of such deprived social, institutional and economic factors are not tackled in a structured way large areas in Colombia will continue to provide the necessary conditions for the continuation of illegal activities such as coca cultivation for cocaine production as well as other illegal extractive activities such as mining (coltan, gold) or palm cultivation. Whether such illegal ventures will flourish or perish in Colombia is thus a matter of reframing past development paradigms and embracing sustainable development (Ballvé, 2009).

### **CHAPTER THREE: Examining spatially varying relationships between coca crops and associated factors in Colombia using geographically weighted regression<sup>4</sup>**

*This article addresses the expansion of illicit crops (coca) and the associated socio-institutional and geographical drivers in Colombia between 2001 and 2008. The analysis is based on a Geographically Weighted Regression (GWR) model and shows that the relationships between the analyzed variables and the coca crops are not constant over space. Similarly, it is demonstrated that the factors commonly associated with the expansion of coca crops are not constant with respect to time, as changes can be seen between the years of the study (2001 and 2008). The article finds that the models that include the local reality offer the best way of understanding the factors associated with the expansion of illicit coca crops in Colombia, a fundamental step in the formulation of effective policies in the reduction of crops for illicit use.*

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<sup>4</sup> A variant of this chapter has been accepted with minor changes for publication in Ecological Indicators, as: Rincón-Ruiz A., Pascual U., Romero M., “Examining spatially varying relationships between coca crops and associated factors in Colombia using geographically weighted regression”.

### 3.1 Introduction

The economic benefits generated by the illegal trafficking of natural resources create an incentive for illegal armed groups to take advantage of the adverse social, economic and institutional conditions that exist in some countries such as the Republic of Congo (coltan), Sierra Leone (diamonds) and Colombia (coca to produce cocaine). Most instances involving natural resources and violent conflicts are found in developing countries and particularly in areas with vulnerable populations, typically with a combination of illegal armed groups and weak government presence (Le Billon, 2001).

Coca is a traditional crop in many Andean countries (Matteucci and J., 2003; Timothy, 1981). However, since the 1970s, the production of coca has been increasingly focused on the manufacture of cocaine because of increased demand, principally from the United States and Europe (Guridi, 2002). In the last few decades, Colombia, Peru and Bolivia have been responsible for the bulk of coca leaf production. Peru was the principal producer of the coca leaf until 1997, when Colombia became the world's number one producer (UNODC, 2008).

In the literature, various factors have been identified as being linked to illicit crops, including the forced displacement of populations and violence (Díaz, 2004; Garcés, 2005b; Vargas, 2005), poverty (Dion and Russler, 2008), corruption (Molano, 2004), land tenure (Fajardo, 2002, 2004), an abundance of land and inaccessible forests (Álvarez, 2003; Dávalos et al., 2009; Dávalos et al., 2011), an absence of the state (Kalmanovitz and López, 2005; Molano, 2004; UNDP, 2003) and the institutional weaknesses of Colombian society (Thoumi, 2005b, 2005c; Thoumi, 2005). Illegal armed groups take advantage of the absence of the state, creating their own rules (Rangel, 2000). Although it has been argued that violence and armed conflict in Colombia are factors that aid in the conservation of forests (Dávalos, 2001) and that isolation from traditional markets, low road density and therefore low accessibility have facilitated environmental protection (Ali et al., 2005; Chomitz and Gray, 1996; Rincon et al., 2006), these assumptions have changed with the expansion of drug trafficking. Inaccessibility and violence are no longer obstacles, but rather combine to facilitate the degradation of forests due to the illegal use of coca crops for cocaine production (Díaz, 2004; Jaramillo et al., 1989; Posada, 2009; Sánchez, 2003; Sánchez, 2007).

This study examined the relationships between the expansion of illicit crops and several of the factors mentioned as drivers of this behavior in the literature. The study emphasizes the importance of local heterogeneity—a topic that has been largely overlooked in the literature on illicit crops. Specifically, answers are sought to the following questions:

Can models that incorporate local realities enable an improved understanding of the factors associated with the expansion of coca crops in Colombia?

Is it possible to make generalizations regarding the factors associated with the expansion of coca crops that are applicable to the entire country?

Are the types of relationships between illicit crops and the associated factors the same on the global and local levels? Are the relationships constant with respect to space (i.e., stationary)?

Are the factors commonly associated with the expansion of illicit crops constant over time?

The aim of the examination of the issues above is to achieve an improved understanding of the factors associated with the expansion of illicit crops in Colombia between 2001 and 2008 by taking the local reality into account. The paper aims to show that the factors associated with the expansion of illicit coca crops have changed geographically during the last decade and therefore demand new policies that integrate local realities rather than more general ones.

### **Modeling the related factors to coca crops**

Previous studies (Dávalos et al., 2011; Dion and Russler, 2008) aimed to define the relationship between coca crops and social, institutional and biophysical factors using global regression analysis. In this study, a “global” analysis refers to an analysis on a national scale without accounting for regional characteristics. Previous studies presented the results as average values, assuming that the relationship does not change over space or time. However, this assumption is not necessarily true. Models testing the influences of related factors on coca crops reveal relationships on a global scale between coca crops and factors such as violence, poverty, accessibility (distance to rivers and roads), aerial fumigation and deforestation (Dávalos et al., 2011; Díaz, 2004; Dion and Russler, 2008; Moreno-Sanchez et al., 2003). Dávalos, et al. (2011) applied logistic regression models to determine how coca

crops increase the risk of deforestation and how so-called protected areas minimize this risk. However, as that study was detailed in its scope, socioeconomic and institutional information, which are typically used at a more aggregated scale, were not included. Moreover, those authors do not consider the spatial or temporal variation in the variables.

A study on Columbia was conducted by (Dion and Russler, 2008) to explain the persistence of coca crops in Colombia over the last decade, but their analysis focused on global models and assumed that there would be no changes in the global parameters. (Díaz, 2004) better determined the spatial relationship and enhanced understanding of the different processes at both local and municipal scales, although their primary focus was the relationship between coca crops and armed conflict.

Interestingly, thus far, no modeling or correlation analysis of coca crops has considered the possible non-stationarity of the analyzed variables, nor has such an analysis included indicators that compare the significance of accessibility, violence and institutional factors (a weak or absent state) over more than a single time period. The Geographically Weighted Regression - GWR (Fotheringham et al., 2002) was recently developed to explore spatially varying relationships and has been employed in different areas such as studies of reforestation (Clement et al., 2009), environmental justice (Gilbert and Chakraborty, 2011), freshwater acidification (Harris et al., 2010), land use and water quality (Tu and Xia, 2008), wealth and land cover (Ogneva-Himmelberger et al., 2009) and deforestation (Pineda Jaimes et al., 2010).

In this study, we applied GWR methods to examine and compare the spatially varying relationships between coca area percentages on a municipal scale and socio-institutional factors and geographical characteristics, such as road density and forest area. GWR is a widely used method for this type of study, in which the local aspects of an area are considered with the aim of improving the understanding of the actual situation, beyond the global and general models (Clement et al., 2009; Gao and Li, 2011). Additionally, this study is the first to apply GWR in examining the impact of socio-institutional and physical variables on the presence of illicit crops over two time periods.

### 3.2 Study area

Colombia covers an area of 2,070,408 km<sup>2</sup>, of which 1,141,748 km<sup>2</sup> correspond to terrestrial territory and the remaining 928,660 km<sup>2</sup> to maritime territory. Colombia is located in the northwestern corner of South America and consists of five continental natural regions (map 6): the Andean (AN) region, Caribbean (CA) region, Pacific (PA) region, Orinoquia (OR) region and Amazon (AM) region. The country is divided into 32 departments and 1101 municipalities, of which 23 departments (72%) and 274 municipalities (25%) reported the presence of coca crops for at least one year during the period 2001-2008. Colombia is responsible for over 50% of the global production of coca for cocaine production (UNODC, 2006). The region with the highest average area and production of coca at the beginning of the study period (2001) is the Amazon region, principally in the departments of Putumayo, Meta and Guaviare. However, in the following years, coca cultivation spread to the Pacific region and the north of Colombia (UNODC, 2006, 2009)



Map 6. Departments and continental natural regions of Colombia.

### 3.3 Methodology

The Geographically Weighted Regression (GWR) model is an extension of the Ordinary Least Squares (OLS) regression model that allows spatial (local rather than global) parameters to be estimated (Fotheringham, et al., 2002; Fotheringham, Charlton, & Brunsdon, 2001). OLS models lead to generalized relationships that are not applicable to the entire territory, while they do not allow for the consideration of the local characteristics of certain areas. This issue becomes an obstacle for the analysis of issues such as the expansion of illicit crops, which is a topic that requires a better understanding of local realities. GWR follows a local statistics approach, introducing a set of local parameter estimates that demonstrate how a relationship varies across space. Subsequently, the spatial patterns of the local variables are assessed to provide an improved understanding of hidden possible causes of the patterns observed (Brunsdon, Fotheringham, & Charlton, 2002). A global regression (OLS) is expressed as follows:

$$(1) \quad Y_i = \beta_0 + \sum_k \beta_k X_{ik} + \epsilon_i$$

Where  $Y_i$  is the dependent variable at location  $i$ ,  $\beta_0$  is the intercept,  $X_{ik}$  is the value for the  $k$ th independent variable at location  $i$ ,  $\beta_k$  is the parameter estimate for the independent variable  $k$  and  $\epsilon_i$  is the error term at location  $i$ .

GWR generates a separate regression equation for each observation and provides a method to assess the degree of spatial non-stationarity in the relationship between the dependent and independent variables. It generates a local regression equation for each observation, which is expressed as:

$$(2) \quad Y_i = \beta_0(u_i, v_i) + \sum_k \beta_k(u_i, v_i) X_{ik} + \epsilon_i$$

Where  $(u_i, v_i)$  are the coordinates at location  $i$ .

GWR is calibrated by weighting all observations around a sample point using a distance decay function (Tu and Xia, 2008), which assumes that data observed near point  $i$  have a greater influence on the estimated values of  $\beta_k$  than data located farther from  $j$  (Fotheringham et al., 2001).



Following (Fotheringham et al., 2002), the weighting function selected is Gaussian:

$$(3) \quad w_{ij} = \exp\left[-1/2\left(d_{ij}/b\right)^2\right]$$

where  $d_{ij}$  expresses the distance between points  $i$  and  $j$ , and  $b$  is the kernel bandwidth (Fotheringham et al., 2002). A fixed kernel has a constant bandwidth across space, while an adaptive kernel can adapt the sizes of bandwidths to variations in data density, such that bandwidths are larger in locations where the data are sparse and smaller where the data are denser (Clement et al., 2009; Tu and Xia, 2008). Both fixed and adaptive kernel bandwidths can be selected in the GWR 3.0.1 software program developed by Fotheringham. We employ an adaptive kernel bandwidth in this study because the sample density varies across the study area. The optimal bandwidth was determined by minimizing the Akaike Information Criterion (AIC) as described in (Fotheringham et al., 2002).

The significance of the spatial variability in the local parameter estimates (the stationarity test) was evaluated using a Monte Carlo simulation (Fotheringham, et al., 2002). As an indication of the extent of the variability in the local parameter estimates, we followed the method proposed by Charlton, et al., (2006): The authors calculated a five-number summary of these parameters: the median, upper and lower quartiles, and the minimum and maximum values of the data; this approach was helpful in obtaining a proxy for the degree of spatial non-stationarity in a relationship by comparing the range of the local parameter estimates with a confidence interval around the global estimate of the equivalent parameter. In this test, the range of values for the local estimates between the lower- and upper-quartiles can be compared with a range of values of  $\pm$  one standard deviation (S.D) of the global estimate. If the range of the local estimates within the interquartile ranges are greater than a limit of two S.D. of the global mean, this suggests that the relationship might be non-stationary (Charlton et al., 2006).

All of these tests were performed using GWR 3.0.1 software developed by Fotheringham (Charlton et al., 2006; Charlton and Fotheringham, 2009; Fotheringham et al., 2002). The outputs of the GWR software include a parameter estimate, a t-value, and the goodness-of-fit for each municipality. All of these results were spatially displayed in a Geographical Information System environment, thus allowing a visual interpretation of the results.

### 3.4 The Data

Information on the major drivers of the expansion of coca crops in Colombia was gathered from the relevant literature. This information included socio-institutional factors, for example violence and the absence of the state, and geographical and biophysical characteristics such as accessibility and the percentage area of forest cover. Only official information available at the municipal level and for the entire country during the study period (2001 to 2008) was used. Table 4 describes the variables selected, their sources and the years for which data are available. The information is on the municipality level.

The index of municipal development (Departamento Nacional de Planeación (DNP), 2002) and the presence of illegal armed groups were selected to indicate the absence/weakness of the state at the municipal level. The latter was estimated via two indicators: the rate of murders committed by illegal armed groups and the forced displacement of individuals.

The geographical and biophysical indicators are represented by the primary road density and the percentage of municipal territory located in a primary forest area. Spatial and alphanumeric information on coca crops was obtained from the Integrated System of Monitoring of Illicit crops of the United Nations on Drugs and Crime (SIMCI in Spanish). The unit of study is the municipality, and the dependent variable in the analysis is the percentage of area under coca cultivation (Percentage Coca Area - PCA). Due to the variations in the size of the municipalities, the percentage was considered to be the best option. In the results, the “coca area” refers to municipalities where coca was present during the study period.

When information was unavailable for a variable in a given year, data from the nearest year were used. In cases where data on a variable were only available for a single year, this information was used for both periods and only one variable was used: primary road density (PRD). This assumption may bias the results for the PRD variable; however, consultations with experts indicated that although the density has changed over time, the regional trends have remained, which may minimize this potential bias. However, we are aware that the accuracy of this result is limited.

Table 4. Variables included in the OLS and GWR models.

Variable	Acronym	Variable name	Year	Source of data	Unit	Additional explanation
Var X	PCA	Percentage of area under coca cultivation	2001 - 2008	Coca maps (shape) - Integrated Illicit Crops Monitoring System (SIMCI: Spanish acronym for "Sistema Integrado de Cultivos Ilícitos")	Percentage	Percentage of hectares of cultivated coca in comparison to the total area of the municipality.
	PRD	Primary roads density	2005	Road map (shape) - Geographic Institute Agustín Codazzi - Estimation by the authors	Mts/roads/ ha	Meters of primary roads per hectare.
Var Y	FDP	Forced displacement of population - expulsion	2001 - 2008	Presidency of the Republic of Colombia - Presidential Agency for Social Action and International Cooperation	Number of displaced people	Number of forced displaced people by violence and conflict. This information is taken from the National System of Integral attention of Displaced People ("Sistema Nacional de Atención Integral a la Población Desplazada")
	IMD	Index of municipal development	2001 - 2008	National Planning Department of Colombia (DNP - Spanish acronym for "Departamento Nacional de Planeación") - Dirección de Desarrollo Territorial Sostenible DDTS	Index from 0 to 100 (where 0 means low municipal development)	Synthetically measuring the performance of municipalities in social and financial variables. The variables taken are: % of population in header, % of households with water supply, % of households with sewage, % households with energy services, % of people without NBI 2005 per head, % of people without NBI 2005 (rest), % alphabets, % school attendance, tax revenues per capita (current \$), municipal public investment per capita (current \$), % of non-reliance on transfers
	MR	Murder Rate by illegal armed groups (used as proxy to presence of illegal armed groups),	2001 - 2008	Colombian National Police - Estimation by the Authors	Number of homicides per 100,000 inhabitants	Number of homicides per 100,000 inhabitants committed by illegal armed groups (FARC, AUC, ELN). Homicides committed by common crime are not taken into account.
	PPF	Percentage of primary forest area	2000	Colombia Ecosystem map (Shape) - Institute of Hydrology, Meteorology and Environmental Studies of Colombia (IDEAM: Instituto de Hidrología, Meteorología y Estudios Ambientales de Colombia) - Estimation by the author	Percentage	Hectares of primary forest as percentage of the total area of the municipality.

### 3.5 Results

The results of the performance assessment of the GWR for 2001 are summarized in Table 5. The results of the R squared and adjusted R squared parameters were 0.93 and 0.91 respectively, showing an appropriate adjustment of the model. Para el 2008, the values of the R squared and the Adjusted R squared decreased to 0.654 and 0.625 respectively, without changing the performance of the model.

Table 5. Performance assessment of the OLS and GWR models (2001 and 2008).

Year	2001		2008	
	OLS	GWR	OLS	GWR
Akaike Information Criterion - AIC	1.757.552.060	-505.018.207	-1.165.804.900	-1.853.635.868
R-square	0.067524	0.935338	0.243399	0.654029
Adjusted R-square	0.062392	0.915425	0.239234	0.625282

The specific results are divided into two sections: 5.1) GWR models: Stationarity Test (2001 and 2008) and 5.2) significance analysis of the GWR model for 2001– 2008.

### 3.5.1 GWR models: Stationarity Test (2001 and 2008)

We employed two tests to determine the stationarity or non-stationarity of the local variables estimated in the GWR models. This first is an informal test, based on the methods documented by (Charlton et al., 2006). This test determines whether the range of the local estimates within the interquartile ranges exceeds the limits by more than two S.D. of the global mean (OLS model); this result indicates that the relationship may be non-stationary. Table 6 presents the results of the stationarity test for the year 2001. These results indicate that the interquartile range of the local estimates is far smaller than two S.D. of the global estimate (OLS model), indicating a stationary relationship among the parameters.

Table 6. Results of the stationarity test for OLS and GWR for 2001.

2001 Variable	OLS Model		GWR Model			
	S.D	2*S.D	Lw Quartile	Up Quartile	Range GWR	Range GWR - 2*S.D
PPF	0,00085	0,00169	0	0,00027	0,00027	-0,00143
PRD	0,01325	0,02651	-0,00029	0	0,00029	-0,02622
FDP	0,00002	0,00004	0	0	0	-0,00003
MR	0,00496	0,00991	0	0,0007	0,0007	-0,00921
IMD	0,00183	0,00367	-0,00017	0	0,00017	-0,0035

For 2008, the results indicate that the interquartile range of the local estimates is greater than two S.D. for all variables (except the density of roads variable), suggesting that the relationships may be non-stationary (Table 7). This result indicates a difference from the 2001 estimates, in which stationary relationships were observed among all variables.

Table 7. Results of the stationarity test for OLS and GWR for 2008.

2008 Variables	OLS Model		GWR Model			
	S.D	2*S.D	Lw Quartile	Up Quartile	Range GWR	Range GWR - 2*S.D
PPF	0,00022962	0,00045924	0,000015	0,001807	0,001792	0,001332757
PRD	0,00350462	0,00700924	-0,006472	0,000057	0,006529	-0,000480237
FDP	7,73E-06	1,55E-05	0,000005	0,000075	0,00007	5,45E-05
MR	0,00363265	0,0072653	-0,000069	0,03378	0,033849	0,026583702
IMD	0,00038969	0,00077937	-0,001517	-0,000066	0,001451	0,000671626

The second test is a Monte Carlo test to assess whether spatial variation in the relationship between each independent variable and the dependent variable is statistically significant across the study region. The results of these tests (Table 7) indicate that the spatial variation in our local parameter is not significant. The results of the Monte Carlo test for 2001 (Table 8) confirm the results found previously.

*Table 8.* Tests based on the Monte Carlo significance test procedure (2001 and 2008).

Parameter	P-value 2001	P-value 2008
Intercept	0.65000 n/s	0.00000 ***
PPF	0.85000 n/s	0.01000 **
PRD	0.27000 n/s	0.00000 ***
FDP	0.88000 n/s	0.39000 n/s
MR	0.99000 n/s	0.04000 *
IMD	0.99000 n/s	0.00000 ***

\*\*\* = significant at .1% level / \*\* = significant at 1% level / \* = significant at 5% level  
n/s = Not significant

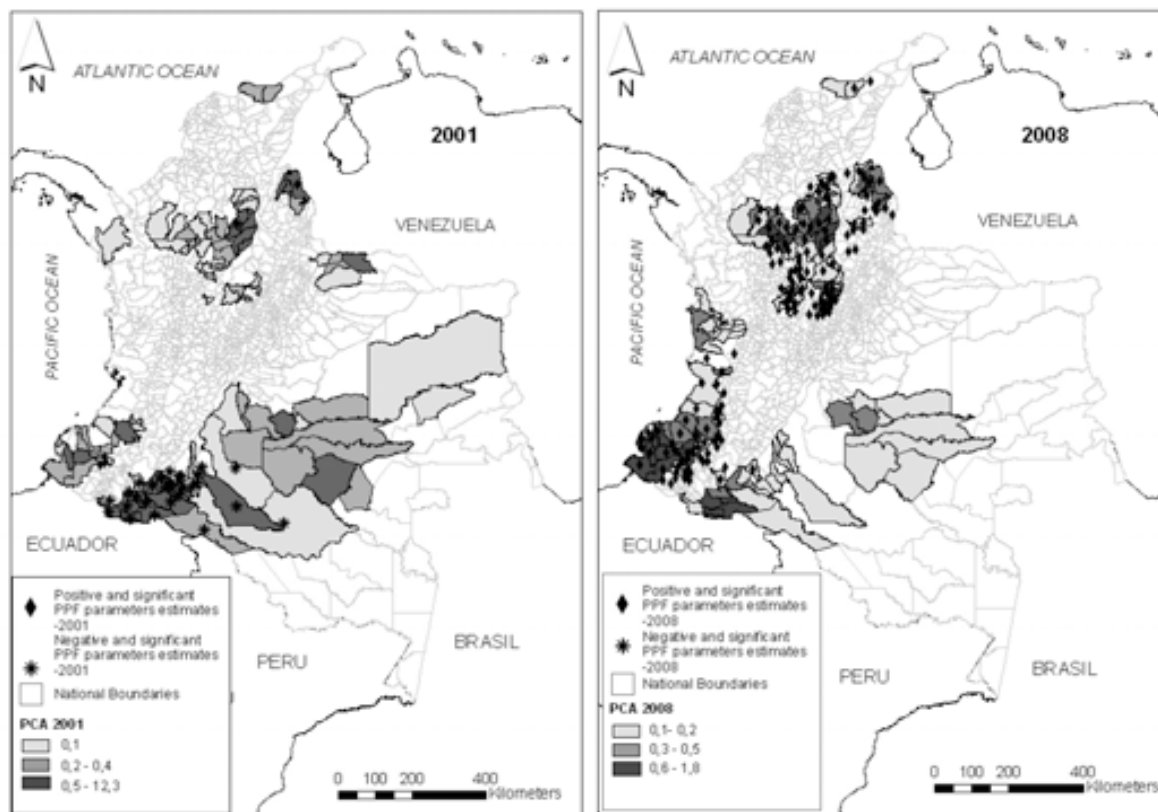
The results of the Monte Carlo test for 2008 indicate that there is significant spatial variation in the local parameter estimates for all variables, except for displacement, as reported in the second column of Table 7. This result complements the results found previously and confirms the change from 2001 (in which a stationary relationship was found) to 2008, where no stationarity was observed.

### 3.5.2 Significance analysis of the GWR model 2001 – 2008

Here, we present an analysis of significance of the variables included in the model for the two years of the study (2001 and 2008), beginning with the percentage of primary forest area (PPF) within a municipality variable, followed by the analysis of primary roads density (PRD), forced displacement of population (FDP), murder rate by illegal armed groups (MR) and, finally, the index of municipal development (IMD). The statistical results make it possible to identify the regional differences in the variables influencing the cultivation of coca. Differences were found between the Amazon, Pacific, Caribbean and Andean regions. Additionally, significant differences were found between the two years studied. In the following maps, the percentage of coca area (PCA) is depicted for each study year (2001 and

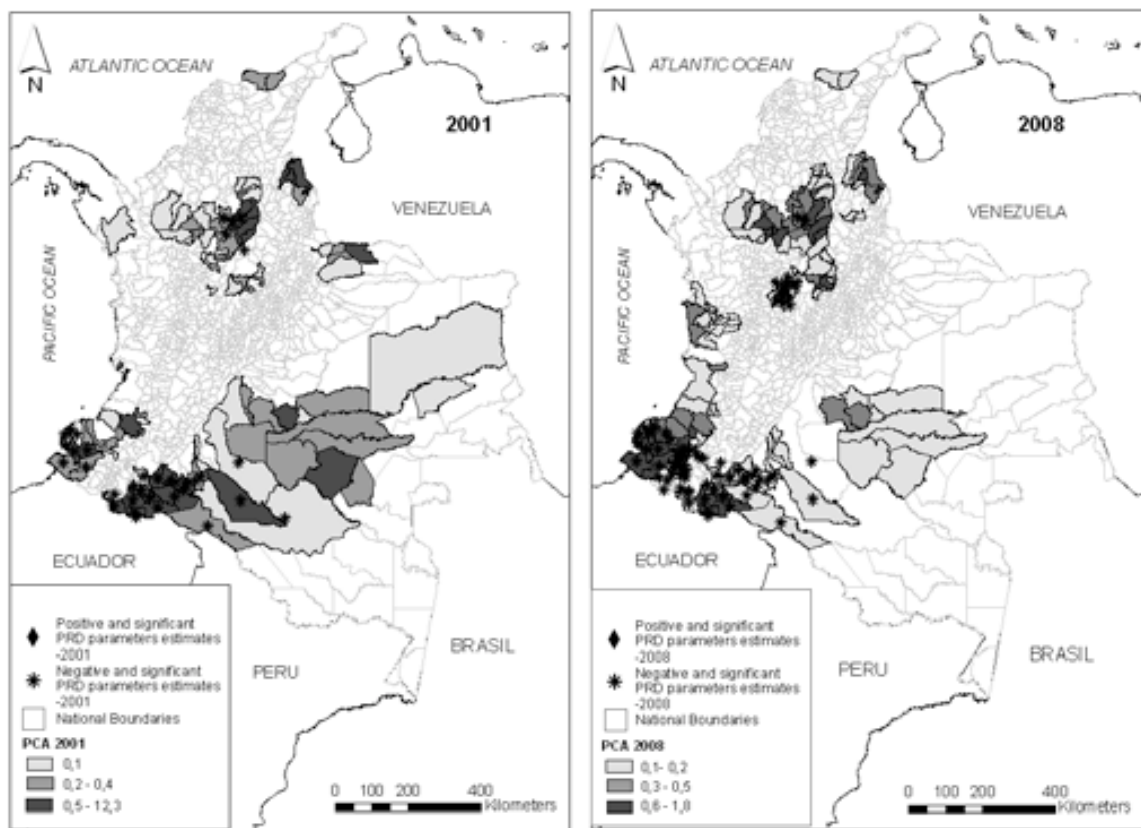
2008) in addition to the associated parameter variables that were significant in both 2001 and 2008.

**PPF:** For 2001, PPF was found to have a significant and inverse relationship with PCA in some municipalities in the Amazon region (southern departments of the country, such as Putumayo and Caquetá). For 2008, this relationship changes in two ways: a) it is no longer significant in Putumayo and Caquetá, and b) it becomes positive and significant in some municipalities of the Pacific and Caribbean regions (see map 7). The reason for this behavior is that in 2001, Putumayo exhibited high levels of forest transformation and had the greatest presence of coca among the departments (showing an inverse relationship); however, by 2008, the coca crops had been displaced to other areas characterized by low levels of transformation (high levels of natural forest cover) in the Pacific region (hence the positive relationship).



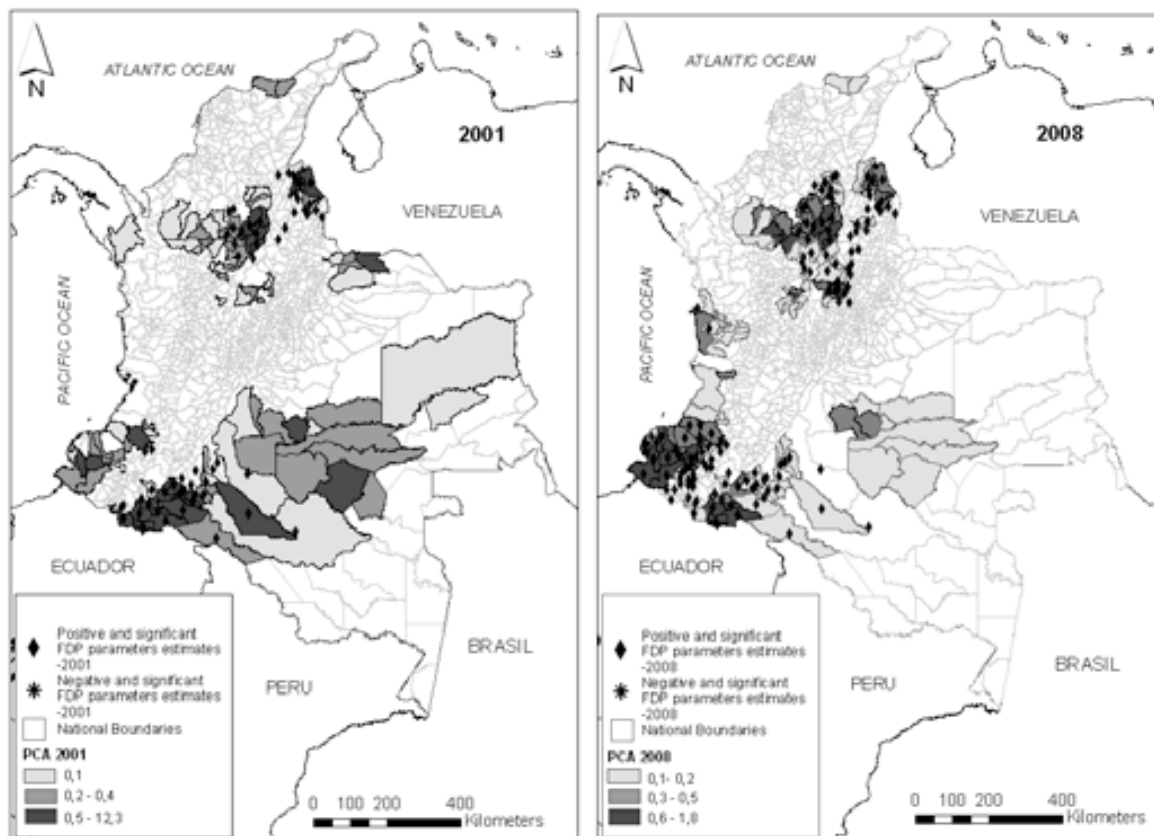
Map 7. GWR model / significant PPF parameter estimates vs PCA (2001 – 2008).

**PRD:** In 2001, PRD had an inverse and significant relationship with PCA in some municipalities of the Amazon region (Putumayo and Caqueta departments), which is similar to the findings for PPF. Additionally, PRD was inverse and significant in some municipalities in the Pacific region (some municipalities of the Nariño department). In the Caribbean region and the north of the Andean region, PRD only became significant in some municipalities in the department of Antioquia. In 2008, this variable continued to exhibit an inverse relationship while becoming more negative and significant in other municipalities in the Pacific region and the north of the Andean region and remaining significant in the municipalities in the Amazon region. The analysis indicates that road density was an important indicator in both periods, but primarily in the south of the country (Pacific and Amazon region), as this variable is almost never significant in the north of the country (map 8).



Map 8. GWR model / significant PRD parameter estimates vs PCA (2001 – 2008).

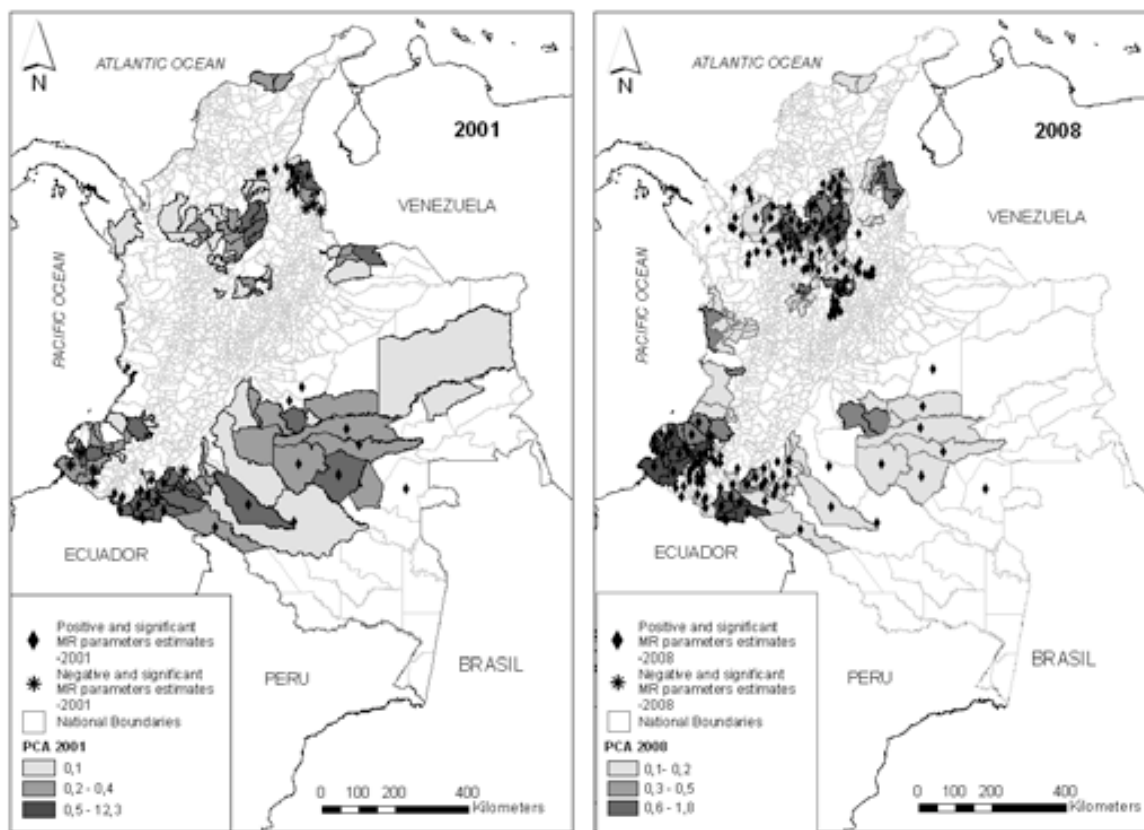
**FDP:** For 2001, FDP was found to have a significant and positive relationship with PCA in some municipalities of the Amazon region (southern departments of the country, such as Putumayo and Caquetá). In 2008, the relationship became significant in the Nariño department and many other coca-growing municipalities in the Pacific region, the Caribbean region and the north of the Andean region (see map 9).



*Map 9.* GWR model / significant FDP parameter estimates vs PCA (2001 – 2008).

**MR:** In 2001, the murder rate by illegal armed groups variable had a positive relationship with PCA in the Amazon region and the north of the Andean region and was the only significant variable for 2001 in the municipalities in the de Meta and Guaviare departments (north of the Amazon region). For 2008, this positive significance included more areas of the country (the Pacific, Andean and Amazon regions). MR was a significant variable in most regions of the country in 2008.

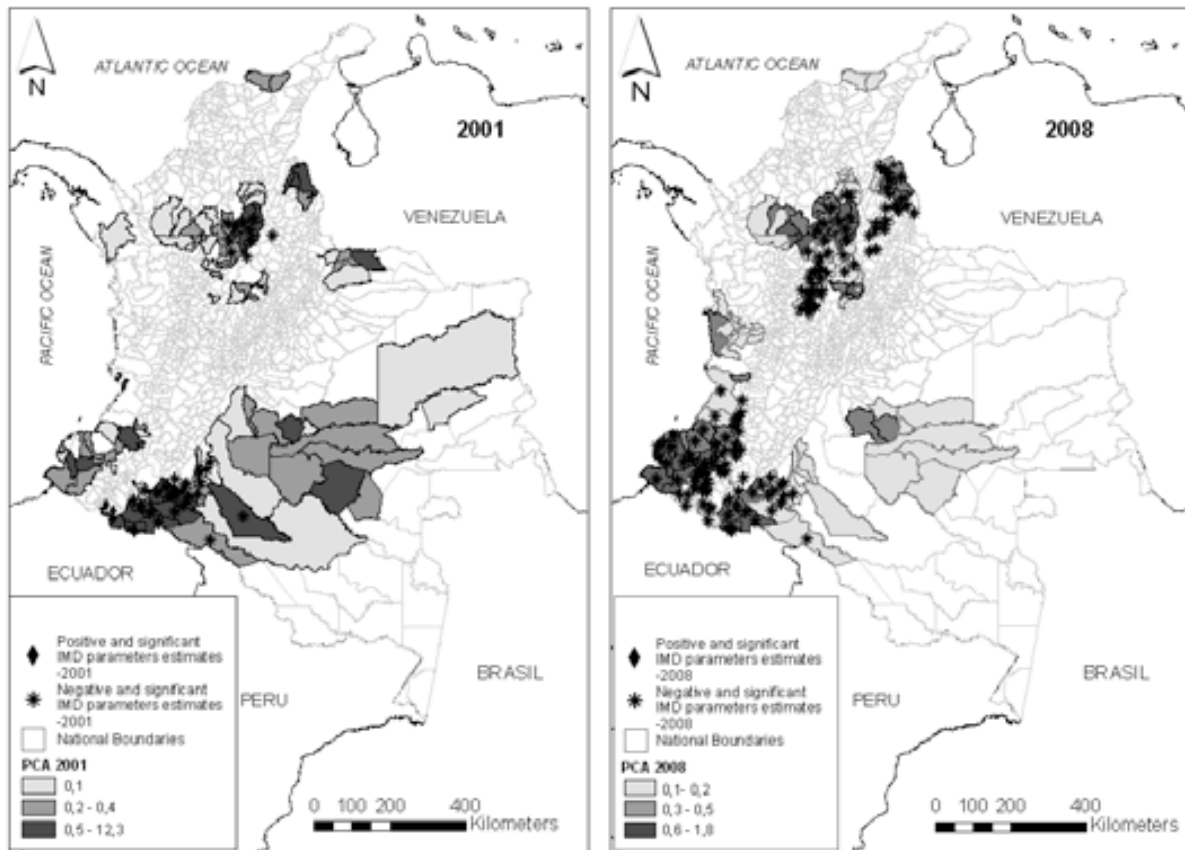




Map 10. GWR model / significant MR parameter estimates vs PCA (2001 – 2008).

**IMD:** The municipal development index was found to have an inverse and significant relationship with the dependent variable in both time periods. In 2001, this index was mainly significant in municipalities of the Amazon and the north of the Andean region; by 2008, there had been an expansion to the Pacific region (mainly in the south) and the Caribbean regions. This index shows a consistent pattern of significance with the municipalities with the highest percentages of coca area (see map 11).

By performing an integrated analysis of the maps of significance for each variable described previously, it was observed that for 2001 all variables were significant in only the southwestern Amazon (Putumayo). This is not true for the other regions, as their estimated values significance was different according to the variable. By 2008 all the analyzed variables retain their significance in the department of Putumayo, but also prove to be significant in the rest of the south pacific region, such as the department of Nariño.



Map 11. GWR model - significant IMD parameter estimates vs PCA (2001 – 2008)

Maps (7-11) are summarized in Table 9. The analysis of the data suggests that in 2001, the percentage of forest area, forced displacement, homicides by illegal armed groups and municipal development were significant in Amazon region (Putumayo and Caqueta in particular) but not in the Pacific region (Nariño and Cauca). By contrast, road density was significant both in the Amazon and Pacific regions, e.g., Putumayo, Caquetá, Nariño and Cauca. In 2008, these significant relationships had expanded in both the Amazon and Pacific regions.

Table 9. GWR model - significant relationships with PCA by region (2001 – 2008).

Acronym	Variable name	2001 (significant relation with PCA by region)	2008 ( significant relations with PCA by region)
PRD	Primary roads density	Inverse relation in: south-central of the country (Putumayo and Caquetar) / southwest (Nariño and Cauca) / North (a few municipalities in Bolivar)	Inverse relation in: south-central of the country (Putumayo and Caquetar) / southwest (Nariño and Cauca) /North (a few municipalities in Antioquia)
FDP	Forced displacement of population - expulsion	Positive relation in: south-central of the country (Putumayo and Caqueta) / North (Bolívar and Santander)	Positive relation in: south-central of the country (Putumayo and Caqueta) / southwest (Nariño and Cauca) / North (Bolívar and Santander)
IMD	Index of municipal development	Inverse relation in: south-central of the country (Putumayo and Caqueta) / North (Antioquia and Bolívar)	Inverse relation in: south-central of the country (Putumayo and Caquetar) / southwest (Nariño and Cauca) / North (Antioquia, Bolívar and Santander)
MR	Murder Rate by illegal armed groups (used as proxy to presence of illegal armed groups),	Positive relation in: south-central of the country (Putumayo and Caqueta) /Southwest (a few municipalities in Nariño) / North (North of Santander)	Positive relation in: south-central of the country (Putumayo and Caquetar) / southwest (Nariño and Cauca) / North (Córdoba, Bolívar, Antioquia)
PPF	Percentage of te municipal territory in primary forest area (2000)	Inverse relation in: south-central of the country (Putumayo and Caqueta)	Inverse realtion in: Southwest (Nariño and Cauca) / North (Córdoba, Antioquia, Norte de Santander and Bolívar )

In the north of the country, the significance was more heterogeneous: in 2001, the municipal development index and forced displacement were significant in the departments of Antioquia and Bolívar and expanded to other municipalities in the north in 2008. The percentage of forest area variable was only significant in 2008 in the northern area. Road density was not generally significant in the north of the country (only in some municipalities). The homicides variable was not generally significant in 2001 in the north; only the North of Santander department showed a significant result. Nevertheless, in 2008, this variable was significant in several municipalities in the north, including the northwest (Antioquia, Córdoba, Bolívar and even Chocó).

For the department of Nariño, which had the highest growth in coca cultivation between 2001 and 2008, road density and homicides by illegal armed groups were the only significant variables in 2001. However, due to the expansion of coca crops toward this department during the 2000s, all of the other variables became significant in 2008.

### 3.6 Discussion

An important factor is the stationarity of the parameters. Stationarity was observed in the 2001 models, indicating that the local situation was similar to the global situation. However, by 2008, none of the relationships exhibited stationarity. The change from stationarity to non-stationarity between 2001 and 2008 can be explained as follows. At the beginning of the decade, and in previous periods, coca was concentrated in particular areas in the Amazon,

particularly in the department of Putumayo (Aiken and Leigh, 1986). This concentration had long remained nearly unchanged, and hence the local situation coincided with the national reality. However, from 2000 to 2008, due to the extreme policy of spraying coca in the Amazon areas and especially in Putumayo, there was a displacement of illicit crops to different parts of the country, especially towards the Pacific and previously unaffected municipalities in the north. The changes generated new local realities, as the expansion of coca cultivation moved into new municipalities with similarly favorable conditions, such as low accessibility and high forest cover in the case of the south.

In 2002, there was only a significant and inverse relationship between forests and coca in the Amazon region (Putumayo department), while in 2008 a significant and positive relationship was found for almost all areas engaged in coca production. This change between 2001 and 2008 is interesting and merits discussion. Although abundant forest cover is initially an incentive for the expansion of coca crops, once the crops are established, they begin to exert substantial pressure on the forest. At the end of the 1990s, Putumayo represented approximately 40% of the total area under coca in Colombia (58,000 ha); in 2000, this figure had increased to 66,000 (UNODC, 2003), which is the reason for the considerable decline in forest cover by the year 2001. Therefore, an inverse relationship between forest and coca was found for this department in 2001. However, due to a fumigation policy that targeted Putumayo, illicit crops moved to other areas, and the areas affected by this expansion coincided with areas of high forest cover. Therefore, a direct relationship is observed between a high percentage of forest cover and coca area in 2008, while this relationship diminished significantly in Putumayo.

The municipal development indicator could be considered to be a key factor in explaining the presence of illicit crops, as it was found to be significant regardless of the region or year (see map 11). Therefore, in the coca regions, which are characterized by low levels of this indicator, we are more likely to observe the emergence of and control by illegal armed groups and thus violence and displacement—variables which were found to be significant in 2008 (see map 10). Low levels of IMD and the increase in the territory controlled by illegal armed groups (high levels of MR) caused the expansion and movement of illicit crops.

Violence and low road density, which could be considered indicators of forest conservation (Álvarez, 2001; Rincon et al., 2006), are ultimately factors that encourage the expansion of

illicit crops and thus deforestation (see maps 8 and 10). Therefore, a weak and absent state is considered to be an important factor in social conflicts that involve the control of natural resources (forest and rivers) for the expansion of illicit crops. Significant expansions of the analyzed variables can be observed throughout the country between 2001 and 2008: in 2001, only a few variables were significant and only for particular regions, mainly in the south. Factors such as poor accessibility, violence (murder by illegal armed groups), displacement, and lower municipal development were demonstrated to have greater explanatory power in the country in 2008.

### **3.7 Conclusions**

This study examined the relationships between the expansion of coca crops and some of the social, institutional and biophysical factors identified in the literature, with a focus on local aspects.

Models that include local characteristics allow for an improved understanding of the factors associated with the expansion of illicit (coca) crops in Colombia. This study examined the relationships between the percentages of given areas under coca cultivation, with institutional and biophysical factors using GWR models. For Colombia, these results demonstrate the importance of considering the country's regional heterogeneity. This method of analysis allows for improved approximations of reality through the improved incorporation and understanding of specific local relationships.

The factors that are commonly associated with the expansion of coca crops cannot be generalized across the entire country. The relationships between coca crops and the associated factors that exist on global and local levels differ. In other words, the relationships are not constant across space (they are not stationary). Although stationarity was found in 2001, it had been replaced by non-stationarity by 2008. The local reality changed between 2001 and 2008: in 2001 the crops were concentrated in a few areas, and the global reality was similar to the local analysis as a result (stationarity). By 2008, the expansion of coca to other regions had led to the creation of multiple situations with differing characteristics, demonstrating how coca crops were associated with different features according to the region where they were located. Consequently, non-stationarity was observed, indicating that a global analysis could not reflect the complex local reality in 2008. The importance of using

models that include the local reality becomes evident in our research. Only through the use of GWR models is it possible to analyze and understand the particular realities that must be taken into account to develop proper policy; failing to do so can lead to serious mistakes. General and OLS models generally identify global factors for an entire country, but many of these factors are not significant in all regions and may change over time. The GWR model revealed significant relationships between coca crops and the majority of the analyzed variables in both periods (2001 and 2008) and for specific variables and zones. This result is important with respect to drug policy, as it implies that specific local realities should be considered rather than applying general policies for the country as a whole.

The statistical results allow for the identification of regional differences in the variables influencing the cultivation of coca. Differences were found between the Amazon, Pacific, Caribbean and Andean regions. Additionally, significant differences were found with respect to the period being studied. For example, in the Pacific region (specifically the department of Nariño), which had the highest growth in coca cultivation between 2001 and 2008, road density and homicides by illegal armed groups were the only significant variables in 2001. However, with the expansion of coca in this department, all other variables had become significant by 2008. In general, we can state that the influence of biophysical, social, economic and institutional variables on coca cultivation in Colombia have changed over time.

GWR provided a valuable new exploratory methodology in identifying the most prominent drivers of coca crop expansion and assessing the heterogeneity of their impacts on a local scale. Local models provide a much better explanation for the existence of coca crops than the averages identified by global models. The results lead to the conclusion that drug policy must be tailored according to local realities rather than, as is currently the case, a general policy that exists for the entire country (Isacson and Poe, 2009; Rodriguez, 2009). Therefore, we argue that locally sensitive policies can be far more efficient than generalized initiatives.

## **CHAPTER FOUR: Caught in the middle: Colombia's war on drugs and its effects on forest and people<sup>5</sup>**

*Coca plantations are the largest illegal agribusiness in the world, and Colombia is the world's leading coca producer. Since 1994, the Colombian state, with the aid of the U.S., has waged a war on drugs based on air fumigation of coca plantations. This article evaluates the social and environmental impacts of this policy. We construct and analyse statistically for the first time a spatial database with social, economic, environmental, coca production and fumigation data for all 1125 municipalities of Colombia for the period 2001-2008. We complement statistical analysis with in-situ observations and secondary literature review. We find that even if the questionable government claims that overall extent of coca plantations has been reduced were to be true, still coca activity has been diffused in the territory, with devastating environmental and social consequences. Biodiversity hotspot areas are being deforested, and local populations, especially afro-colombian communities, are being displaced from their territories. Our statistical analysis provides quantitative evidence to back up previous claims based on victims' experience, single case-studies and ethnographic observation. We question the effectiveness of the fumigation policy and suggest that what is actually eradicated by the war on drugs is not coca, but humans and the forest.*

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<sup>5</sup> A variant of this chapter has been accepted for publication in *Geoforum* as: Rincón-Ruiz A., Kallis G., “Caught in the middle: Colombia's war on drugs and its effects on forest and people

## 4.1 Introduction

Coca production is the largest illegal agribusiness in the world. The global cocaine retail value is estimated at US\$80–\$100 billions, equivalent to 0.15% of global GDP, and at the level of the annual GDP of countries such as Iraq or Slovakia (UNODC, 2010). Cocaine, consumed mostly in North America and Europe, is primarily produced in the Andean region. The plantation of coca crops for cocaine is concentrated in three countries: Colombia, Peru and Bolivia. Since 1997, Colombia is the main coca producer, accounting for more than 50% of total world production, with some 81.000 ha of coca cultivated and 450 metric tons of cocaine produced in 2008. Coca production in Colombia accounted for 623 millions of dollars of revenue in 2008, 0.3% of GDP and 3% of agriculture's GDP (UNODC, 2008a). Unlike Peru and Bolivia, whose anti-drug policy is based on manual eradication, Colombia is the only country in the world to use aerial fumigation.

Colombia's fumigation policy began cautiously in the end of the 1970's in order to fight marijuana plantations, but was extended in 1994 to the expanding cultivations of coca. Aerial fumigation intensified and proliferated with the signing of 'Plan Colombia' in 1999 by Colombia and U.S.A. and the subsequent creation of the 'Program of Eradication of Illicit Crops with Glyphosate' in 2000. Plan Colombia has been celebrated as a great success in reducing the total area of the country occupied by coca from 144.800 ha in 2001 to 81.000 ha in 2008 (UNODC, 2010), presumably liberating local populations from the grip of the illegal business and its devastating consequences. The Colombian government has also heralded the environmental benefits of the war on drugs; the coarse hypothesis behind such statements is that coca has negative environmental effects and any policy that reduces must by definition have positive ones (Álvarez, 2007; Bernal, 2007). Yet, other researchers argue that fumigation goes hand-in-hand with deforestation and environmental degradation (Ávila et al., 2007; Vargas, 2004a; Walsh et al., 2008a), negative health effects (Ávila et al., 2007; IDEA, 2005; Nivia, 2001), and social impacts, including forced displacement, disproportionately



falling on afro-colombian groups and low-income population (Defensoria del Pueblo, 2007; OAIPC, 2010).

How does aerial fumigation affect coca production, the livelihood and settlement patterns of human populations and the state of ecosystems? This is an important question if one wants to know how and why anti-drug interventions “from a safe distance”, such as aerial fumigation, may produce counterproductive results at the ground that undermine their proclaimed intentions. We provide new evidence at a finer spatial scale than ever before, which substantiates the claim that aerial fumigation has negative social and environmental effects, and we then explain why this is the case. We argue that the aerial fumigation policy is ill-suited for the socio-environmental interdependencies present at the complex socio-ecosystem of the Colombian forests, where most of coca production is concentrated. In this, we position our research as a case study of the broader thesis about the failure of State improvement schemes based on schematic visions that do violence to complex socio-ecosystem interdependencies (Norgaard, 1994; Scott, 1998).

We are not the first ones to study the social and ecological impacts of cocaine production or the war on drugs. There is a long literature on the failures of the US-driven war on drugs in Latin America and particularly the negative effects of the forced displacement of cultivations (Guáqueta, 2005), compared to more structural solutions offering employment alternatives to producers (Guridi, 2002). The failure of forced policies to make peasants to leave cocaine production has been documented for the case of Bolivia (Guridi, 2002) and Peru (Aristizabal, 2009). A grand part of the literature on aerial fumigation evaluates direct impacts, most notably on health (e.g. (Ávila et al., 2007; Hewitt et al., 2009; IDEA, 2005; Nivia, 2001; Solomon et al., 2005a; Solomon et al., 2005b)), and the environment and agriculture (Ávila et al., 2007; Eslava et al., 2007; Messina and Delamater, 2006; Nivia, 2001, 2001a; Varona et al., 2009). Concerning indirect effects, there are studies, which have looked at the displacement of peasants and legal crops in Bolivia and Peru (Bradley and Millington, 2008). For Colombia there is anecdotal evidence that the fumigations destroy the revenue base of the peasant economy and displace both coca production and peasants to new areas (Vargas, 2004a). Scrutinizing the official data at the national level, González (2006) finds inconsistencies that raise questions about the proclaimed effectiveness of the eradication policy. Also an inter-temporal econometric analysis at the national level by Moreno-Sanchez

et al. (2003) shows that the cultivation area of coca in Colombia has increased as eradication efforts have intensified, because farmers compensate for eradication by cultivating the crop more extensively. This pattern is confirmed by a statistical analysis at the level of the 32 sub-national departments of Colombia by Dion and Russler (2008), who find that fumigation displaces, but does not eradicate, coca production. This displacement effect has been called in the drugs literature the “balloon effect” (Laffiteau, 2010; UNODC, 2008a) and attributed to an inelastic demand, that will be satisfied in one way or the other by the producing regions.

Whereas this literature offers many useful reference and entry points, there are several gaps if one wants to get a more accurate picture of how aerial fumigations affect production, settlement and ecological patterns in Colombia. First, the national or regional scale analyses hide important shifts and effects at lower spatial scales, where complex interdependencies are at play. We provide here for the first time data coverage on fumigations and coca cultivation down to the municipal level (1125 municipalities). Second, much of the interest until now has been on production patterns, and the effects of fumigation on the acreage and location of coca cultivations. Despite claims for the dislocation of people or the uneven impacts of the policy on the basis of race or class, no other study to our knowledge has examined such effects rigorously. We cover a greater number of variables per year (also for a more recent period, 2001 – 2008, than other studies) identifying new associations between coca cultivation and its social impacts, especially dislocation, which has not been evaluated before. Third, concerning environmental impacts, whereas Dávalos et al. (2011) before us also looked at the complex relations between illicit crops and deforestation in Colombia at the municipal level, we extend his analysis by using a different methodology on the basis of a mapping of ecosystems which permitted us to evaluate land-use changes at the ecosystem level (see methods below). Fourth, and most importantly, this is the first study that attempts an integrated and multi-dimensional analysis of both direct and indirect effects of fumigations at the most refined scale possible. Whereas other studies before focused either on health, environmental or production effects, we examine all these together. This gives us the opportunity to offer a more accurate understanding of the multi-faceted effects of fumigation on people and the territory, and through it draw wider claims on how improvement schemes and anti-drug policies from a distance produce negative effects in complex socio-ecosystems such as those of Colombia.

In summary, our main claim is that the fumigation policy is failing in Colombia, because it does not eradicate, but diffuses coca production, shifting it to forests of ecological importance and to areas inhabited by low-income, especially Afro-Colombian and indigenous communities, which as a result are increasingly displaced. The broader significance of our claim is the confirmation of a broader pattern whereby government “improvement” policies imagined from a distance fail miserably in the face of complex local socio-ecological interdependencies.

Section 2 presents the methods used to generate the evidence for this claim and the new data mobilized or constructed for this analysis. We employ a novel spatial approach to respond to the above questions demonstrating the importance and contribution of geographical analysis. In particular, we analyze statistically a newly-compiled geographical and longitudinal dataset of aerial fumigation, coca production and various socio-economic and demographic variables at the municipal level, complementing it with qualitative information from interviews and secondary documents, as well as in-situ assessments of the impacts of aerial fumigation

Section 3 presents the empirical evidence that supports our claim. We find that:

1. Fumigation has not eradicated, but displaced coca production to other regions. Such a “Balloon effect” has been noted by others for manual eradication and at the macro-regional level (Bradley and Millington, 2008; Laffiteau, 2010; The Economist, 2001; UNODC, 2008). Our intra-national study finds in addition that aerial fumigation not only displaces, but actually diffuses the production of coca in the territory, and that the effect of fumigation is temporary, as production often returns after a while. This creates a negative spiral of fumigation and cultivation that affects more and more territories and people.
2. Fumigation in Colombia displaces production to areas of primary forest of great environmental significance.
3. Fumigation causes negative health impacts but these are contested and hard to verify. The level of complaints launched by local communities suggests that fumigations do impact negatively local livelihoods.

4. Fumigation is associated with increased human displacement.
5. Less developed communities, including indigenous and Afro-Colombian communities, are disproportionately impacted by fumigation and coca displacement. There is no evidence however to suggest discriminatory fumigation by the authorities.

Section 4 discusses the main findings of our research and attempts to explain why is the policy failing. We argue that the policy overlooks complex interdependencies at the local level, and in particular does not account for the lack of alternative sources of income, as well as the particular socio-ecological features of the coca economy, which make it selectively shift to areas of primary forest and low development. Section 5 reinstates our main conclusion and draws its policy implications: the Colombian anti-drugs policy of aerial fumigation has caused a displacement and diffusion of coca cultivation in the territory, impacting socially and ecologically vulnerable areas and expanding the war on drugs to new areas, affecting the livelihoods of more people. We add our voice to those who argue that the U.S. and Colombian governments should reconsider thus policy and shift resources instead to policies that curb demand for drugs at its source or that provide meaningful livelihood alternatives to local populations at the production regions.

## **4.2 Data sources and methods**

The research findings discussed in this article were gathered following a multi-evidentiary strategy consisting of four components. First, an extensive literature review was conducted of all peer-reviewed and government publications concerning antidrug policies and the social, economic, environmental and political aspects of coca plantations in Colombia. This preliminary phase of the research benefited by discussions with experts of the Integrated Illicit Crops Monitoring System (SIMCI in Spanish), the National Office of Narcotics of Colombia (DNE in Spanish), the Ministry of Defense, and the NGOs Transnational Institute (TNI), the Arcoiris Foundation and Acción Andina, as well as other researchers from Colombian Universities.

Second, and at the heart of the research findings is a database at the municipal level, the first of its kind, including data for all 1125 municipalities of Colombia with respect to social, economic, environmental and institutional features, as well as information on the extent of coca production and aerial fumigation. We used existing data but we are the first ones to construct this comprehensive database for the purposes of this research. The data for municipal coca production (2001-2008) are taken from the official data produced by SIMCI, whereas for fumigation we used municipal level data from the DNE, which has been reported by UNODC (UNODC, 2008a, 2009). Such official data is highly suspicious and controversial, as it is often invoked to support the success of the government's anti-drug policy. Data from CIA's Crime and Narcotics Center (CNC) suggests a lesser impact for the fumigation program (GAO, 2008). However the CNC data is available only at the national and not the municipal level. Unfortunately, the SIMCI/UNODC data is the only source available at the municipal level and with this we had to work. Since we are interested more on longitudinal cross-sectional differences the possible biases in the absolute levels are less crucial for our case. Furthermore, we will show that even with this government data that may have been manipulated to paint a better picture, a disaggregated analysis at the municipal level shows that the fumigation policy is failing.

Table 10 details the variables used in the database, their definition and the sources of the data. This list was constructed on the basis of the literature review and our initial research questions after consultation with experts and taking into account the availability of data at the municipal level. On the basis of this database, we test for (spatial association and correlation analysis) hypotheses concerning the socio-economic characteristics of the expanding coca frontier, and the relationships between aerial fumigation, the spatial distribution of coca production, environmental effects and people displacement. The statistical significance of the correlations was carried out using 10,000 permutations (Anselin, 2005; Anselin et al., 2002). Analysis of spatial information and the statistical tools were done using the software SPSS, Geoda and ArcGIS.

Third, we analysed the deforestation and ecosystem impacts of coca cultivations by overlapping information about land coverage from the national map of ecosystems in 2000 in shape format (IDEAM et al., 2007) with geospatial information about coca cultivations from SIMCI's maps for the 2001-2008 period. A total of 154 ecosystems were grouped into 3

principal and 32 sub-biomes. Sixteen types of land cover were grouped into 8 natural classes (natural continental waters, shrubs, natural forests, grasslands, grasses and coastal bushes, continental hydrophytes, coastal lakes and estuaries, and secondary vegetation) and 8 transformed classes (heterogeneous agricultural areas, largely alternated areas, urban areas, artificial continental water, forest plantation, annual or transitory cultivations, (semi-) permanent crops and grasses). Our analysis was based in the natural cover and ecosystems estimated in 2000 (IDEAM et al., 2007) and the expansion of coca crops during 2001 – 2008 (Coca census 2001 – 2008). We estimated the share of natural ecosystem transformed at the municipality level. Where relevant, we also used maps (shape format) divided according to the legal status of Colombian territories into: Collective territories of Afro-Colombian communities, indigenous territories, forest reserve, natural national parks and subtracted area from the forest reserve (subtracted area means the area that ceases to be in forest reserve) (Accion Social, 2009), allowing in this way to document differentiated changes in cultivation and fumigation in each of these territories. The results were complemented with data from the United Nations Office on Drugs and Crime. Dávalos et al. (2011) before us also looked at the complex relations between illicit crops and deforestation in Colombia. He used however remote sensing images, and where heavy clouds did not allow a clear picture, the data was classified as missing. This was a problem especially for the Pacific region and likely to lead to an underestimation of deforestation. Our analysis which overlaps municipal and ecosystem data does not suffer from this problem, though we might have overestimated deforestation due to coca in cases where what was classified as natural forest in 2000 was already transformed to agriculture and another type of land use and only after that turned into coca cultivation.

Fourth, a rapid assessment was conducted in the department of Nariño (map 12), one of the areas most affected by the expansion of illicit coca crops in the 2000s. Between 2001 and 2008 the department of Nariño had an increase of 162% of the area cultivated with coca crops and it has been a growing target of fumigations. During a period of one month of field-work, the first author interviewed a total of 18 people, ten of them representing different scales of affected by or involved in coca production (including indigenous leaders, Interior departmental advisers, members of the health department secretary, members of the national police) and eight people from local communities. Additional information on the impacts of fumigation on the local population was collected through a review of governmental

documents from the Ombudsman, the local police, the health secretary and the hospitals of Nariño and through direct conversations with local people, particularly with five peasants from the coca-growing areas of the department of Nariño and leaders of the indigenous community indigenous Awá that inhabit the southwest of Colombia, one of the communities most affected by armed conflict in Colombia and the war on drugs (Saavedra, 2009).

Below we report on the key findings of our analysis structured around each of the five sub-claims identified in the introduction. The core findings are based on the municipal statistical research and the ecosystem impact assessment, grounded where relevant with material from secondary literature research and the Nariño visit.

Table 10. Description of variables included in the analysis.

Name	Variable Name	Years	Source	Unit	Description
PRD	Primary road density	2005	Road map (shape) by Geographic Institute Agustín Codazzi - Estimation by the authors	Mha	meters of primary roads per hectare.
FDP	Forced displacement of population	2001 to 2008	Presidency of the Republic of Colombia - Presidential Agency for Social Action and International Cooperation	Number of displaced people	Number of forced displaced people by violence and conflict. This information is taken from the National System of attention to Displaced People ("Sistema Nacional de Atención Integral a la Población Desplazada")
RUBN	Rural Unsatisfied Basic Needs Index	2005	National Administrative Department of Statistics - (DANE Spanish acronym for "Departamento Administrativo Nacional de Estadística")	Index from 0 to 100 (From 'no basic need satisfied' to completely satisfied)	The index is determined through 5 indicators: adequacy of housing, degree of household overcrowding, adequacy of basic household services, degree of economic independence of the household; household with children at school-age which are not attending scho
IMD	Index of municipal development*	2001 to 2008	National Planning Department of Colombia (DNP - Spanish acronym for "Departamento Nacional de Planeación") and Direction of territorial sustainable development (DDTS - Spanish acronym for "Dirección de Desarrollo Territorial Sostenible")	Index from 0 to 100 (where 0 means low municipal development)	Synthetically measuring the performance of municipalities in social and financial indices, including: % of households with water supply, % of households with sewage, % households with energy services, % of people without Unsatisfied Basic Needs in urban area
VAIA	Number of violent acts by illegal armed groups	2001 to 2006	Los Andes University Bogotá and Ministry of defense Colombia	Number of violent acts	Number of violent acts by Illegal Armed Groups (FARC, AUC, ELN) per Municipality, including terroristic acts, assaults, attacks, roadblocks, ambushes, harassment, attacks on population.
MR	Murder Rate by illegal armed groups	2001 to 2008	Colombian National Police - Estimation by the Authors	Number of homicides	Number of homicides per 100,000 inhabitants committed by illegal armed groups (FARC, AUC, ELN). Homicides committed by common crime are not taken into account.
MAG	Number of murders by illegal armed groups	2001 to 2008	Colombian National Police	Number of homicides by illegal armed groups	Homicides committed by common crime are not taken into
PPF	Percentage of primary forest area	2000	Colombia Ecosystem map (shape) - Institute of Hydrology, Meteorology and Environmental Studies of Colombia (IDEAM - Spanish acronym for "Instituto de Hidrología, Meteorología y Estudios Ambientales de Colombia") - Estimation by the authors	Percentage	Hectares of primary forest as percentage of the total area of the municipality.
PCOCA	Percentage of coca area	2001 to 2008	Coca maps (shape) - Integrated Illicit Crops Monitoring System (SIMCI: Spanish acronym for "Sistema Integrado de cultivos ilícitos")	Percentage	Hectares of cultivated coca as percentage of the total area of the municipality.
NCOMP	Number of complaints to the Ombudsman by citizens concerning aerial spraying	2001 to 2008	Local and National Ombudsman's Office	Number of complaints	Number of complaints to the Ombudsman by citizens concerning aerial fumigation
AF	Aerial fumigation	2001 to 2008	National Direction of Narcotics (DNE - Spanish acronym for "Dirección Nacional de Estupefacientes")	Number of hectares	Number of fumigated hectares per municipality
CA	Coca Area	2001 to 2008	Coca maps (shape) - Integrated Illicit Crops Monitoring System (SIMCI: Spanish acronym for "Sistema Integrado de cultivos ilícitos")	Number of hectares	Ha of area cultivated with coca in the municipality
RPOP	Rural population	2005	National Administrative Department of Statistics - DANE, estimation by the authors	Number of persons	Number of persons living in the rural zones of each municipality
AF01-08	Area fumigated between 2001 and 2008	Total 2001 - 2008	National Direction of Narcotics (DNE - Spanish acronym for "Dirección Nacional de Estupefacientes")	Number of hectares	Total area fumigated between 2001 and 2008
SDC01-08	Indicator of variation in coca cultivation	Total 2001 - 2008	Coca maps (shape) - Integrated Illicit Crops Monitoring System (SIMCI: Spanish acronym for "Sistema Integrado de cultivos ilícitos")	Number of hectares	Standard Deviation of the area of coca cultivated from the 2001-200
ABC and AIT	Area of the municipality belonging to indigenous territories and black communities		Maps of black communities and indigenous territories (shape) - Geographic Institute Agustín Codazzi	Number of hectares	Number of hectares under legal status of indigenous territory (AIT) or under title of black communities (ABC)
AECO	Area of natural cover and natural ecosystems at municipal level	2000	Colombia Ecosystem map (shape) - Institute of Hydrology, Meteorology and Environmental Studies of Colombia (IDEAM - Spanish acronym for "Instituto de Hidrología, Meteorología y Estudios Ambientales de Colombia") - Estimation by the authors	Number of hectares	Hectares of natural cover of a certain ecosystem type within the municipality
CALS	Area cultivated with coca in each of the main territorial divisions according to legal status	2000 - 2008	Coca maps (shape) - Integrated Illicit Crops Monitoring System (SIMCI: Spanish acronym for "Sistema Integrado de cultivos ilícitos") and maps of black communities territories, indigenous territories, National Natural parks, Subtracted area from forest reserve - Geographic Institute Agustín Codazzi	Number of hectares with coca in each of the legal status of the territory selected, by year	Number of hectares with coca crops in afro-colombian territories, indigenous territories, forest reserve, subtracted area from the forest reserve and national natural parks



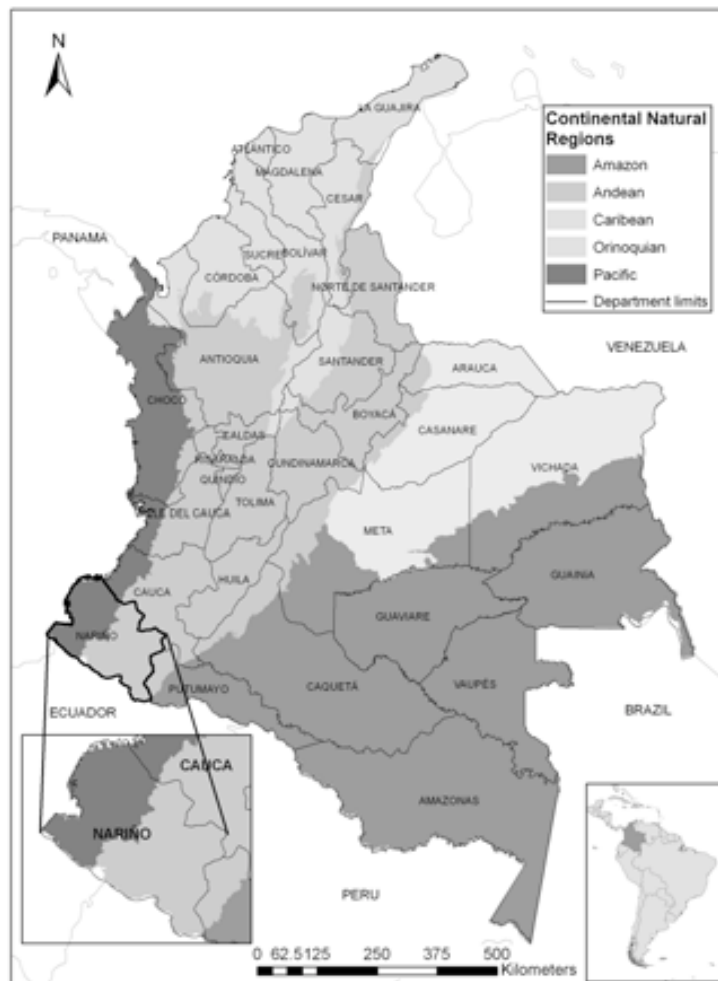
## **4.3 Evidence**

### **4.3.1 The effects of aerial fumigation on coca production**

According to the government data that we used, between 2000 (commencement of Plan Colombia) and 2008, coca cultivations at a national level have been reduced from an area of 163.000 ha to half, i.e. 81.000 ha. However, unlike what the government claims, CIA's Crime and Narcotics Center (CNC) has reported that between 2001 and 2007 the area cultivated with coca has remained stable at around 170.000 ha. (GAO, 2008). Rather than such national aggregates, we are more interested in the territorial distribution and impacts of coca production. We will show that even with the use of the official government data that should have been favorable to the effects of fumigation, it appears that fumigation policy has not eradicated, but diffused production to the territory, especially in socially and ecologically vulnerable zones, affecting the lives of more people.

Before the start of fumigations, most coca cultivations were concentrated in the northern region of Colombia, at the Colombian Amazon (Map 12). In 2000 the three departments of the Amazon region alone (Putumayo, Guaviare and Meta), out of the total of 32 departments in which Colombia is divided, accounted for 58% of the national production of coca. And it was there that 56% of the fumigations in 2000 concentrated. However, following the fumigation policy coca production was dispersed to new regions principally in the Pacific region (Nariño and Chocó departments). We demonstrate this "balloon effect" (Paredes and Correa, 2007) in four ways: 1) graphically (maps 13 and 14), 2) statistically (table 11), 3) with a cross-sectional municipal analysis (figure 1 and map 15) and 4) in section 5, with a case-study (fig 2). Since our analysis focuses on the fumigation policy, we do not include manual eradication. This makes it likely that we are overestimating the effects of fumigation in causing the "balloon effect". Note however that fumigations have affected a greater part of the territory than manual eradication (172.000 ha vs. 41.000 ha in 2006, and 133.00 vs. 95.000 ha in 2008; (UNODC, 2006, 2008a, 2009).

Maps 13 and 14, which are derived from our municipal database (table 10), compare changes in area fumigated (2002-2003 and 2006-2007) with changes in the area occupied by coca crops in the subsequent year (2003-2004 and 2007-2008). We find that in the municipalities where fumigations increased (black colour – maps 13a and 14a), the extent of land covered by coca area declined in the subsequent period (grey colour – maps 13b and 14b). However there was an increase in the extent of the cultivated area in the municipalities neighbouring the areas fumigated (black color – maps 13b and 14b). Therefore the shrinking of coca production in one part came at the expense of expanding in another. In other words, even if overall coca cultivation were to be decreasing (as the official data claims), it is nonetheless diffusing in the territory.



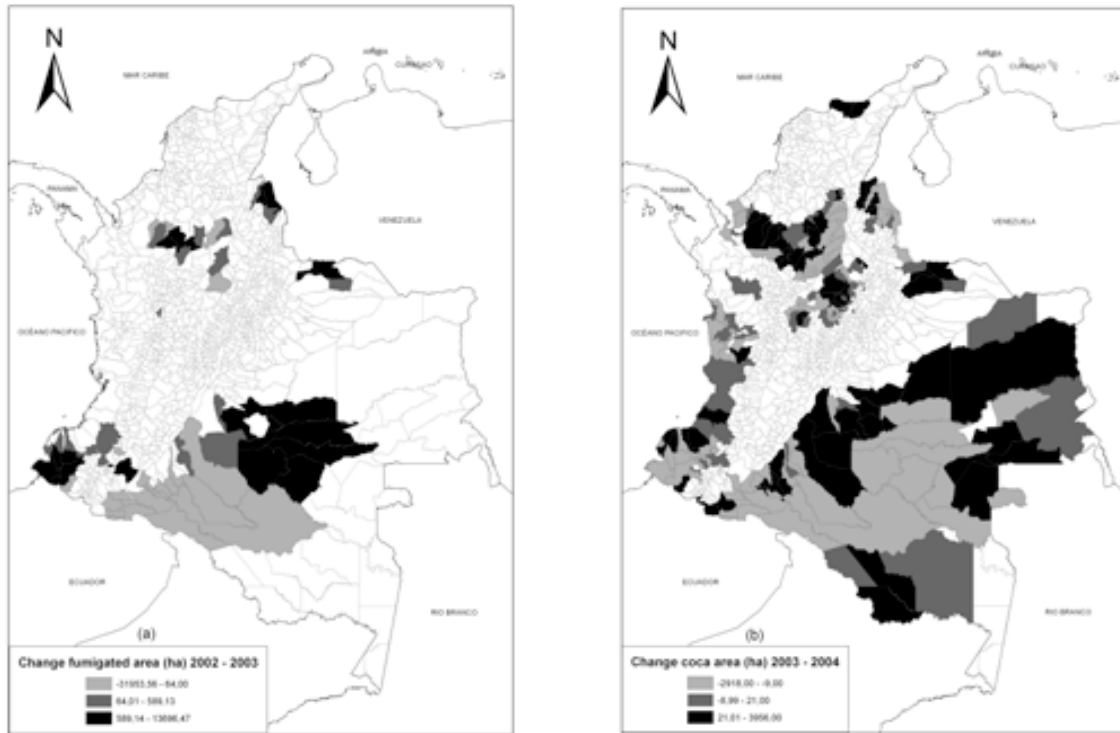
Map 12. Departments and Natural (continental) regions of Colombia.

In addition to the visual representations of Map 13 and 14, we test the proposition of a balloon effect by analyzing statistically the spatial association between the fumigated area by municipality for the year  $n$  and the area under coca in the bordering municipalities in the year  $n + 1$ . The estimation was done using the multivariate Moran's I coefficient, an indicator of spatial correlation (Anselin et al., 2002). We found a positive association between the area fumigated in a municipality in year  $n$ , and the area under coca plantation in bordering municipalities in the year  $n + 1$  (Table 11). In other words, there is a direct association between aerial fumigation of a municipality and subsequent increase of coca production in a nearby one. This finding of a “balloon effect” is not unique to aerial fumigation or Colombia, but has also been observed in the cases of manual eradication programs in Bolivia and Peru (Bradley and Millington, 2008; Salisbury and Fagan, 2011).

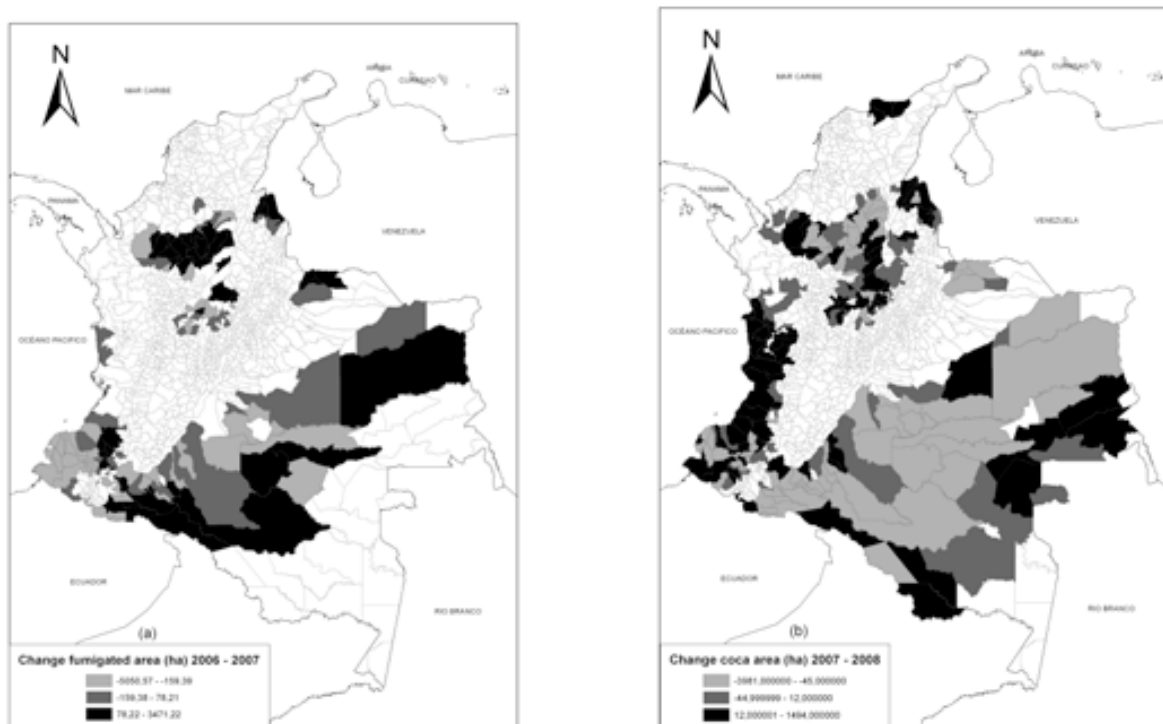
Correlation is not causation. First, while we can ascertain expansion in neighbouring areas after fumigation, we do not have data to document actual displacement. However it is not far-fetched to hypothesise that expansion in neighbouring areas is the result of displacement, as corroborated by many of our interviews.

Second, it can be that the departure of coca production from one area is the result of other factors, such as a coca production saturation effect, increased local conflict or changes in labour conditions. The hypothesis here would be that the areas experiencing these changes would be the ones with more intense development of coca production and hence the ones more likely to be fumigated. Fumigation therefore would correlate with expansion in neighbouring areas (through displacement) but with no causal relation. Again, such factors were not identified as important neither in the literature review nor the interviews, but of course these alone cannot rule them out. Given however that we compare fumigation at time  $n$  with neighbouring production at time  $n+1$ , we find it less plausible that such a clear “cat and mouse” dynamic would emerge simply by fumigation following year after year saturated or conflicting areas, i.e. zones where production was already at the point of moving to a neighbouring zone. What we cannot rule out however is the possibility that fumigation acted in concert with some of these or other factors to cause the migration of production; for example it can be that the areas fumigated were also the ones where there were other forms of confrontation or violence causing displacement of cultivation, and so displacement was not

the effect of fumigation alone. Further research is necessary to isolate the causal contribution of each factor and their interactions.



Map 13. (a) Change fumigated area 2002-2003 and (b) Change coca area 2003-2004.



Map 14. (a) Change fumigated area 2006-2007 and (b) Change coca area 2007 - 2008.

*Table 11.* Moran's I – Spatial correlation of area fumigated per municipality in year n with area under cultivation in the same municipality in year n+1 / \* Significant correlation (0,05).

Area sprayed by municipality in the year n	coca area in the neighborhood municipalities in year n +1	Moran's I
2001	2002	0,105*
2002	2003	0,102*
2003	2004	0,217*
2004	2005	0,192*
2005	2006	0,121*
2006	2007	0,235*
2007	2008	0,179*

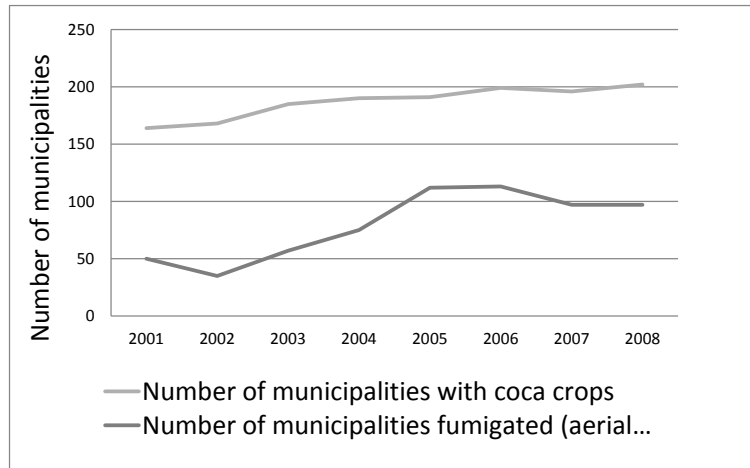
\*. Correlation is significant at the 0.05 level (2-tailed).

Contributing to the understanding of the balloon effect, we find that it is not so much the case that the geography of coca production is shifted from one area to the next, but that production is diffused across municipalities. The number of municipalities with coca plantations within their territories increased from 164 in 2001 to 202 in 2008 (Figure 1.). All the new (to coca) municipalities have plantations that exceeded the 100 hectares, suggesting that there is extensive cultivation going on, and that this is not a minor side-effect. Furthermore, while by 2001, only 85 municipalities had coca cultivations exceeding 100 ha, by 2008 the number of municipalities with such extensive cultivations had increased to 106.

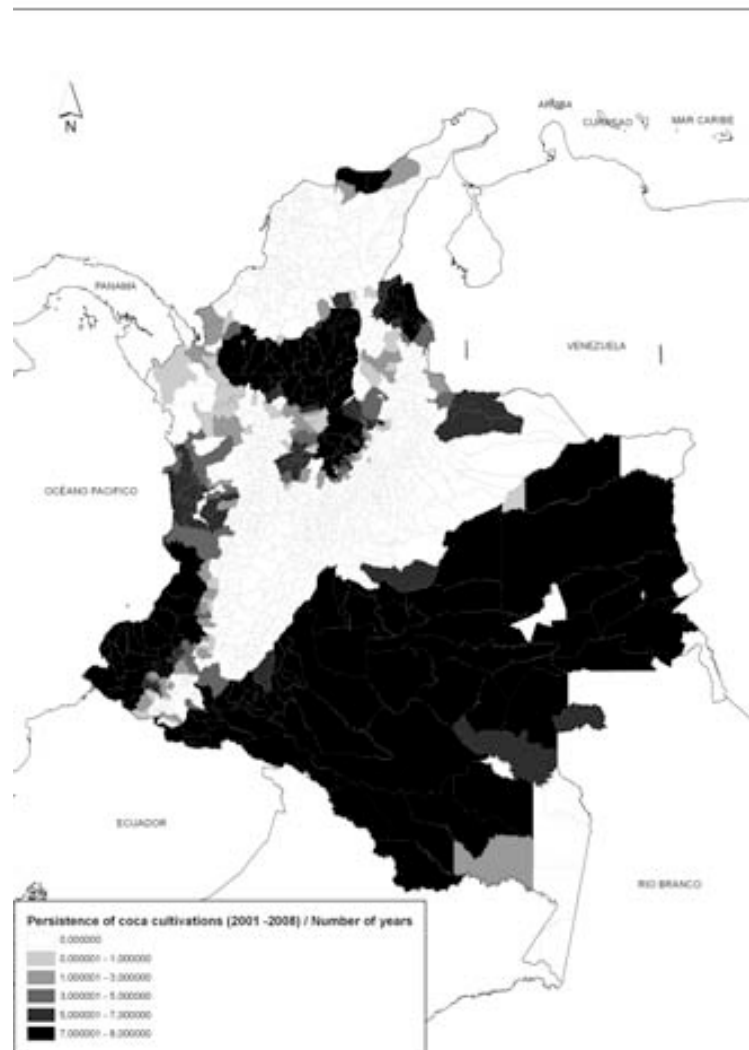
This expansion of the cultivation to new territories, has produced a subsequent increase of aerial fumigation in the new territories. In turn, and in a vicious cycle mode, this has caused new displacement of coca cultivations. Interestingly in some cases, this has caused a return to areas previously fumigated. A consequence is that the number of municipalities fumigated increased accordingly. Figure 1 shows that in 2001, 50 municipalities were fumigated, but this number increased to 97 in 2008. Rather than an intensification of the policy, this can be seen as evidence of its failure to eradicate coca production in the targeted areas. The result is the geographical expansion of both coca and the war on drugs frontier. Map 4 illustrates spatially the persistence of coca production in the territory by indicating the number of years that each municipality has experienced coca cultivation (minimum 1, maximum 8): many municipalities have seen a continuous production of coca in their territory. In none of the

municipalities fumigated during the study period were crops eliminated completely. In fact 81 of the 143 fumigated municipalities show an increasing trend of coca crops<sup>6</sup>.

*Figure 1.* Growth in municipalities with coca cultivations and in municipalities being fumigated (2001-2008).



<sup>6</sup> The trend was estimated by lineal regression: coca area = f (time)



Map 15. Persistence of coca cultivations. Number of years that the municipalities had coca cultivations in the 2001-2008 period.

Our data suggests also that coca plantations go away during fumigation, but come back after the territory stops being fumigated. The evidence is the statistically significant correlation<sup>7</sup> between the size of the area fumigated between 2001 and 2008 and an indicator of variation in coca cultivation, measured as the standard deviation of the area of coca cultivated from the 2001-2008. In other words, the more a municipality is sprayed the more “back and forth” of coca production it experiences.

<sup>7</sup> Pearson Correlation 0.728 / significant at the 0.01 level

In conclusion: fumigation is associated with expansion of production to other areas, which can be taken as evidence of displacement. Such displacement diffuses the problem in the territory, with coca production affecting more areas, and presumably more people. Furthermore, production returns, even if at a lower level, to the areas from which it was supposedly eradicated by aerial fumigation. Our local level analysis confirms national and regional level studies, which have claimed that fumigation is not an effective approach in eradicating coca production. Furthermore, in addition to the displacement pattern identified by these studies, we highlight a broader pattern of diffusion.

### **4.3.2 Fumigation and deforestation**

The official government discourse is one that links fumigation and sustainability, in the sense that more fumigation means less coca production and hence less deforestation. Instead we find that the territorial diffusion of coca activities leads to continued and expanding deforestation, and we attempt to characterize the environmental characteristics of the new areas of the forest affected by coca and fumigations.

On the basis of the crossing of the ecosystem map of Colombia in 2000 and the coca maps (2001 - 2008) in shape format, we estimated the extent of natural ecosystems (forest) affected by coca diffusion year by year, based upon data on existing ecosystems and natural cover for 2000. Table 12 presents the extents of natural forest affected by coca during the period 2001 - 2008. At the beginning of the decade, the Amazon and Orinoco region ecosystems were those most affected, but impact upon them has decreased over time: 71.920 ha of coca in 2001 were occupying natural forest in 2000, but in 2008 this area decreased to 22.270 ha. In contrast in 2008 the natural forests of the Caribbean region and especially of the Pacific region, which is considered one of the biodiversity hotspots of the world, showed significant increases in coca conversion. 1.982 ha. that were natural forests in 2000 in the Pacific became coca cultivations by 2001, and by 2008 this area had increased to 8166 ha.

Even if fumigations had reduced the total area of coca cultivations in Colombia, they have increased deforestation since the balloon effect means that new areas of primary forest are deforested as the war pushes the frontier to new territories. Furthermore, the primary forest



that is lost to coca plantations is irreplaceable. Even though fumigation may displace coca, the previous state of the forest is not recoverable. According to the data of SIMCI the displacement of coca crops to new areas has generated a deforestation of primary forest of 110,026 ha between 2001 and 2008.

*Table 12.* Natural forest in 2000 converted into coca cultivations between 2001 to 2008.

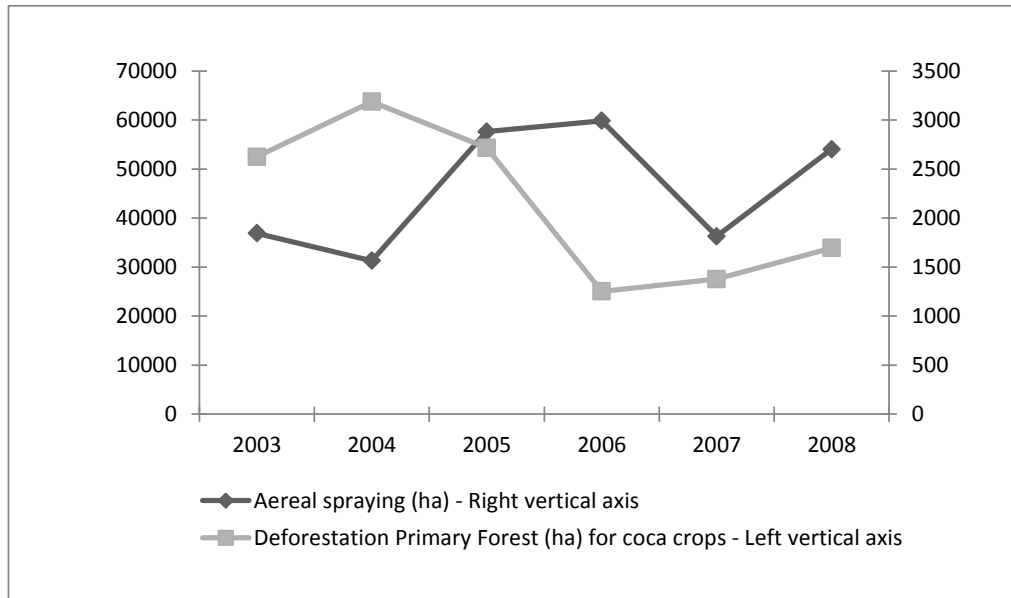
Natural forest in 2000 converted into coca cultivations between 2001 to 2008	2001	2002	2003	2004	2005	2006	2007	2008
Amazon and Orinoquian Region	71910	61536	39027	33616	39684	33120	35613	22270
Pacific Region	1982	4640	4526	3821	3792	2788	5839	8166
Caribe Region	3797	3352	3918	3258	4039	2336	6125	5712

Our research at Nariño confirms this pattern at the level of a department. About 40% of the area under coca in Nariño in 2008 was natural forest in 2000. Nariño has ten eco-regions, five of them occupied by coca cultivations; between 2003 and 2008 18%, of the total of deforestation caused by coca in Colombia took place in Nariño. According to SIMCI data, 13.000 ha of natural forest has been converted to coca in Nariño in 2003-2008. 22% of the total area cultivated with coca in 2008 was tropical rain forest in 2000. 8% was riparian forest.

Whereas there is a clear link between coca production and deforestation, this should not be read as an argument in favour of fumigation (and the common replacement by oil palm plantations). Fumigation diffuses and expands deforestation, while an industrial tree plantation is no substitute for primary forest loss. Figure 2 illustrates the persistence of coca crops and the vicious cycle of fumigation, that characterizes Nariño. An increase in fumigation is associated to a decrease in deforestation (without deforestation disappearing altogether). Nevertheless, when fumigation decreases, the deforestation due to coca cultivation starts increasing again. Interviews with peasant from the area confirm that coca cultivations that had moved to nearby territories return to where they had left from. Rather than an argument for a continuous or intensified fumigation, the point here is that fumigation causes merely spatial displacement and additional destruction, and is ultimately ineffective as a strategy of reduction of coca cultivation. An exception to this pattern of displacement is the last years depicted in figure 2 (2007 – 2008), where despite the increase in fumigation there is

an increase also in coca-driven deforestation. A possible explanation is that coca production is no longer displaced to other department but to new municipalities within Nariño itself.

*Figure 2.* Aerial fumigation (ha sprayed) and deforestation into coca crops in Nariño / Colombia (2001 – 2008).



In conclusion: fumigation does not reduce deforestation. It displaces production from areas where the primary forest is already lost biodiversity hotspots where additional primary forest is destroyed.

#### 4.3.3 The effects of fumigation on health and agriculture

The impacts of aerial fumigation on the health of local population and the legal crops are intensely debated in Colombia. Some researchers cannot find statistically significant evidence given that local people usually have contact with many other toxic substances that can cause health effects (such as pesticides and herbicides used on crops) (Varona et al., 2009). Plan Colombia fumigation continues on this basis, the anti-drug police spraying the territory with a mixture of the herbicide 'Roundup Ultra', commercial name by its proprietary 'Monsanto' that holds glyphosate and the surfactant polyethoxylated tallowamine (POEA) and 'Cosmo-flux 411F'. In Colombia, pesticides containing glyphosate such as 'Roundup' are registered

under the toxicological class IV (slightly toxic) (Nivia, 2001). The US Environment Protection Agency (EPA) registers glyphosate in Toxicity Category III (with Category I being the most toxic and IV the least). In terms of carcinogenicity it has been placed in Category E, i.e. with evidence of non-carcinogenicity in humans (Sherret, 2005).

Various government sources argue that fumigations have not exceeded health or environmental norms and have not had negative effects, an argument that has been used in favor of the continuation of the policy (United States Department of State, 2010). The Organization of American States (OAS) also published a study in 2005 noting that the chemicals used to aeri ally eradicate coca did not pose significant risks to humans and most wildlife (Solomon et al., 2005a; Solomon et al., 2005b). Similar is the conclusion of the International Narcotics Control Strategy Reports financed by OAS, which also added that the damage from drug crop production and processing far outweighs the negligible risk from exposure to glyphosate due to coca or poppy spraying. (Bernal et al., 2009; Bolognesi et al., 2009; Brain and Solomon, 2009; Hewitt et al., 2009).

On the other hand other researchers and NGOs working in the region have provided evidence on the negative impacts of the fumigations on the population's health and the environment (Ávila et al., 2007; Eslava et al., 2007; IDEA, 2005; Nivia, 2001, 2001a; Walsh et al., 2008a). In several countries "Roundup" was among the first pesticides that was reported to cause human poisoning, and effects reported after exposure include nausea, dizziness, respiratory problems, increased blood pressure and allergic reactions (Nivia, 2001). And according to the Farm Chemicals Handbook (1990), it is not recommended to use glyphosate via aerial application due to environmental effects. Colombia's fumigations with glyphosate have reportedly generated environmental problems in neighboring Ecuador, as verified by government institutions and scientists (Ávila et al., 2007). Glyphosate has been developed to be applied directly to plant leaves and not through the air (Haney et al., 2000). Similarly (Sherret 2005) argues that the problem with aerial fumigation in Colombia is not the toxicological profile of glyphosate per se, but the open violation of the norms for its application whether through ignorance or intent.

Local communities insist on their experience of the negative impacts of the aerial fumigation, and have denounced the crime perpetrated against them with national-level protests and

communiqués (Defensoria del Pueblo, 2007, 2009; La Nación.com.co, 2010; OAIPC, 2010; Oslender, 2010). Studies also of the Institute of Environmental Studies of the National University of Colombia question the results of the OAS studies (Solomon et al., 2005a; Solomon et al., 2005b). Of course, such struggle over scientific uncertainty and complexity in an environmental health issue is not unique to fumigation in Colombia, but characteristic of many other environmental controversies. The government continues to deny any link between fumigations and adverse health effects, whereas NGOs call for an application of the “precautionary principle”, i.e. a precautionary banning of fumigation given its unknown and disputable, yet highly risky health effects, but in vain (Kennedy and Stefani, 2009).

Health effects are very difficult to verify and this is beyond the purpose of our study. Still, our data confirms a significant correlation between area fumigated and the number of complaints submitted to the Ombudsman and local authorities, a rough indicator of impacts on livelihoods (Table 17). At the beginning of the decade, aerial fumigation was especially concentrated in the department of Putumayo, which received 47% of all aerial fumigation in Colombia (of 224.516 ha sprayed in Colombia between 2001 and 2002, 104.397 ha were in Putumayo). According to our analysis of archives between mid 2001 and mid-2002 the Ombudsman received 318 complaints concerning health impacts or the loss of (legal) crops from aerial fumigation in the 3 municipalities of Putumayo where 6076 families live. A 2002 study conducted by the health department of Putumayo on the impact of fumigations in community territories showed that 4883 (81.5%) of the 5,929 people that had filed complaints reported health problems when interrogated by municipal officials. Furthermore, a 2007 report of the Ombudsman's Office in Putumayo, based on direct observation of the people recovered in the local hospitals, revealed that vomiting and diarrhea, headaches and respiratory problems were common symptoms of those exposed to fumigation. (O'Shaughnessy, H. 2005) documents also negative health effects in the poorer segments of the population, based on field-work in Putumayo. After the increase of claims between 2001 and 2003, there was a decreasing tendency of claims starting in 2004. Our interviews suggest that farmers stopped to report due to the lack of response by PECIG, the authority overseeing the program of eradication. People no longer believed that the state will attend their claims and complaints. And this may explain why a total of 2559 claims in 2003 were reduced to 781 in 2008. Our field-work and our collection of interviews and photographic material convinced us of the actual impact of fumigations on legal crops, even though we could not

conduct proper scientific assessments. Media have also documented with interviews and reports the impacts fumigation in local communities of the Colombian pacific region (TeleSur\_TV, 2011, 2011a)

In Nariño, the arrival of aerial fumigation was followed by an increase in formal complaints and claims by the local population. Of the reported claims on the aerial fumigation in the country between 2001 and 2008, 45% came from Nariño and concerned health and crops loss, while at the peak of 2003, 76% of the total claims (1950 claims) were from Nariño. (Defensoria del Pueblo, 2007, 2009; Policia Nacional de Colombia - Dirección de Antinarcoticos, 2010). Our analysis of the archive of the complaints shows that between 2000 and 2006, a total of 1177 families reported effects from aerial fumigation including death of domestic animals (ducks, chickens, pigs and cows), pollution and destruction of legal crops used for self-consumption (chiro, chilma, cassava, papacum, chontaduro, banana, coconut, cacao, corn, etc.) and impacts on their health. Indigenous testimonies reported the deaths of three children and two abortion cases between 2000 and 2006 due to the fumigation. CODHES, an organization monitoring human rights and displacement, denounced the death of 25 indigenous children from starvation due to the impact of fumigation on food crops (El Espectador, 2008). During our interviews, indigenous leaders told us that there was no previous consultation or warning about the fumigations and claimed that their water sources have been contaminated and that they have lost seeds and medicinal plants. At the time of writing of this article, indigenous groups continue to denounce publicly the displacement that fumigations cause (Autoridades Indígenas AWÁ – UNIPA, 2011). There is still no evidence of any intervention or assistance from public or private entities as a response to the indigenous claims, despite the repeated denunciations of the terrible impacts (Oslender, 2010; Walsh et al., 2008b).

In conclusion: it is not possible to verify beyond doubt the negative impacts on the health of the people residing in the fumigated areas. There are however serious indications that fumigation affects the health of people and their legal crops. Relevant evidence includes the explosion in the number of formal complaints associated to the fumigations and anecdotal experiential evidence, such as this collected in our interviews with local people and the photographs we took of agricultural crops affected by fumigations.

#### 4.3.4 Aerial fumigation and human displacement

Nariño has been one of the departments of Colombia that has suffered the most in terms of forced human displacement. In 2000 when aerial fumigation started in Nariño, 732 displaced cases were reported, representing a 0.3% of the total in Colombia. But between 2001 and 2008 and as production and fumigations increased so did displacements reaching a total of 31,314 in 2008, corresponding to a 10% of the total of the population displaced in Colombia (301,754)<sup>8</sup>.

What is happening in Nariño is part of a broader pattern. Based on our analysis, 70% of the municipalities that experienced increased fumigations between 2001 and 2008 also present increasing tendencies in forced displacement of the population, as measured by the National Registry on forced population. There is also a significant correlation between fumigated areas and forced displacement for all the years analyzed. In other words, the more the area fumigated in a municipality, the higher the number of people that leaves it.

According to our interviews there are two factors at play: first, part of the population was economically dependent on coca and traditional crops and the destruction of cultivation by the fumigations forced them to move to other municipalities. Second, the aerial fumigation impacted the traditional crops even of those families that were not involved in coca, affecting food security and forcing them to migrate (see also Messina (2010) for Putumayo, who documented that fumigation does not affect only areas with coca but also areas with other cultivations). Indigenous and Afro-colombian communities have denounced the displacement of population from their communities as a consequence of the water contamination, land degradation and loss of food security caused by fumigations (CODHES, 2011; Martinez-Alier et al., 2010; OAIIPC, 2010; Oslender, 2010; Solomon et al., 2005a; Walsh et al., 2008a)

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<sup>8</sup> Displacement in Colombia and subsequent migration also had to do with the Pudricion de Cogollo (PC), a disease the oil palm had, and which hit gravely all the farmers that had adopted monoculture palm systems and dedicated less time to subsistence crops.

The government emphasises the first driver, i.e. the displacement of coca farmers. From its perspective this is not necessarily a problem, since these are workers who are involved in illegal activities. Furthermore, the government puts blame on other factors and argues that it is not the fumigations that have impacts on the population (Solomon et al., 2005a). and force them to leave The proposition is that displacement is mostly a result of the general armed conflict and the violence of the armed groups and not the fumigations *per se*. Fumigations target the areas where coca and illegal groups presence is strong; according to this narrative, it is not the fumigations that make the people leave but the violence of the coca business and the illegal groups. However other researchers and NGOs (CODHES, 2008, 2009; Ibáñez and Moya, 2007; Ibáñez and Vélez, 2008) suggest that aerial fumigation is directly related and implicated in the armed conflict, and is in many and different ways a cause of displacement in Colombia.

To test the claim of a relation between fumigation and displacement we investigate whether there is a statistically significant correlation between the extent of area fumigated and the number of people displaced. To isolate this from the direct displacement effects of violence, we control for murder rate and violent acts by illegal groups (State-used indicators of violence). In both cases we find a statistically significant correlation (Tables 13 and 14), which confirms that fumigation is associated to displacement independent of the effects of violence. This is not to deny the effect of violence on displacement, only to suggest that fumigation may have a separate effect over and on top of violence. Furthermore formal econometric research along the lines of Angrist (2008) could shed more light on the relative weights of the factors that affect displacement and their possible interaction. One possible causal chain that needs to be further interrogated concerns a secondary displacement effect, whereby fumigation in one area causes displacement to a neighbouring one, escalation of the violence there, leading to further displacement.

Table 13. Partial correlation between Aerial Fumigation (AF) and Forced Displacement of Population (FDP) controlled for Violence (number of murders by illegal armed groups - MIAG).

Control Variable	Var 1	Var 2	Partil Correlation	Value
MIAG 2003	AF 2003	FDP 2003	Correlation	0,075
			Significance (2-tailed)	0,011
MIAG 2004	AF 2004	FDP 2004	Correlation	0,189
			Significance (2-tailed)	0,000
MIAG 2005	AF 2005	FDP 2005	Correlation	0,118
			Significance (2-tailed)	0,000
MIAG 2006	AF 2006	FDP 2006	Correlation	0,131
			Significance (2-tailed)	0,000
MIAG 2007	AF 2007	FDP 2007	Correlation	0,170
			Significance (2-tailed)	0,000
MIAG 2008	AF 2008	FDP 2008	Correlation	0,217
			Significance (2-tailed)	0,000

Table 14. Partial correlation between Aerial Fumigation (AF) and Forced Displacement of Population (FDP) controlled for Violence (number of violent acts by illegal armed groups - VAIA ) / There was not statistical significance for 2007.

Control Variable	Var 1	Var 2	Partil Correlation	Value
VAIA 2002	AF 2002	FDP 2002	Correlation	0,122
			Significance (2-tailed)	0,000
VAIA 2003	AF 2003	FDP 2003	Correlation	-0,019
			Significance (2-tailed)	0,535
VAIA 2004	AF 2004	FDP 2004	Correlation	0,142
			Significance (2-tailed)	0,000
VAIA 2005	AF 2005	FDP 2005	Correlation	0,080
			Significance (2-tailed)	0,007
VAIA 2006	AF 2006	FDP 2006	Correlation	0,073
			Significance (2-tailed)	0,014

We investigated also whether there remains a correlation between aerial fumigation and displacement after controlling for the number of people actively employed in coca, i.e. to exclude the possibility that a higher displacement is simply the effect of more people



working in coca, and being displaced as a result of fumigation kicking out the crop. In other words, our goal is to see whether people leave because of fumigation or because coca is eradicated. Since there is no data available on the number of people employed in coca in each municipality, we use the ha of coca cultivated as a proxy for employment. Again, we find a statistically significant correlation, suggesting that fumigation displaces also normal residents, and not only those involved in coca cultivation (Table 15), which is in accordance with what peasants told us in Nariño (see below)..

*Table 15.* Partial correlation between Aerial Fumigations (AF) and Forced Displacement of Population (FDP) controlled for coca crops area (CA) / There was no statistical significance for 2003 and 2008.

<b>Control Variable</b>	<b>Var 1</b>	<b>Var 2</b>	<b>Partil Correlation</b>	<b>Value</b>
CA2001	AF-01	FDP-01	Correlation	0,113
			Significance (2-tailed)	0,001
CA02	AF-02	FDP-02	Correlation	0,156
			Significance (2-tailed)	0,000
CA04	AF-03	FDP-04	Correlation	0,190
			Significance (2-tailed)	0,000
CA05	AF-04	FDP-05	Correlation	0,169
			Significance (2-tailed)	0,000
CA06	AF-05	FDP-06	Correlation	0,130
			Significance (2-tailed)	0,000
CA07	AF-06	FDP-07	Correlation	0,077
			Significance (2-tailed)	0,014

In conclusion there is suggestive evidence that fumigation is associated with increased human displacement, even after taking into account the contribution of violence and the displacement of the labour working in the coca fields.

#### **4.4 The uneven effects of fumigation**

Is everyone in Colombia affected the same by fumigation and by its side-effects, i.e. displacement and arrival of coca production from the areas that were fumigated?

The first important finding is that the new coca areas where production moves after fumigation tend to be less developed, impoverished areas, populated by indigenous and Afro-Colombians. 73% of the municipalities exhibiting an increase in coca cultivation between 2001 and 2008 have a Rural Unsatisfied Basic Needs Index (RUBN) superior to 50% (generally considered the limit value indicating impoverishment). A second index of impoverishment and public services is the “municipal development index” (IMD): 83% of municipalities that have exhibited increasing coca cultivation between 2001 and 2008 have an index value less than 50. This indicates that poverty is prevalent in the majority of the departments where coca advances (Dion and Russler, 2008).

Our data shows also a statistically significant correlation between coca cultivation and the presence of illegal armed groups, which are typically (though not always) those involved in the coca business, as well as with the remoteness of an area (Table 16; the presence of illegal armed groups is captured in indicators such as the number of violent acts and murders by illegal armed groups). In Nariño 17 people from the Awá indigenous community were massacred in 2009, events that have been covered by the mass media and were reported to us in our interviews with indigenous leaders (ACNUR, 2009; Espectador, 2009).

Coca cultivation is correlated also well with (low) road density and (high) level of natural cover. There is also a statistically-significant and strong inverse correlation between the percentage of the municipal area cultivated with coca and indicators of development (RUBN and IMD) (Table 16). All this suggests a particular geography of the ballooning coca frontier towards remote and impoverished areas where violence is already present (Garcés, 2005b), with the possibility of escalating levels of violence after the arrival of coca (Angrist and Kugle, 2008), since the general income hardly increases (Davalos (2009).

Table 16. Pearson's correlations between % municipal area cultivated with coca and other variables associated.

% coca crops area / Road Density 2000								
Year	2001	2002	2003	2004	2005	2006	2007	2008
Pearson Correlation	-,093(**)	-,168(**)	-,178(**)	-,174(**)	-,193(**)	-,179(**)	-,193(**)	-,216(**)
Sig. (2-tailed)	0,002	0,000	0,000	0,000	0,000	0,000	0,000	0,000
N	1.125	1.125	1.125	1.125	1.125	1.125	1.125	1.125
% coca crops area / Municipal Development Index								
Year	2001	2002	2003	2004	2005	2006	2007	2008
Pearson Correlation	-,101(**)	-,186(**)	-,194(**)	-,190(**)	-,207(**)	-,202(**)	-,235(**)	-,283(**)
Sig. (2-tailed)	0,001	0,000	0,000	0,000	0,000	0,000	0,000	0,000
N	1.102	1.102	1.102	1.102	1.102	1.102	1.102	1.102
% coca crops area / Forced displacement of population - FDP (number of people)								
Year	2001	2002	2003	2004	2005	2006	2007	2008
Pearson Correlation	,192(**)	,228(**)	,138(**)	,144(**)	,264(**)	,305(**)	,262(**)	,378(**)
Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
N	1.124	1.124	1.124	1.124	1.124	1.124	1.124	1.124
% coca crops area / % Natural Cover 00								
Year	2001	2002	2003	2004	2005	2006	2007	2008
Pearson Correlation	,109(**)	,256(**)	,246(**)	,220(**)	,261(**)	,238(**)	,254(**)	,316(**)
Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
N	1.124	1.124	1.124	1.124	1.124	1.124	1.124	1.124
% coca crops area / rate of Forced displaced of population								
Year	2002	2003	2004	2005	2006	2007	2008	
Pearson Correlation	,152(**)	,090(**)	,094(**)	,172(**)	,167(**)	,210(**)	,275(**)	
Sig. (2-tailed)	0,000	0,003	0,002	0,000	0,000	0,000	0,000	
N	1.124	1.124	1.124	1.124	1.124	1.124	1.124	
% coca crops / Murders by illegal armed groups								
Year	2003	2004	2005	2006	2007	2008		
Pearson Correlation	,119(**)	,108(**)	,328(**)	,286(**)	,289(**)	,259(**)		
Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000		
N	1.124	1.124	1.124	1.124	1.124	1.124		
% coca crops area / rate murders by illegal armed groups								
Year	2003	2004	2005	2006	2007	2008		
Pearson Correlation	0,030	,129(**)	,214(**)	,291(**)	,279(**)	,226(**)		
Sig. (2-tailed)	0,320	0,000	0,000	0,000	0,000	0,000		
N	1.102	1.102	1.102	1.102	1.102	1.102		
% coca crops / RUBN 05								
Year	2005	2006	2007	2008				
Pearson Correlation	,185(**)	,130(**)	,174(**)	,176(**)				
Sig. (2-tailed)	0,000	0,000	0,000	0,000				
N	1.116	1.116	1.116	1.116				

\*\* . Correlation is significant at the 0.01 level (2-tailed).

\* . Correlation is significant at the 0.05 level (2-tailed).

The communities where coca expands, possibly as a result of fumigation, tend to be predominantly indigenous and Afro-Colombian. According to our analysis, during the early 2000s, 7% of the area of coca cultivation was found in indigenous territories, 4% in collective territories of Afro-Colombian communities and 2% in natural parks. By 2008 there is a significant change, as the crops become located mainly in the collective territories of Afro-Colombian communities (36% of the crops). It is estimated that there was an increase of the areas cultivated with coca in the collective territories of Afro-Colombian communities from 10231 ha in 2001 to 29076 ha in 2008. On the other hand the coca area in indigenous territories decreased (according to the official data always) between 2001 and 2008 from 11791 ha to 6049 ha, but following the general pattern it has spread to new indigenous territories, such as the indigenous territory AWA, which is discussed later.

We do not address here why coca moves to this type of regions. Physical-geographical factors that have to do with forest cover, remoteness vis-à-vis lack of access infrastructure are important, but so are socio-political ones of a historical nature (Hough, 2011), socio-economic and institutional factors (Garcés, 2005b; Rangel, 2000; Rocha, 2000; Rubio, 2005) probably related to the low social capital of certain regions (Thoumi, 2005a, 2005d), particularly in those zones where low state capacity and the presence of terror groups prevail (Oslender, 2008).

The same type of statistically significant correlations is observed between fumigation, poverty and remoteness indicators; this makes sense, given that fumigations concentrate to the areas where coca is cultivated and coca cultivation also correlates with these indicators (Table 17). There is therefore an association between the extent an area is fumigated and low levels of rural and municipal development and high levels of rural population. On the other hand, looking at the territorial distribution of coca according to the legal status of a territory, we find that between 2000-2008 coca production increased only in collective territories of Afro-Colombian communities (Table 18), which are suffering disproportionately from the effects of the war on drugs (Walsh et al., 2008b), something confirmed also by our in-situ observations. Afro-Colombian groups have denounced on several occasions the fumigation policy (OAIPC, 2010).

Table 17. Pearson's correlations between aerial fumigation and other variables associated.

Aerial spraying / complaints related to impacts by aerial spraying								
Year	2001	2002	2003	2004	2005	2006	2007	2008
Pearson Correlation	,661(**)	,507(**)	,301(**)	,294(**)	,567(**)	,287(**)	,402(**)	,510(**)
Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
N	1.124	1.124	1.124	1.124	1.124	1.124	1.124	1.124
Aerial aspersion / Municipal Development Index								
Year	2001	2002	2003	2004	2005	2006	2007	2008
Pearson Correlation	-,109(**)	-,096(**)	-,122(**)	-,154(**)	-,095(**)	-,185(**)	-,159(**)	-,240(**)
Sig. (2-tailed)	0,000	0,001	0,000	0,000	0,002	0,000	0,000	0,000
N	1.102	1.102	1.102	1.102	1.102	1.102	1.102	1.102
Aerial aspersion / Murders carried out by illegal armed groups								
Year	2003	2004	2005	2006	2007	2008		
Pearson Correlation	,110(**)	,151(**)	,140(**)	,365(**)	,347(**)	,258(**)		
Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000		
N	1.124	1.124	1.124	1.124	1.124	1.124		
Aerial aspersion / RUBN 2005								
Year	2005	2006	2007	2008				
Pearson Correlation	,066(*)	,131(**)	,124(**)	,153(**)				
Sig. (2-tailed)	0,028	0,000	0,000	0,000				
N	1.116	1.116	1.116	1.116				
Aerial aspersion / Rural population 2005								
Year	2005	2006	2007	2008				
Pearson Correlation	,136(**)	,104(**)	,107(**)	,089(**)				
Sig. (2-tailed)	0,000	0,001	0,000	0,003				
N	1.112	1.112	1.112	1.112				

\*\* . Correlation is significant at the 0.01 level (2-tailed).

\* . Correlation is significant at the 0.05 level (2-tailed).

A further question is whether there is *intentional* discrimination by the government on its fumigation targets, i.e. whether Afro-Colombian and indigenous areas are more likely to be fumigated than those populated by whites, other factors equal. Our data does not suggest so, since there is no remaining correlation between area fumigated and the area occupied by indigenous territories and Afro-Colombian communities if we control for the extent of coca cultivations in the municipality. In other words, the areas mostly fumigated are those that have the most coca. We confirm together with (O'Shaughnessy and Branford, 2005) that these are areas of poor peasants ("campesinos"), often of indigenous or Afro-colombian communities, who therefore suffer disproportionately more from the war on drugs, but we do not find evidence of selective targeting. Nonetheless, this is still a "war on the poor", since it

is the poor that live in the areas where the coca frontier moves and the ones who suffer the impacts of both the coca trade and the chemicals that are supposed to stop it (O’Shaughnessy and Branford, 2005).

*Table 18.* Area cultivated with coca in each of the main territorial divisions according to legal status.

<b>Legal Status of the Territory</b>	<b>2000</b>	<b>2008</b>
Collective territories of afro-Colombian communities	3429	15032
Natural National Park	3877	2691
Forest Reserve	40919	19007
Indigenous territories	11876	5636
Subtracted area from forest reserve	82909	16450

*Table 19.* Expansion of the aerial fumigations 2001-2008 in Colombia and Nariño (ha fumigated).

<b>Aerial Spraying / año</b>	<b>2000</b>	<b>2002</b>	<b>2004</b>	<b>2006</b>	<b>2008</b>
Aerial spraying in Colombia (ha)	58.074	130.364	136.551	171.754	133.496
Aerial spraying in Nariño (ha)	6.442	17.962	31.307	59.865	54.050
% of the total area sprayed in Colombia corresponding to Nariño	11	14	23	35	40

In conclusion: fumigations and coca cultivations are disproportionately concentrated in impoverished areas of peasant, indigenous and Afro-Colombian communities. There is probably no selective fumigation targeting of such communities by the government, but this should not divert us from the basic fact that at the end it is these communities that suffer the most from the indiscriminate chemical “war on drugs”.

#### **4.5 Discussion**

Why does aerial fumigation fail? Here we follow this body of literature which suggests that centrally managed social plans often misfire, when they impose schematic visions that do violence to complex local interdependencies that are not fully understood (Scott, 1999). Norgaard (1994) for example, investigated the failure of State development programs in the

Brazilian Amazon and argued that ecological conditions posed obstacles and huge transaction costs to the development approaches that the Brazilian State imported from other parts of the world. In particular he showed how the productive practices of local groups were well adapted through a historical trial and error process to the ecosystem features of the rainforest, ensuring that small surpluses could be drawn with little transaction costs. Our case-study here, which concerns not a developmental intervention but an “anti-crime” State project of improvement, confirms this thesis of Scott and Norgaard in a very different context. We argue that State policies of fumigation fail to see the particular ecological economy of coca production in the Colombian territory, and hence fail to understand why and how a policy of fumigation is likely to backfire.

The illegal nature of the coca business requires remoteness and ability to hide the plantations. Tropical forests provide ideal environments for growing coca. One reason is that their bio-physical characteristics are favorable to the growth of the crop and to high yields. Equally important however is that access to tropical forests is limited, as it is very difficult to develop road infrastructure there. Their remoteness renders them beyond direct central State control, allowing criminal organizations to hide and avoid persecution (Díaz, 2004; UNODC, 2011). It is therefore the same factors of remoteness vis-à-vis the lack of modern state-based development that render forests both primary biodiversity and conservation hotspots (since human activity has been historically limited) and ideal “habitats” for coca production<sup>9</sup>. From the outset therefore, any policy which has as a result the displacement of production, without being able to control its relocation elsewhere, is likely to cause more deforestation, as illegal groups are likely to move to new patches of remote tropical forest.

For those invested in the coca business, the tropical forests serve multiple functions: stock, shelter and territory (Díaz, 2004; Thoumi, 2005b; UNODC, 2006). Despite distance from urban areas, the abundance and diversity of hydrological resources and flora and fauna can

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<sup>9</sup> Colombia is at the top 12 countries with greatest biodiversity in the world Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B., Kent, J., 2000. Biodiversity hotspots for conservation priorities. *Nature* 403 (6772), 853-858.. With a land area of only a 0.7% of the planet's surface, Colombia hosts about 10% of the fauna and flora of the world. Two of the world's most important biodiversity hotspots are in Colombia: the tropical Andes and the Chocó Humid Forests *ibid.*.

sustain both production and the daily needs of the armed groups that battle for control over territory for coca cultivation. The tremendous surplus generated by the business makes it possible for the criminal organizations to finance and sustain lavish settlements for themselves (and livable for the workers), even if located very distant from markets. Transport and connection are secured by fluvial or aerial transport. (Le Billon, 2001) explains how this peculiar socio-environmental geography of products like coca, which are produced diffusively in the territory (i.e. they are not localized resources, such as mines) and require remoteness, go hand-and-glove with “war-lordism”, i.e. armed illegal groups controlling production and engaging in war with the far-positioned central government. From a government perspective, he explains, fighting war-lords in remote jungles requires risky ground engagement. Aerial fumigation emerges then as a risk-less war from control centers in the cities, yet, it is one of questionable effectiveness.

Why does coca production move though to poor areas and particularly areas where indigenous and Afro-Colombian groups reside? For historical reasons, which are well covered in other works (Álvarez, 2001; Angrist and Kugle, 2008; Fajardo, 2002; Ibáñez and Moya, 2007; Oslender, 2008; Thoumi, 2005) , the areas where these groups reside are also the least-developed (in economic terms) in the Colombian territory and the most remote. Not only they provide ideal hiding and growing locations and are far from the range of intervention of the military, but also, other factors equal, it is easier for the illegal groups to recruit labour there.

The majority of the labor in coca production is allocated to cultivation. Some of the wage laborers not only cultivate but also process the coca leaf. In addition there is a floating population of day laborers who sell periodically their labour on different parts of the chain depending on seasonal production cycles. Wages are generally higher than wages in the labor market (Ibáñez, 2010), although this is not the significant difference. It is the stability and security of income and employment that coca offers that is most appealing to producers. This relative stable profit is tempting enough to compensate for the personal and social disapproval that coca cultivation generates (Ibanez and Carlsson, 2009; Ibáñez, 2010). Again, supply-side policies of distant engagement, such as fumigation, do little to change these dynamics. By destroying legal together with illegal crops, they retain coca production as an attractive livelihood option for poor peasants. As more and more people become destitute as



a result of the fumigations and the terror of the illegal groups, the supply of mobile coca labourers increases, making coca production more responsive and adaptable to fumigation, labour and production moving back and forth from fumigated areas with more ease.

There are different policy options, more fit to the complex socio-ecology of Colombia's tropical forests and the ecological economy of the coca industry. Armenteras et al. (2006) for example documents how in Putumayo the most effective way of eradicating coca was by hand, rather than by plane. Close engagement reduces the benefits of remoteness and hiding in the tropical forest, whereas it allows a more selective targeting of coca cultivations, without affecting negatively other agricultural activities. A comparative analysis of the relative effects of manual and aerial eradication of coca in Colombia is an important object for further study. Another policy option is the investment in alternative modes of development (or *alternatives to* State-led, Western-type development), responding to the needs of local population, with poverty reduction and development of local public infrastructure (Dion and Russler, 2008). Local development can change the choice domain for peasants, and make coca production an unattractive alternative, reducing the labour supply for the illegal groups and making production more expensive and less profitable. Still, supply-side policies alone are not likely to be effective, as long as there are no policies to curb global demand for processed coca (Laffiteau, 2010). The costs of labour and the production process in general, are very small compared to the profits, which in their majority accrue at later stages of the commodity chain, i.e. in trafficking. Demand-side policies are likely to have a much stronger effect on the benefits of the trade than supply-side ones.

Why then is an ineffective policy, this of fumigation, sustained in the presence of better alternatives? This is an important question, but one that is beyond the purposes of this article. Others have studied Colombia's anti-drug policy, in the context of its geopolitical relations with the U.S. and the dynamics of globalized capitalism (Corva, 2008; Crandall, 2008; Guizado, 2006; Thoumi, 2005a; Thoumi, 2005). Our goal here has been more modest and consisted of developing a spatialized information base for evaluating the impacts of aerial fumigation and informing understandings of why and how the policy has been failing.

## 4.6 Policy implications and conclusions

This article offered new evidence on the socio-environmental consequences of Colombia's war on drugs, and more specifically, its fumigation policy. Fumigations have diffused the frontier of coca cultivation, expanding deforestation to some of the world's most important biodiversity hotspots. The potential causal link suggested by our research is important: it is not coca production alone that causes the deforestation; it is the fumigation that is continuously pushing it to new areas. More and more people are being displaced, particularly from the more vulnerable segments of the population, including Afro-Colombian descendants. Even if fumigations have been reducing the cultivated area, which is questionable, their goal of total eradication is not feasible; illegal groups have easily adapted and responded to fumigation with fast relocation, forest clearance and production anew. While the intention of the fumigation policy may have been to make coca cultivation too costly to maintain, illegal groups have managed to shift the cost to producers and the local people, maintaining the lucrative cocaine trade going on. The costs of this ineffective war on drugs are disproportionately distributed along lines of class (income), race and ethnicity. Colombia continues to receive massive amounts of US aid to wage this chemical air war on drugs. The policy implications of our study for Colombia and beyond are clear: any government that attempts to stamp out coca production through aerial fumigations should think twice about its effectiveness and its side-effects.

In essence the problem at stake is one of (environmental and social) justice. Whereas the State and the illegal organizations may satisfy some of their purposes with the existing status-quo, the local populations and the forest upon which they depend for their livelihood loose. Correcting this grave injustice and ending up the ineffective fumigation policy is not easy as there are strong political-economic forces and interests at play that we did not address here. Our goal was more modest and was to reinforce in a more rigorous, integrated and scale-refined manner the documentation of the social and environmental effects of the war on drugs upon people and forests. The hope is that such documentation will contribute to building-up the pressure for a real public debate on the social and environmental costs of the policy, and provide fodder to those who are arguing for alternative approaches and for justice to be given.

## **CHAPTER FIVE: Can Common Property Regimes in Colombia curb the expansion of coca crops?<sup>10</sup>**

*The beginning of the 2000s saw the extension of a policy of forced eradication of coca crops (for illicit use) in Colombia, based principally on fumigation and manual eradication; this policy generated a displacement of the crops to other zones, such as the Pacific region. The creation of collective territories in this region started in the 1990s and expanded in the 2000s, and (Vélez, 2009, 2011) put forward the hypothesis that such territories, considered by (Ostrom, 1990, 2005) to be one of the first steps in the establishment of robust, sustainable, self-governing bodies, could be a factor in the curbing of the expansion of coca crops in the region, an area which is of great cultural and environmental importance. In our investigation, we show that this is not the case, and demonstrate that in fact, the cultivation of illicit crops has led to fragmentation in the collective territories through the increase in violence and forced displacement of people, all of which may have impeded the establishment of these collective territories. With one case study, however, we show that under another type of anti-drug policy based on strengthening of the community and encouraging self-organization, collective territories can indeed impede the expansion of coca cultivation.*

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<sup>10</sup> This chapter has been submitted for publication to the Journal *Latinoamerican perspective*. As a Rincón-Ruiz A., Can Common Property Regimes in Colombia curb the expansion of coca crops?.

## 5.1 Introduction

Since the publication of *The Tragedy of the Commons* (Hardin, 1968), a belief has been held that users of common resources, such as fish and woodland, are incapable of utilizing these resources in a sustainable manner, instead being motivated by individual self-interest to each maximize their own profits. This logic leads firstly to the inevitable destruction of the resources, and next to the need for a solution via either the state or privatization. Contrary to what had been asserted by Hardin, (Armenteras et al., 2006; Ostrom, 2005) showed that local communities with adequate incentives are capable of developing practices that allow for the sustained use and preservation of collective resources. By documenting numerous cases adopted by local governments from all over the world that demonstrate how resource users have overcome the so-called tragedy of the commons, Ostrom identifies the factors that enable local communities to establish adequate ways to use the common resources without the need for the presence of a central state. Ostrom questions the need for the management of resources to be determined by a central order (which in many cases exacerbates the problem) and insists that under certain criteria, local communities are able to use common resources in a sustainable manner. Since Ostrom's work, there has been more and more evidence of the importance of the role of local communities in the appropriate management of natural resources, beginning with the strengthening of local government (Cleaver, 2000; Richards, 1997). This is very important in the case of Latin America, where communities possess 25% of the forest, and 8% has been legally allocated for their use (Larson et al., 2010).

By means of a case study in one department of the Colombian Pacific region, (Aristizabal, 2009; Vélez, 2009) identified the creation of collective territories of Afro-Colombian communities (Community Council – CC) as a fundamental step in the establishment of a form of government that can ensure the sustainability of its own resources. With the establishment of CC, advances were made in the assignment of property rights and the exclusion of non-members from these communities. In his investigation, (Aristizabal, 2009) put forward the hypothesis that the establishment of community councils could help to impede the spread of coca crops to these territories. This expansion began at the beginning of the century as a consequence of anti-drug policy (Dion and Russler, 2008; Moreno-Sanchez et al., 2003; Vargas, 2004b) which was based on aerial fumigation and manual eradication

and focused on the main coca-producing regions of Colombia (UNODC, 2006, 2008a). Despite achieving a reduction in coca cultivation in the principal areas, it produced an expansion of the illicit crops to vulnerable areas such as the Pacific region (Oslender, 2010; Walsh et al., 2008a).

Vélez's hypothesis could be based on the fact that the collective territories of Afro-Colombian communities, which started in the 1990s and increased in the 2000s, have undergone a long process of ethnic construction, formed on an ancestral, historical and political basis over the course of several decades, allowing them to forge their own path and define themselves as a heterogeneous ethnic group, sharing a common culture, and whose members are united by an awareness of a historically established common identity (Sánchez, 2004). Additionally, the organization of Afro-Colombian communities in Colombia is not new, but dates back to the 1960s (Wade, 1996), although it has become stronger at different moments; for example, during the social movement of Afro-Colombian communities that has been developing in the Pacific region since the start of the 1990s and which includes a network of several organizations. This became known as the Process of Afro-Colombian Communities, and emphasized social control of the territory as a prerequisite for the survival and strengthening of culture and biodiversity (Escobar and Pedrosa, 1996).

The ethnic construction of African descendants in the Pacific region and their historical transformation will not be examined in-depth in this paper; However, it is important to stress that Afro-Colombian communities have their own understanding of biodiversity and its conservation – an understanding that is different from those expounded by other actors (such as intellectuals and NGOs), showing that it is possible to organize life, work, nature and culture in ways that differ from the dominant cultural and economic models (Escobar, 1999).

With the creation of the community councils, one would expect an increase in social capital in the Afro-Colombian communities, a strengthening of self-government, moving towards autonomous development and accompanied by a focus on conservation by the communities, and sustainable use and preservation of collective resources. Although the establishment of property rights was the first step in generating the appropriate incentives for the protection and sustainable use of the territory and its resources (Alston and Muller, 2005; Schlager and Ostrom, 1992), the success of this process depended on the establishment and continuance of the CC as a way to ensure self-government of common resources (Armenteras et al., 2006;

Ostrom, 2009); here we argue that this process did not occur because or due to the expansion of coca crops as a consequence of failed anti-drug policy.

In this paper it is established how the creation of community councils, despite the presence of favorable circumstances for the generation of self-government that should ensure an adequate management of common resources, succeeded in curbing neither the expansion of coca crops nor the degradation of natural ecosystems, and that in addition, the increase in cultivation generated violence (Holmes and De Piñeres, 2006) and forced displacement in the collective territories, which could have been a factor in their failure to become properly established. The creation of community councils coincided with a period of intensification in the war against drugs which led to a displacement of illicit crops from the traditional coca regions in the Amazon to the Colombian Pacific coast, most of this area being occupied by collective territories of Afro-Colombian communities. It is a traditionally poor region, rich in natural resources and with little state presence.

At the end of the investigation, we analyzed a particular case study, unique in being the only community council that has successfully eradicated illicit crops by abandoning the traditional anti-drug policy, the only example where anti-drug policy was not applied in the same way as in the rest of the country, and showed how using another type of integrated anti-drug policy, robust and sustainable territories could be established despite the expansion of illicit crops in the region.

The community council is called Las Varas, and is part of a program, financed by the the United States Agency for International Development (USAID), called “Sí, se puede” (“Yes, we can”), which aims to generate institutional coordination, civic participation, good governance and regional integration, with the objective that vulnerable communities and those affected by illicit crops make the transition towards legal, sustainable economies.

### **5.1.1 The Colombian Pacific region**

The Colombian Pacific region is a geographical unit and a natural region located in western Colombia and stretching between the borders of Panama and Ecuador. It has an area of over 116,000 km<sup>2</sup> and contains four departments: Chocó, Valle del Cauca (Buenaventura), Cauca and Nariño (see map 16). The whole territory shares certain characteristics: forest vegetation

and drainage basins over wide and sometimes swampy valleys from which emerge the Baudó Mountains in the Department of Chocó and the Andes in the Departments of Cauca and Nariño.

Three fundamental characteristics converge in the Pacific region of Colombia: a) it is one of the poorest regions in the country, b) it is one of the most environmentally important areas in the country and c) most of the population is Afro-Colombian. Each of these features will now be examined in further detail.



Map 16. Departments of the pacific Region of Colombia.

a) *Poverty*: The Pacific region of Colombia is one of the poorest regions of Colombia and one of the worst in terms of certain social statistics. It has one of the highest rates of unsatisfied basic needs (UBN): while the national average in 2005 was 27.78, the departments in the Pacific had much higher indices: Chocó (79.19), Cauca (46.62), Nariño (43.79) and Valle del Cauca – Buenaventura (35.50). In addition, while 45.5% of Colombians were living below

the poverty line, this percentage was found to be higher in the Pacific departments: Chocó (70.5%), Nariño (56.9%) and Cauca (70.1%). (Mesep, 2009).

b) *Environmental importance*: The Colombian Pacific region forms part of what is known as the Chocó biogeographic region, an area that includes territory in Colombia, Ecuador and Panama, and whose natural environment is amongst the best conserved in the Americas. The area is considered to contain one of the best reserves of endemic biodiversity, in terms of both flora and fauna (IDEAM et al., 2007), and is catalogued as one of the most important hotspots on the planet (Myers et al., 2000; UNODC, 2011). Its high rainfall, tropical status and isolation (separated from the Amazon Basin by the Andes mountain range) have all contributed towards making this region one of the most diverse on the planet: it is home to 9,000 species of vascular plants, 200 of mammals, 600 of birds, 100 of reptiles and 120 species of amphibians (IDEAM et al., 2007).

c) *Population*: In 2005 there were estimated to be 4,311,439 Afro-Colombians in the country, of which 44% were found to be in the departments of the Pacific region (Nariño, Valle, Cauca and Chocó). In other words, almost half of the Afro-Colombian population lives in just four of the 32 departments in Colombia. Additionally, almost 27% of the Afro-Colombian population in the Pacific (505,352) live in rural areas (DANE, 2005, 2006).

### **5.1.2 Creation of community councils (CC) in the Colombian Pacific region**

Two decades ago, an open-access regime applied to the Pacific region; with this system natural resources could be exploited by anyone without previously consulting the inhabitants, and as observed by Vélez (2011), logging companies were even granted mining concessions in the area. However, in Article 55 of the Colombian Constitution of 1991, the national government recognized the right to the collective awarding of land titles to the Afro-Colombian communities that had historical presence in territories in the Pacific region (Vélez, 2011); this opened an important area in the collective titling that was consolidated with Law 70 in 1993, which aimed to recognize Afro-Colombian communities' rights to collective property and also establish mechanisms for the protection of cultural identity and the rights of the Colombian Afro-Colombian communities as an ethnic group. This law changed the property system in the Pacific region from an open regime to one of common and collective property, which transformed the political map of the region and promoted the



formation of CC as a new way of self-government, changing the destiny of the afro Colombian communities, which from that point in time obtained the legal mechanisms with which to protect and exercise authority within their territory (Aristizabal, 2009).

Since the inaction of Law 70 of 1993, 159 collective territories of Afro-Colombian communities have been created (mostly since the year 2000), of which the majority are located in four departments in the Pacific region (out of all the people living in collective territories in Colombia, 96%, or 329,530 people, live in these departments (DANE, 2006a).

## **5.2 Methodological aspects**

### **5.2.1 Information and data used**

Firstly, a literature review was conducted of all peer-reviewed and government publications concerning anti-drug policies and the social, economic, environmental and political aspects of coca plantations in Colombia (Angrist and Kugler, 2008; Costa Storti and De Grauwe, 2009; Dion and Russler, 2008; O'Shaughnessy and Branford, 2005; Pereira, 2010; Walsh et al., 2008a), especially information associated with the Pacific region in the period from 2001 to 2008 (Asher and Ojeda, 2009; Oslender, 2008, 2010; UNODC, 2011) and the Afro-Colombian communities (Aristizabal, 2009; Escobar, 1999; Grueso et al., 1998; Oslender, 2008).

We constructed a database at the municipal level, including data for 137 municipalities in the four departments (Nariño, Choco, Cauca and Valle) that make up the Pacific region of Colombia (see map 16) and containing variables concerning coca crops, fumigations and aspects such as violence and forced displacement that, according to the literature, are associated with the expansion of coca crops (Díaz, 2004; Rubio, 2005).

The data regarding coca at a municipal level between 2001 and 2008 were taken from censuses provided by the Integrated System for Illicit Crop Monitoring (SIMCI: Sistema Integrado de Monitoreo de Cultivos Ilícitos); this is the only official source of information and provides the only available data on coca crops at a municipal level. The information

referring to aerial fumigations was taken from the National Narcotics Bureau, which has records of the areas fumigated in each municipality.

The variables were selected based on reviewing the literature, consultations with experts, fieldwork and the availability of information at a municipal level for all municipalities studied. On this basis a database was constructed containing the available municipal information (Table 20).

*Table 20.* Variables selected for the analysis of the municipalities of the Colombian Pacific region.

Name	Variable Name	Years	Source	Unit	Description
FDP	Forced displacement of population	2001 - 2008	Presidency of the Republic of Colombia - Presidential Agency for Social Action and International Cooperation	Number of displaced people	Number of people forcibly displaced by violence and conflict. This information is taken from the National System of Attention to Displaced People ("Sistema Nacional de Atención Integral a la Población Desplazada").
VAIA	Number of violent acts by illegal armed groups	2001 - 2007	Los Andes University, Bogotá and the Colombian Ministry of Defense	Number of violent acts	Number of violent acts by Illegal Armed Groups (FARC, AUC, ELN) per municipality, including terrorist acts, assaults, attacks, roadblocks, ambushes, harassment, and attacks on the population.
MIAG	Number of murders by illegal armed groups	2001 - 2007	Colombian National Police	Number of homicides by illegal armed groups	Homicides committed by common criminals are not taken into account.
PPF	Percentage of primary forest area	2000	Colombia Ecosystem map (Shape) - Institute of Hydrology, Meteorology and Environmental Studies of Colombia (IDEAM: Instituto de Hidrología, Meteorología y Estudios Ambientales de Colombia) - Estimation by the author	Percentage	Hectares of primary forest as percentage of the total area of the municipality.
PCOCA	Percentage of coca area	2001 - 2008	Coca maps (Shape) - Integrated Illicit Crop Monitoring System (SIMCI: Sistema Integrado de cultivos ilícitos)	Percentage	Hectares of cultivated coca as percentage of the total area of the municipality.
NCOMP	Number of complaints to the Ombudsman by citizens concerning aerial spraying	2001 - 2008	Local and National Ombudsman's Office	Number of complaints	Number of complaints to the Ombudsman by citizens concerning aerial fumigation.
AF	Aerial fumigation	2001 - 2008	National Narcotics Bureau (DNE: Dirección Nacional de Estupefacientes)	Number of hectares	Number of fumigated hectares per municipality.
AF01-08	Area fumigated between 2001 and 2008	Total 2001 - 2008	National Narcotics Bureau (DNE: Dirección Nacional de Estupefacientes)	Number of hectares	Total area fumigated between 2001 and 2008.
BC	Area of the municipality belonging to black communities	2001 - 2008	Maps of black communities (Shape) - Geographic Institute Agustín Codazzi	Number of hectares	Number of hectares under legal status of black communities (ABC).
AECO	Area of natural cover and natural ecosystems at a municipal level	2000	Colombia Ecosystem map (Shape) - Institute of Hydrology, Meteorology and Environmental Studies of Colombia (IDEAM: Instituto de Hidrología, Meteorología y Estudios Ambientales de Colombia) - Estimation by the author	Number of hectares	Hectares of natural cover of a certain ecosystem type within the municipality.
MUNCC	Presence of community councils (Afro-Colombian communities) by municipality	2008	Maps of Afro-Colombian communities - Geographic Institute Agustín Codazzi	0 or 1	0 if there are no community councils in the municipality; 1 if there are community councils in the municipality.
PERC_CC	Percentage of area in community councils (Afro-Colombian communities) by municipality	2008	Maps of Afro-Colombian communities - Geographic Institute Agustín Codazzi	Percentage	Percentage of area in community councils (Afro-Colombian communities) by municipality
CALS	Area cultivated with coca in black communities	2000 - 2008	Coca maps (Shape) - Integrated Illicit Crop Monitoring System (SIMCI: Sistema Integrado de Cultivos Ilícitos) and maps of black communities' territories - Geographic Institute Agustín Codazzi	Number of hectares with coca in black communities by year	Number of hectares with coca crops in Afro-Colombian territories.

### 5.2.2 Estimation of illicit crop trends based on the legal status of the territory and deforestation analysis

Within the framework of environmental legislation at a national level, there are areas of special regulation that define infractions within a territory based on the land's owner(s) and usage. The designated areas of special regulation are: a) Forest reserves b) Indigenous communities (Resguardos) c) Collective territories of Afro-Colombian communities (Community Council) d) National Natural Parks e) Areas excluded from the forest reserve:

over the last few decades, clearing of forest reserve has begun in many zones, principally for the purpose of settlement. These zones are ultimately privatized and become another part of Colombian territory that is subject to private property regulations.

In this investigation we analyzed trends in the expansion of coca crops under the different areas of special regulations during the period from 2001 to 2008, focusing especially on the trend of expansion of the coca crops to the collective territories of Afro-Colombian communities (see map 17).

In addition, we estimated the impacts of coca cultivations on ecosystems by overlaying information about land coverage from the national map of ecosystems in 2000 in Shape format (IDEAM. et al., 2007) with geospatial information about coca cultivations from SIMCI's maps for the 2001-2008 period. Our analysis was based on the natural cover and ecosystems estimated in 2000 (IDEAM. et al., 2007) and the expansion of coca crops between 2001 and 2008 (UNODC, 2008a, 2009, 2010).

We used maps (Shape format) of forest reserves, indigenous communities, collective territories of Afro-Colombian communities, areas of the National Natural Park System (Sistema de Parques Nacionales Naturales – SPNN in Spanish) and areas of forest reserve that have been cleared.

### **5.2.3 Association analysis**

Information was collected for the 137 municipalities belonging to the four departments of the Colombian Pacific region. With this information, we were able to carry out an initial analysis of the association between the percentage of the area of each municipality producing coca and the variables of violence, forced displacement and aerial fumigations, considered to be three key factors offering evidence for the association between the expansion of illicit crops and social destabilization in the region. Community councils were present in 38 of the municipalities analyzed, and in 69 we found presence of coca production for at least one year between 2001 and 2008.

In view of the expansion of illicit crops to the Pacific region, Vélez (2011) suggested that it is possible that the presence of community councils has slowed this development, which is to say that in their absence the expansion could have been greater. To examine this possibility, two variables were created called “presence of community councils by municipality” and “percentage of area with community councils by municipality”; the first variable could have one of two values: 1 if the municipality had associated community councils and 0 if there were no associated community councils. The second variable is given as a percentage of area in community councils (Afro-Colombian communities) by municipality. The aim of this was to determine whether there was a significant and inverse relationship between the percentage of the area of a municipality producing coca and the presence of community councils, as Vélez (2011) inferred.

#### **5.2.4 Fieldwork: Case study**

As part of the investigation, we decided to analyze and document what could be considered the only case in which coca crops were successfully eliminated in a voluntary manner, based on an integrated approach that was very different from the standard anti-drug policy implemented at a national level throughout Colombia. The case occurred in Las Varas Community (located in the municipality of Tumaco in the Department of Nariño (see Map 17); Las Varas has an area of around 15,000 hectares and a population of 5,948 (Diócesis de Tumaco, 2009).

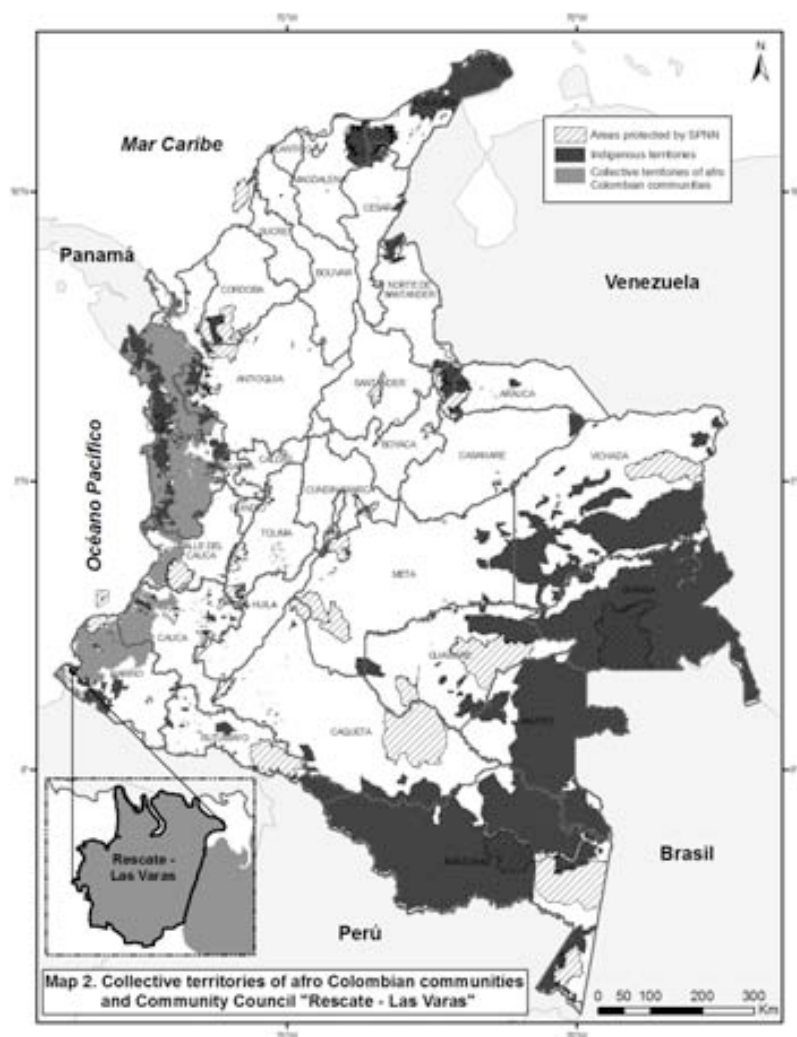
In 2008, tired of the violence that coca cultivation had brought with it, as well as the disintegration of trust between neighbors, the loss of social integration and dialogue, and the constant pressure from illegal armed groups, the community council took the decision to abandon coca cultivation and ask its leaders to present the governmental department with a proposal of voluntary eradication in exchange for investment for an integrated development plan for the community, the idea being to replace the crops and increase the standard of living of its inhabitants. This was consolidated into an initiative called “Sí, se puede” (“Yes, we can”), financed by the United States Agency for International Development (USAID).

In order to document this process, fieldwork was carried out in the area, interviews were conducted and dialogue held with community leaders and members, experts on the subject

and local authorities, with the aim of finding out how successful the initiative had been. In total, four Las Varas Community Council leaders, five members of the community, and the coordinators of the Las Varas “Sí, se puede” (“Yes, we can”) program were interviewed. Las Varas Community Council was visited to learn about the various initiatives developed by the community within the “Sí, se puede” program, photographic and video material was gathered and the majority of the interviews were recorded.

The interviews focused on 1) learning about the expansion of coca cultivation in Las Varas, 2) understanding what the “Sí, se puede” program consisted of, 3) determining how the elimination of the illicit crops was achieved through this program and 4) finding out what future challenges lie ahead for the community. All of the audio, photographic and video material was analyzed and described in the results, showing how the Las Varas Community Council succeeded in virtually eliminating the coca crops through the “Sí, se puede” program.

In addition, we used spatial information on coca cultivation from Las Varas Community Council, Tumaco Municipality and the Department of Nariño for the years 2007, 2008 and 2009. This information was provided by SIMCI and proved to be fundamental in the estimation of coca crop trends before and after the “Sí, se puede” program.



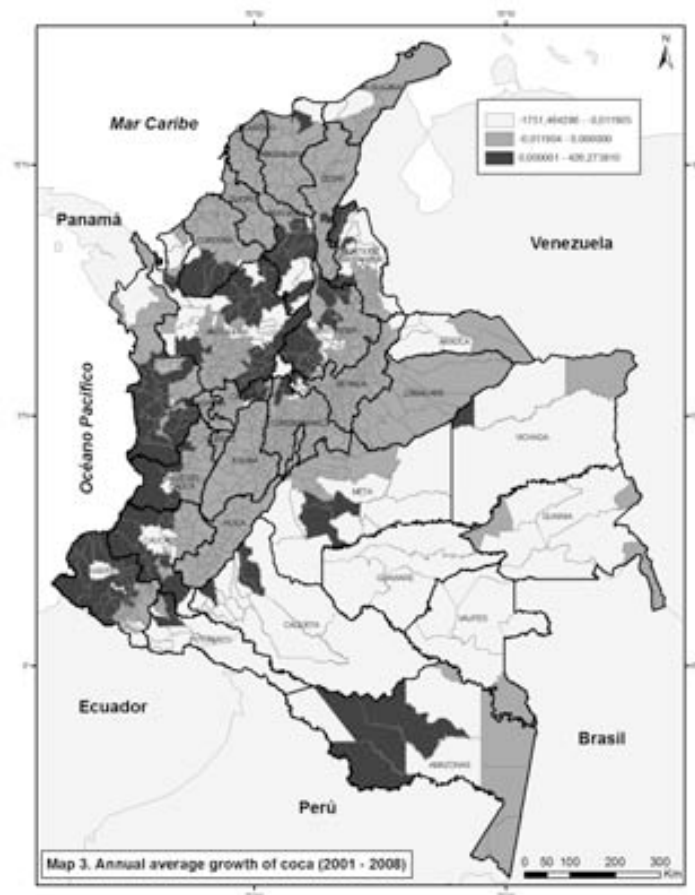
Map 17. Collective territories of Afro-Colombian communities and Community Council “Rescate – Las Varas”.

### 5.3 Results

#### 5.3.1 Failure of anti-drug policy: Expansion of illicit crops to collective territories of Afro-Colombian communities and an increase in deforestation

During the first decade of the 2000s, the total area used for coca production in Colombia decreased from 163,000 ha in 2000 to 80,948 in 2008 (UNODC, 2008, 2010), principally as a consequence of the anti-drug policy implemented by the government, which was based on

aerial fumigations with glyphosate, manual eradication and voluntary substitution (Ministerio del Interior y de la Justicia, 2006). This reduction generated a displacement of coca crops from the zones in which they had been concentrated (mainly in the north of the Department of Amazonas) to other areas of great environmental importance, such as the Pacific region (Map 18). So while the cultivation was decreasing in absolute terms, the deforested area due to the coca crops continued to increase in areas such as the Pacific region.

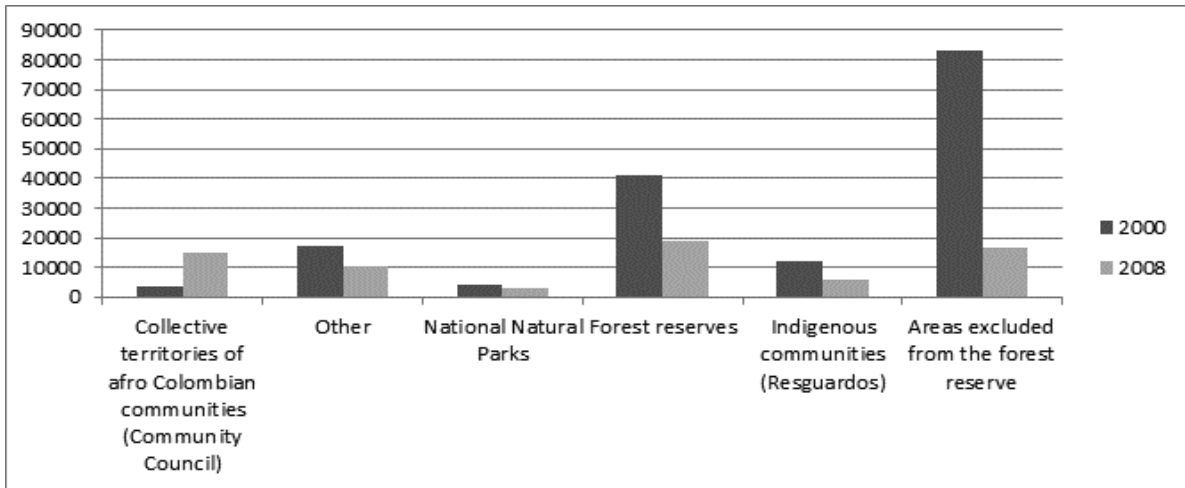


Map 18. Annual average growth of coca (2001 - 2008) ha.

According to studies that have been carried out, it has been estimated that within the 49,649 km<sup>2</sup> occupied by collective territories of Afro-Colombian communities, there were 3,429 hectares of coca in the year 2000. Over the next few years this area grew, reaching 15,032 ha in 2008, signifying an increase of more than 300%. This trend of increasing areas of coca in Afro-Colombian collective territories contrasts with a decrease in area of coca production in

the other types of territory (areas of forest reserve, indigenous communities and national parks). See Figure 3.

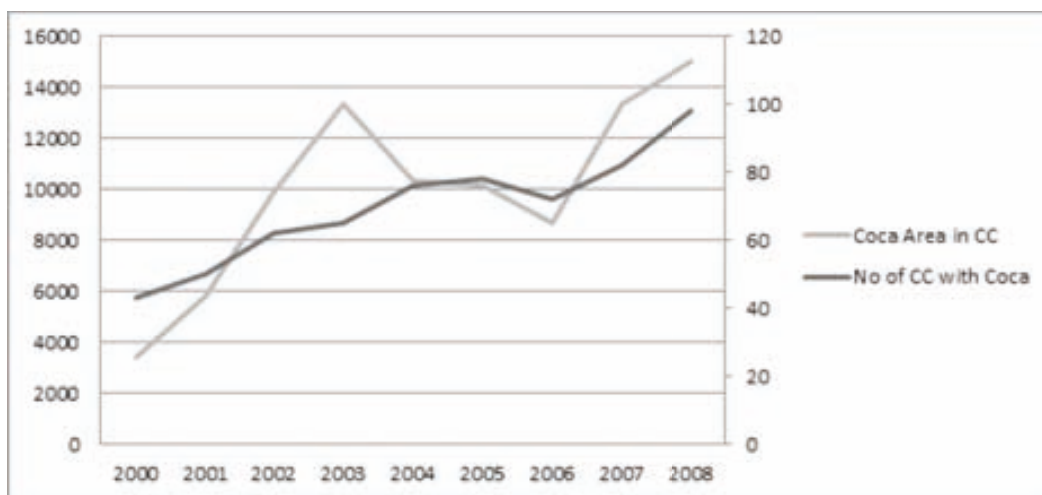
Figure 3. Area of coca production in different types of territory: 2000 and 2008.



Source: SIMCI, Author's calculations.

The increase in the area of coca production in the collective territories also coincides with an increase in the number of communities containing coca (Figure 4); in particular, a trend of increasing areas of coca was found in the collective territories in the departments in the Pacific region, concentrated principally in the municipalities in the department of Nariño (Figure 5).

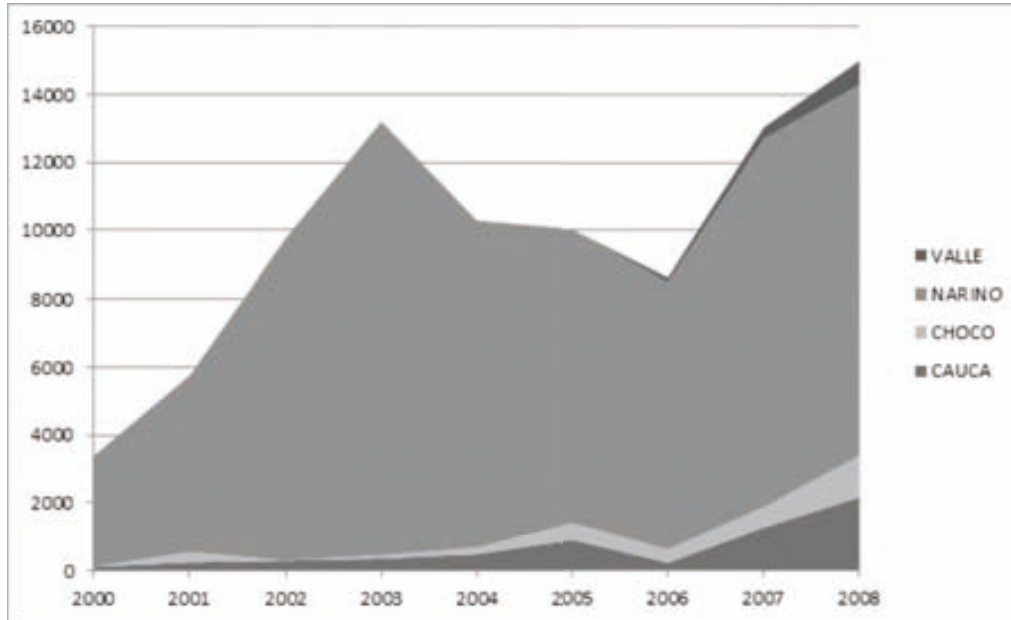
Figure 4. Coca area in CCs vs Number of CC with Coca (2000 – 2008).



Source: SIMCI, Author's calculations.



Figure 5. Area of coca in collective territories in departments of the Pacific region (2000-2008).



Source: SIMCI, Author's calculations.

By performing correlation (Table 21), it was found that the municipalities with the largest areas of coca in the Pacific region tended to be in the parts with the most natural cover and that in turn; the areas with the most natural cover were significantly associated with municipalities containing community councils. This gives rise to the hypothesis that the trend of illicit crops is towards territories with a high level of natural cover given the difficulty in being detected and that these areas coincide with municipalities in which community councils are present.

The expansion of coca cultivations towards areas with the highest levels of natural cover and CC present constitutes a concerning trend, since the Pacific region is considered to be one of the most important areas on the planet in terms of biodiversity (Myers et al., 2000) and the establishing of collective territories was thought to ensure environmental sustainability. However, in the investigation we found that the expansion of illicit crops in Colombia is causing deforestation that is principally affecting humid tropical rain forest in the Pacific

region. According to our estimations, 1,982 hectares of coca cultivations in the Pacific region had been humid tropical rain forest in 2000; by 2008 this figure had increased to 8,166 ha.

In conclusion, during the first decade of the 2000s, there was a displacement of illicit (coca) crops towards the Pacific region, principally to areas rich in natural forest and where there were collective territories of Afro-Colombian communities, contrary to what one would expect with the presence of community councils, i.e. that the creation of local self-government would lead to the sustainability of common resources. The expansion of coca crops in the Pacific region occurred regardless of whether CC were present at the municipal level, which answers the question posed by Vélez (2011) regarding the possibility of the community councils' presence having limited the expansion of illicit crops. Analysis of this correlation shows that this is not the case; in fact, a positive significant association was found between the percentage of area used to grow coca per municipality and the variables percentage of area with community councils by municipality and presence of community councils by municipality, both in 2001 and 2008 (see Table 21).

### **5.3.2 Coca crops, an increase in violence, forced displacement and fumigation in community councils in the Pacific region**

The association analyses carried out in Pacific region municipalities show a difference between 2001 and 2008; in the year 2008 a direct and significant association was found to exist between the percentage of area used for growing coca and forced displacement; as well as between the former and variables associated with violence (total homicides, number of violent acts). However, in 2001 these associations were not significant. These results demonstrate how the expansion of illicit crops that began in the Pacific region in 2000 has been accompanied by an increase in the levels of violence and forced displacement (see Table 21).

The variables defined as percentage of forest cover and area fumigated were significant for both years in the study (2001 and 2008). The significance of the percentage of forest cover shows how the characteristics that make the Pacific region so environmentally important in terms of biodiversity and dense tropical forest are also favorable for coca cultivation. The significance of the area fumigated variable, although expected, shows how the fumigations increase with the expansion of illicit crops. Another result that was found as expected was the

significant association in both 2001 and 2008 between the percentage of area used for growing coca and formal complaints related to effects of the fumigations, which are in turn considered to be an additional cause of displacement (CODHES, 2011; Defensoria del Pueblo, 2007; Oslender, 2010). The dynamic was one of cat and mouse: an increase in fumigations led to a displacement of coca cultivations to other areas, but the crops were pursued to these new zones by the fumigations.

*Table 21.* Significant correlations between the percentage of area used for growing coca and associated variables (2001 and 2008) in municipalities in the Colombian Pacific region.

Significative correlation 2001		PPF 2001	AF 2001	MUNCC	PERC_CC
PCOCA2001	Pearson correlation	.249**	.324**	.174*	.198*
	Sig. (bilateral)	.003	.000	.041	.020
	N	137	137	137	137

Significative correlation 2008		PPF 2008	FDP 2008	VAIA 2007	MIAG 2008	COMP 2008	AF 2008	MUNCC	PERC_CC
PCOCA2008	Pearson correlation	.372**	.280**	.246**	.315**	.427**	.771**	.401**	.411**
	Sig. (bilateral)	.000	.001	.004	.008	.000	.000	.000	.000
	N	137	137	137	70	137	137	137	137

\*\* . La correlación es significativa al nivel 0,01 (bilateral).

\* . La correlación es significativa al nivel 0,05 (bilateral).

Overall, it can be said that the expansion of illicit crops to the Pacific region as a consequence of intensely enforced anti-drug policy in the traditional coca-growing regions brought with it an increase in violence, forced displacement and fumigations. Although we do not have access to analysis associating factors such as violence and forced displacement with the loss of social capital, a causality analysis carried out by (Mejia, 2009) on the Colombia case, in which similar information was used regarding social capital and violence (albeit less up-to-date), showed that violence was one of the factors that explained the reduction in social capital in the country. According to data analyzed for 1997, the Pacific region exhibited the highest levels of social capital in the country as measured by two of the indicators estimated for Colombia: *Ksocial* and *Confie*<sup>11</sup> (Hurtado et al., In Press; Sudarsky, 2007). The values of

<sup>11</sup> **Ksocial**: This measures factors such as reciprocity, political participation, civic participation and horizontal relationships. **Confie** measures confidence in institutions. However, the estimations were made mainly for cities, so a bias could be present. Methodological details can be consulted in Sudarsky (2007)

these two indicators had declined by 2005, and decreased again between 2005 and 2011 (see Table 22); one possible explanation could be the expansion of illicit crops in the region and the associated violence, displacement and fumigations; however, we do not possess the tools in our analysis to prove this association and leave this hypothesis for future investigation.

*Table 22.* Decline in indicators associated with social capital in the Colombian Pacific region.

Social Capital Indicators	Colombia		
	1997	2005	2011
Ksocial	-0,0959505	0,3396316	-0,0125463
Confie	0,3352759	0,3773017	0,1339924
Fenoval	0,0969772	0,1524535	-0,0576775

Source: (Hurtado et al., In Press)

In conclusion we can said that the expansion of coca crops to the Pacific region during the first decade of the 2000s is associated with an increase in violence, forced displacement and fumigation policy applied in the territory. Although these variables were not significant in 2001, in 2008 all of the variables analyzed showed positive significance. At the same time, there was a reduction in social capital in the region, and although we are unable to prove the cause of this reduction, it could be associated with the increase in coca cultivation and violence. The circumstances described in these results were not appropriate for the strengthening and establishment of the community councils.

### **5.3.3 A successful case study amidst increasing coca cultivation: An integrated policy in the Community Council “Rescate - Las Varas”**

A process of interviews and dialogue with the leaders of the “Rescate - Las Varas” (“Rescue Las Varas” Community Board confirmed what had previously been shown with statistics: There had been a process of expansion of illicit crops and violence to the communities in the Pacific region as a consequence of failed anti-drug policy in the country that had generated a displacement of coca crops. In the case of Las Varas, the expansion of coca crops began at

the beginning of the 2000s and increased over the following years; however, starting in 2008 the community managed to achieve something that had never been seen in Colombia before: an almost total elimination of coca crops in the territory, brought about in a voluntary manner. There follows a summary of this process which describes how an alternative program, very different from traditional anti-drug policy and conceived within the community itself, managed to accomplish this: the process was called “Sí, se puede” (“Yes, we can”). Via conducting interviews and compiling information, the process was understood and is described in this paper in three parts: Las Varas Community before the arrival of coca, the coca expansion phase and the arrival of the “Sí, se puede” program. Finally, a summary is given of the factors that explain why the program was able to achieve something that no other initiative in Colombia has managed.

**Las Varas before the arrival of coca:** Before 2001, the area now administered by Las Varas Community Council was free of coca crops, according to several community leaders whose ancestors never knew about this plant, and the territory was traditionally dedicated to other crops (cocoa, plantain, coconuts and other foods). The illicit crops arrived with outsiders, from other regions such as the Department of Putumayo (where coca production had originally been concentrated). Before the arrival of coca crops, Las Varas had been a united community, albeit a poor one that was deficient in basic services such as health, education, and sewers. Although it was officially named a collective territory in 2006, for many years it had traditionally been a united and collective community. However, it had never felt supported by the national government, had never received social investment and felt abandoned by the state.

**Expansion of coca cultivation:** Shortly after the formation of Las Varas Community Council, according to the leaders, something tragic and unfortunate occurred: the arrival of coca to the territory (see map 19). Partly due to the poverty and the absence of the state, the conditions were appropriate for the cultivation of coca. The crops came with outsiders, people who were not from the territory. Two types of people brought coca to the territory: those from the country and those from other towns, the latter group including people who financed large-scale coca cultivation (drug traffickers). Shortly afterwards, these new arrivals were followed by illegal armed groups.

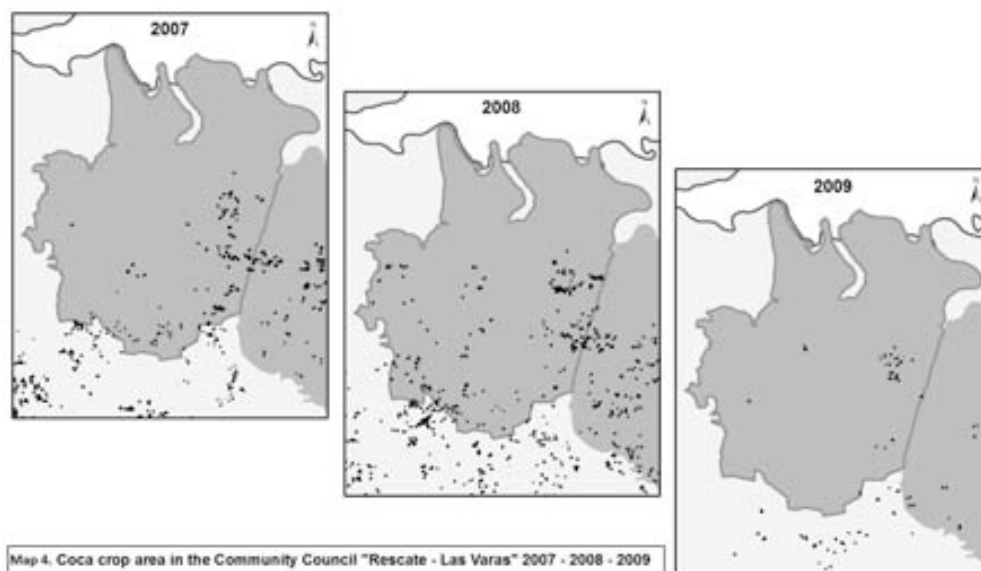
After the arrival of coca, the community fragmented and a focus on easy money developed, generating a new culture in which it was more important to have money than to help others; violence increased and material possessions started to become more important than the tradition of being part of a community. As the situation deteriorated, things that had previously been done voluntarily and selflessly were now charged for, and internal levels of trust fell. During this period the number of violent deaths rose along with harassment from illegal armed groups. Fear spread, and the mobility of the inhabitants within the territory became restricted under the threat of violence. The community became more individualistic and materialistic. In general, the mentality of the population changed and a culture arose in which people wanted to have more at any cost. Furthermore, the national anti-drug policy, based principally on aerial fumigation, affected much of the community, since the herbicide not only killed coca plants but also legal crops that were growing, generating more poverty and exacerbating the loss of trust in the national government.

**Start of the “Sí, se puede” program:** Faced with violence, expanding coca crops, and aerial fumigation, the leaders of Las Varas community council took a proposal to the provincial government of Nariño. They proposed strengthening the community through financial support and projects that would restore trust and traditional community values and move away from the cultivation of coca.

The community council’s proposal was heard by the provincial government and was formally established as the Las Varas “Sí, se puede” program whose primary objectives were the organizational development of the community, the restoration of trust and the creation of alternatives to enable the community to abandon the illicit crops in a voluntary manner; in addition, it was deliberately set apart from traditional anti-drug policy that focused on aerial fumigation.

The program began in 2008 and was financially maintained by international cooperation (USAID) until 2011. With the initiative, the community managed to move away from illicit crops and return to a culture of legality, to working together, sometimes in exchange for food, thereby achieving something unique in Colombia: the almost total elimination of coca crops from the territory (which had previously been showing trends of increasing coca) in a voluntary manner, within a year and without any aerial fumigation. According to estimates

based on coca censuses carried out by SIMCI, in 2007 there were 50 ha of coca in Las Varas, a figure which rose to 80 ha in 2008 and then fell sharply by 86% to 11 ha in 2009 (see Map 19), despite a growing background of violence. But how was this reduction achieved? Next, we shall expound upon the principal factors found in this investigation from interviews with the community and its leaders.



Map 19. Coca crop Area in the Community Council "Rescate – Las Varas" 2007 – 2008 – 2009.

### **How was the reduction of coca crops achieved with the "Sí, se puede" program?**

*Talk of substitution, rather than elimination of coca crops:* Unlike traditional policy which is based on forced manual eradication and aerial fumigation, the community organized and carried out a process which they called "voluntary substitution of illicit crops". Whereas in other areas forced manual eradication had caused confrontation between the community and the state, in Las Varas this was permitted by the community without confrontation; as they themselves say, it was a voluntary process. Although at the start of the process not all of the districts had accepted the agreement, a few months into the program all 15 of the districts had signed up to the voluntary elimination of illicit crops.

Restoration of internal trust within the community: The projects undertaken by the program restored internal trust within the community, the construction of a sports center aided social integration and projects such as “Painted House”, which consisted of friends and neighbors painting the neighboring house, restored a spirit of fraternity amongst the population. Projects such as a food security program generated confidence in a better future away from violence and illicit crops. A soccer field was installed where young people from the various districts constantly interacted. All of the projects originated from the community itself, which increased the levels of trust in as well as the appreciation for what was being carried out.

The “Sí, se puede” program succeeded in restoring trust in the community since it was not a policy imposed by the state, but one agreed upon by the community itself. This led to the people caring for the project as something of their own.

Social investment for the whole territory: One component of traditional anti-drug policy consisted of making payments to coca growers to stop them from doing it. This measure excludes the remainder of the population – the people that do not grow coca – fostering unrest and sending the wrong message: to receive monetary support, one should grow coca. The “Sí, se puede” program overcame this problem by being a plan for the whole territory. The projects and investment offered something for everybody: infrastructure, roads, footbridges, sewers, education, a food security program and productive projects such as cocoa farming.

No to fumigations: One maxim was repeatedly used by the community and its leaders: “We are not friends of coca but we are enemies of fumigation”. Fumigation generates unrest and loss of trust in the government and does not result in a genuine elimination of coca but a displacement of crops to other zones. Forced (as opposed to voluntary) policies, i.e. eradication and fumigation, lead to loss of trust in the government and malaise in the communities which continue to grow coca in any case. In addition, fumigation damages legal crops, threatening the municipality’s food security. With the “Sí, se puede” program, an agreement was reached with national governmental institutions; with the international community present to witness and monitor the proceedings, it was agreed that there would be no fumigation in the territory of Las Varas Community.



Governmental restructuring and social organization: The “Sí, se puede” program allowed the community to organize itself internally, resulting in a governmental structure in which the community could trust. This self-organization, though a complex process, was easier than in other areas as the community had a tradition of internal dialogue and community character, something which had started a long time ago (yet had not been well documented). The governance of the territory was planned on a bottom-up basis and began with restoring the tradition of dialogue and cooperation. A brief description of this organization is given below:

A general assembly was created for the community council, which was the highest authority in the territory; this was named the community council Assembly and was composed of one representative from each of the 15 districts in addition to one legal representative and one president of the entire community who was democratically elected. In turn, each district formed a district committee as well as sub-committees to deal with specific areas such as infrastructure, education, productive projects such as cocoa farming and so on. These committees would meet periodically to follow up on agreements, evaluate plans and define responsibilities. Furthermore, an internal monitoring and reporting system was created to guarantee the transparency of the process.

Almost everybody who was interviewed agreed that this self-organization was the source of the power needed to replace the coca crops, only the joint action undertaken as a community and the consequent generation of trust were able to raise the strength required to rid the territory of coca crops. This self-organization was established between 2008 and 2011, the period in which the program existed. Most of the community associated with the structural organization of the community council did not receive monetary compensation for their work; it was carried out on a voluntary basis.

An initiative born and developed within the community: Sí, se puede – Las Varas is a proposal developed on a bottom-up basis which was combined with traditional state policy later on (in February, 2010), but preserving respect for the initial rules which originated from the community. This locally conceived initiative was removed from standard anti-drug policy that was a part of Plan Colombia and came from a national mandate. Despite having been formed within the community, the initiative was supported by the government via a team of professionals that helped the local people.

*Coordination between the community and regional and international authorities:* Although the “Sí, se puede” program was a local initiative, it managed to coordinate regional, national and international cooperation. The first clear detail that arose from the communities was that the success to date was the product of a long internal process, and not a result of the Consolidation Plan or any nationally ordered directive. The Las Varas community council Assembly was the internal organization that allowed national and international cooperation to operate within the territory in an organized fashion.

#### **5.4 Discussion**

The expansion of illicit crops coincided with the establishment of the community councils in the Pacific region. This is an unfortunate and regrettable coincidence, and a result of failed anti-drug policy that generated a displacement of coca crops to vulnerable areas such as the Afro-Colombian communities in the Pacific region of Colombia.

In the case of Las Varas Community Council, the leaders found themselves in difficult times, forced to decide between a process that would organize and unite the community and a continuation of the fragmentation brought by the coca crops. The decision to abandon the illicit crops was not an easy one as it came with a high human cost for the community, as murders and even massacres were perpetrated by those who sought to put a stop to the new direction the community was taking, it being unfavorable for the interests of the illegal armed groups who had clear incentives to continue the drug-trafficking business which relied upon coca cultivation to produce its raw materials. Despite all of this, the community managed to move forward through the process of self-organization.

Furthermore, as manifested by the community, the state had been largely absent and within the community there was a high level of distrust in the national government. With the end of the “Sí, se puede” program toward the end of 2011, a process was halted that had been working well, leaving many initiatives incomplete, and this has generated a resurgence of this distrust within the community, requiring the leaders to make a big effort to maintain the trust and organization that they know to be the basis of all the success. The members of the community played their part in the elimination of coca, but they are afraid that the state has

abandoned them again. They want to continue having resources for education, the aqueduct and productive initiatives.

The whole community recognizes the success of the “Sí se puede” program, but currently they find themselves once more without economic resources, hoping that the government will support them in their efforts to consolidate what has begun. On visiting the community we realized that the four years that the program lasted was little time to establish a sustainable initiative within the community, although it had been long enough for the community to virtually eliminate the illicit crops.

At the time of writing, the community continues its wait for government resources, as a crisis builds around it, fueled by an increase in violence in the territory that has left the entire population of Tumaco without power as armed groups have destroyed the town’s electricity pylons. Funding was only available to the community council from the end of 2007 to the end of 2011; in other words, at the time of writing, almost a year has passed without resources to continue the process of self-organization within the community. Although we do not have access to up-to-date information regarding the area of coca in Las Varas Community, from SIMCI reports for the year 2011 it can be inferred that the illicit crops have started to increase again, with the decrease in the economic aid that was strengthening social capital in the community.

## **5.5 Conclusions**

During the first decade of the 2000s, there was a displacement of coca cultivation towards the Pacific region, principally areas rich in natural forest and where there were collective territories of Afro-Colombian communities. Along with the expansion of illicit crops came a rise in the levels of deforestation as well as increases in the levels of violence, forced displacement and fumigation policy in the region. This combination of phenomena made conditions difficult for the community councils to achieve their objective of generating robust, sustainable self-government.

Although the expansion of coca crops to the Pacific region marred the establishment of the community councils (due to anti-drug policy based on aerial fumigation and manual eradication that generated a movement of coca cultivation rather than a genuine reduction), it

was found that community councils can be an institution fundamental to the creation of robust, sustainable self-government, and even the reduction and elimination of illicit crops, provided that traditional anti-drug policy is avoided and locally based, integrated policies are used that promote the idea of collective, community territory. This idea is based on the successful case of the Las Varas Community Council in the Department of Nariño. The process that was followed in this case could be an important role model, and one to be replicated in other regions.

It can also be concluded that the expansion of coca cultivation to the Pacific region took place regardless of the presence of community councils in the municipality, which answers the question posed by Vélez (2011) about whether the existence of community councils had prevented a greater expansion of illicit crops. Correlation analysis shows that this prevention did not occur. From this it can be concluded that the existence of community councils, although fundamental in guaranteeing a territory for the community, is not sufficient; it is essential that these councils have economic resources available in order to enable the community to organize itself, plan and carry out projects. The most important conclusion of this investigation is that although we have seen that community councils have not managed to slow the expansion of coca, we have shown how support of integrated initiatives developed by the community itself constitutes a far more effective and sustainable policy regarding the elimination of illicit crops than the traditional anti-drug policy that has been operating in Colombia for over a decade.

## CHAPTER SIX: CONCLUSION

In our investigation, we have succeeded in achieving a better understanding of the factors associated with the expansion of coca cultivation in Colombia in the first decade of the 21<sup>st</sup> century, an understanding that has proved to be fundamental in giving an adequate diagnosis of the complex problem that has brought social and environmental costs to the country, both from the spread of the coca crops themselves and the application of anti-drug policy.

Our analysis shows that the expansion of illicit crops in Colombia produced a process of deforestation in the reference period which mainly affected the humid tropical forests of the Pacific region. This has caused several significant and in many ways irreversible impacts on forest ecosystems. In Chapter 2, we found three fundamental results that need to be borne in mind regarding the factors associated with the existence of coca crops in Colombia: 1) none of the variables usually associated with the existence of coca cultivation can be considered to be exclusively associated with the coca-growing areas since significant associations were also identified in regions without coca; 2) although there are no individual regional factors exclusively associated with the coca-growing areas, there is a set of common factors that are characteristic of these areas, including low levels of municipal development, low road density, high presence of primary forest, high presence of forced displacement, the presence of illegal armed groups and a high prevalence of unsatisfied basic needs; and 3) a spatial displacement of the coca crops towards the Pacific, the Caribbean and the northern area of the Andean region was observed between 2001 and 2008. In the new coca-growing areas a similar set of significant spatial correlations was found regarding the variables analyzed in 2001, implying that between 2001 and 2008 the coca crops were displaced to areas with similar social, economic, institutional and environmental characteristics. The analysis shows that coca-growing areas in Colombia have particular regional characteristics that create favorable conditions for deforestation. In addition to coca-cultivating areas being mostly those containing a high percentage of primary forests and having favorable environmental conditions for coca production, these areas remain not only physically isolated (low road density), but also socially deprived, as reflected by their high unsatisfied basic needs indices, as well as being institutionally impaired, as shown by their low levels measured by the municipal development index. These characteristics together create favorable circumstances

for the existence of illegal armed groups to forcibly take control of the territory and its population through violence and forced displacement. Under such circumstances the forests and the local population become easily exploitable for illegal activities. Through violence, a new structure of rules is created in these regions, in which the forest is considered to be an easily and freely usable resource. In combination with the rural population living in deprived social conditions, a scenario is created that facilitates deforestation by coca crops for illegal use.

In Chapter 3 we encountered other aspects fundamental to the understanding of the subject that proved to be complementary to those mentioned in Chapter 2 and that succeeded in giving an integrated diagnosis of the factors associated with the presence of coca. We found that the factors commonly associated with the expansion of coca crops cannot be generalized over the whole country. The types of relationships between coca crops and the associated factors are not the same on a global level as on a local one. In other words, the relationships are not constant with respect to space (they are not stationary). Although stationarity was found in 2001, it had been replaced with non-stationarity by 2008. The local realities changed between 2001 and 2008: in 2001 there was a concentration of crops in a few areas; for this reason the global reality was similar to the local analysis (stationarity). By 2008 the expansion of coca to other regions had led to the creation of multiple situations with differing characteristics, showing how coca crops were associated with different features according to the region in which they were located. As a result, non-stationarity was found, indicating that global analysis could not reflect the complex local realities in 2008. Only through the use of GWR models was it possible to analyze and understand that there are particular local realities that must be taken into account for appropriate policies to be drawn up. The results of the statistical analysis allow for identification of the regional differences in the influencing variables on the cultivation of coca. Differences were found between the Amazon, Pacific, Caribbean and Andean regions. In general, we can state that the influence of biophysical, social, economic and institutional variables on coca crops in Colombia have changed over time. GWR provided a valuable new exploratory methodology in identifying the most prominent drivers of coca crop expansion and assessing the heterogeneity of their impact on a local scale. Local models give a much better explanation of coca crops' existence than the average identified by global models.

The results of Chapters 2 and 3 demonstrate the necessity of a re-evaluation of the drug policy that has been implemented in Colombia during the last decade or so, specifically relating to aerial spraying and manual eradication. If the root causes for the existence of such deprived social, institutional and economic factors are not tackled in a structured way, large parts of Colombia will continue to provide the necessary conditions for the continuation of illegal activities such as coca cultivation for cocaine production as well as other illegal activities such as mining (coltan, gold) or palm cultivation. Whether such illegal ventures will flourish or perish in Colombia is a matter of reframing past development paradigms and embracing sustainable development (Ballvé, 2009). Additionally, our results lead to the conclusion that drug policy must be tailored according to local realities rather than adopting a general policy for the entire country as happens now (Isacson & Poe, 2009; Rodriguez, 2009), as we consider that locally sensitive policies can be considerably more efficient than generalized initiatives.

Based on these results, that lead one to consider the importance of understanding the complex factors associated with the expansion of coca cultivation, in Chapter 4 we described some significant conclusions that offer new evidence about the socio-environmental consequences of Colombia's war on drugs, and more specifically the failure of the fumigation policy. Fumigation has blurred the boundaries of coca cultivation, expanding deforestation to some of the world's most important biodiversity hotspots. The potential causal link suggested by our research is an important one: It is not coca production alone that causes the deforestation; it is the fumigation that is continuously pushing it to new areas. More and more people are being displaced, particularly from the more vulnerable segments of the population, including Afro-Colombian descendants. Even if fumigations have reduced the cultivated area, which is questionable, their goal of total eradication is not feasible; illegal groups have easily adapted and responded to fumigation with swift relocation, forest clearance and renewed production. While the intention of the fumigation policy may have been to make coca cultivation too costly to maintain, illegal groups have managed to shift the cost to producers and the local people, and kept the lucrative cocaine trade going. Any government that attempts to stamp out coca production through aerial fumigation should think twice about its effectiveness and its side effects. In essence the problem at stake is one of (environmental and social) justice. Whereas the state and the illegal organizations are, to a certain extent, satisfied with the

existing status-quo, the local populations and the forest upon which they depend for their livelihood lose out. Correcting this grave injustice and ending the ineffective fumigation policy is not easy as there are strong political and economic forces and interests at play that we have not addressed here.

The final chapter is where, through a case study, we showed how the displacement of coca crops generated by the anti-drug policies even ended up affecting territories that in theory should have been able to help curb their expansion. By this we mean the collective territories of Afro-Colombian communities, which answers the question posed by Vélez (2011) about whether the existence of community councils had prevented a greater expansion of illicit crops. Correlation analysis shows that this prevention did not occur. From this it can be concluded that the existence of community councils, although fundamental in guaranteeing a territory for the community, is not sufficient; it is essential that these councils have financial resources available in order to enable the community to organize itself, plan and carry out projects. The most important conclusion of the fifth chapter is that we have shown how support of integrated initiatives developed by the community itself constitutes a far more effective and sustainable policy regarding the elimination of illicit crops than the traditional anti-drug policy that has been operating in Colombia for over a decade.

The hope is that such documentation will contribute to the pressure that is building for a real public debate on the social and environmental costs of the policy, and provide support for those who are arguing for alternative approaches to be considered and for justice to be carried out.



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