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Social Investment and Smallholder Coca Cultivation in Colombia

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ABSTRACT *Colombia is the largest supplier of coca leaf in the world, and fields smaller than one-hectare account for more than 60 per cent of cultivation. Despite the obvious relevance of smallholding growers to the strategies to control illicit crops, there are few insights into what motivates these smallholders to cultivate coca. We analyse the motivations of coca growers by estimating a discrete choice model including head of household characteristics, household variables, and agricultural unit attributes. We found that extremely poor farmers are more likely to grow coca than non-poor farmers in the same area, while households connected to the energy grid, with access to credit, and receiving cash payments for their licit crops, are less likely to grow coca crops. Our results suggest that strategies aiming to discourage farmers from growing coca should: 1) target specifically the poorest households in the region and not just seek to improve general living conditions, 2) expand rural electrification, and 3) enhance legal productivity by providing access to credit, technical support, and/or contracts on harvests before planting.*

1. Introduction

Coca cultivation is one of the main challenges to economic, social, and environmental stability in the Andean region. Smallholder households grow most of these crops (UNODC, 2009),[1] and the cumulative effects of their actions have made Colombia, Peru, and Bolivia the only three global producers of illegal coca (UNODC, 2016b). While most coca cultivation remains linked to colonisation fronts in western Amazonia (Dávalos, Sanchez, & Armenteras, 2016), nowhere in the Andean region is coca more widely dispersed than in Colombia, where it is found in 21 out of 32 *departamentos* (UNODC, 2016a), political units roughly equivalent to states or provinces. Despite theoretical models demonstrating the economic advantages of coca cultivation in the Andean region (Kennedy, Reuter, & Riley, 1993), not all the households with the potential to produce coca adopt its cultivation (Ibañez, 2007). Thus, why some households grow coca, while others do not, remains an outstanding question.

Colombia, in cooperation with the international community, has implemented two strategies to control coca cultivation: forced eradication including manual eradication and aerial spraying, and alternative development programs based on voluntary eradication. Despite local gains in reducing coca cultivation,[2] coca persists, and Colombia remains the top global producer with more than 90,000 hectares in cultivation (UNODC, 2016a). To date, only three out of the 24 Colombian *departamentos* that have ever had coca have completely cleared their coca crops (UNODC, 2016a).

As of 2013, small coca fields – plots less than one hectare in size – accounted for more than 60 per cent of the total area under coca cultivation (UNODC, 2014). As a result, strategies used to

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control coca crops target smallholder crops. While most analyses of coca cultivation focus instead on aggregate growth of drug trafficking in Colombia (Chumacero, 2008; Grossman & Mejia, 2008; Ortiz, 2002; Rocha, Thoumi, & Uribe, 1997; Thoumi, 1995), or theoretical modelling to understand the growth of illicit crops (Kennedy et al., 1993; Whynes, 1991), household incentives for coca cultivation have been neglected. Hence, there are few insights into what motivates smallholder households to cultivate coca, despite the obvious relevance for strategies to control illicit crops.

Models to approximate regional decision-making under conditions of armed conflict and illicit crop eradication were first introduced in the 2000s (Gorbaneff & Jácome, 2000; Vargas, 2004). The closest approximation to decision-making in coca-growing households has been a survey-based choice experiment analysing responses by 293 coca and non-coca farmers from four municipalities in one *departamento* in Colombia (Ibañez, 2007). This analysis succeeded in highlighting the influence of non-economic factors such as religion and awareness campaigns on negative effects of coca cultivation, but the data collection approach made the conclusion case-specific. First, coca growers answering the survey were self-selected, reporting productive activities on their farms for the past 3 years. Thus, these data may not necessarily represent average farmers and could contain measurement error induced by the social desirability of not being classified as criminals. Second, the sample size was relatively small. It accounted for only one out of 24 *departamentos* where coca is grown. Finally, the *departamento* selected – Putumayo – has been historically affected by illicit crops, with about 80 per cent of its municipalities having coca cultivation (UNODC, 2010). Thus, it is an extreme case that might not be generalisable.

Here, we seek to close the gap left by previous analyses by estimating a discrete choice model that reflects the decision-making process of smallholder households. The goal is to inform policy decision-makers by investigating and quantifying socioeconomic correlates of coca cultivation among smallholders, assuming the current legal status of coca cultivation will continue. The model is tested using a random sample of 440 smallholder households – coca growing and non-coca growing farms – representative of agricultural units located in the Northeast and South Bolivar regions of Colombia. The area of study encompasses nine *departamentos*, including 601 municipalities. Our results are generalisable for agricultural units located in these regions.

Our results suggest that households in coca-growing areas are not uniformly prone to coca cultivation. Instead, extremely poor farmers within already poor and underserved areas are more likely to grow coca crops compared to non-poor farmers in the same area. Basic household and agricultural unit characteristics also influence farmer decisions to grow coca crops. Households connected to the energy grid, with access to credit, and receiving cash payments for their licit crops, are less likely to grow coca crops. Based on our results, strategies aiming to discourage farmers from growing coca should aim to 1) target specifically the poorest households in the region and not just seek to improve general living conditions, 2) expand rural electrification, and 3) enhance legal productivity by providing access to credit, technical support, and/or contracts on harvests before planting.

2. The economics of crime control strategies and social investment

The economic theory of crime suggests that individuals distribute time between legitimate market opportunities and criminal activities depending on the expected return from each occupation and the probability and severity of the punishment (Becker, 1968; Block & Heineke, 1975; Ehrlich, 1973; Stigler, 1970). Following this framework, crime control strategies need to generate the right incentives to regulate human behaviour by increasing the punishment for performing criminal activities, increasing the reward for conforming to a set of standards accepted by society, or both. The government, as central agent, could encourage individuals to behave according to social norms using law enforcement. But increasing the returns from legal market options also increases the opportunity cost of committing crime. Therefore, there is another useful public policy approach to control crime: social investment.

In general, social expenditures are redistributive transfers whose main goal is improving quality of life, but they also increase the opportunity cost of incarceration (Benoit & Osborne, 1995). There are different types of social investments. Here we refer to the budget spent on infrastructure and human capital, based on International Monetary Fund (IMF) guidelines (IMF, 2001). Infrastructure is the portion of the budget spent on fixed capital such as land, roads, buildings, and equipment, while human capital includes: teacher salaries, training, school feeding programs, and education material.

In principle, redistribution reduces the inequality between criminals and potential victims and gives criminals more to lose (Eaton & White, 1991), but in different ways. Public investments in infrastructure, for example, revitalise local economies, expand markets, and increase job opportunities, while public investments in human capital build skills, increase productivity, and boost future earning power. Public expenditures in health programs, for example, work as subsidies that increase available income. These redistributive transfers allow families to consume other goods that would have not been consumed if they had to spend part of their income on medical bills (for example, recreation activities). Both infrastructure and human capital investment have the potential to shift the balance away from criminal activity.

Criminal activities are linked to many social variables, in more or less predictable ways. In general, income inequality and poverty are positively related with both property crime and homicide rates (Cotte Poveda, 2011; Ehrlich, 1973; Enamorado, López-Calva, Rodríguez-Castelán, & Winkler, 2016; İmrohoroğlu, Merlo, & Rupert, 2000; Kelly, 2000; Ouimet, 2012; Stucky, Payton, & Ottensmann, 2016), while market wages have a negative relationship with crime rates (Gould, Weinberg, & Mustard, 2002; Grogger, 1998). There are, then, many mechanisms through which public spending could prevent and deter crime. Social investments in infrastructure and human capital in coca-growing areas prevent new coca crops in particular (Davalos, 2016), but most strategies to control coca cultivation focus on law enforcement (that is coercion). Thus, the potential for social investment to shape decision-making by farmers remains unexplored.

3. Historical background and local strategies to control coca crops

In Colombia, as of 2017, an illicit crop is defined as planting more than 20 plants from which illegal psychoactive drugs can be extracted (‘Ley 30 de 1986’, 1986). Growing illicit crops is a felony, and illicit crop growers could face up to 12 years in prison and 400 monthly minimum wages in fines, or around USD 100,000 (‘Ley 30 de 1986’, 1986). In 2017, the monthly minimum wage in Colombia was COP 737,717, and the exchange rate COP to USD was around three thousand pesos per dollar. Internationally traded cannabis, coca leaf and opium poppy – the natural sources of drugs that cause psychological and/or physical dependency – have all been cultivated in Colombia. This study focuses on Colombian coca cultivation, as this crop covers the greatest area of the three illicit crops in Colombia.

The first illicit crops in Colombia were marihuana fields planted in Santa Marta mountains during the 1970s. US-based traffickers recently displaced from Mexico provided the seeds, financing, and agro-technical support for marihuana cultivation (Zornoza, 1998). In 1978, and under political pressure from the US government, the administration of Julio César Turbay authorised forced eradication of illicit crops using *N,N′*-dimethyl-4,4′-bipyridinium dichloride, commercially known as Paraquat (R. Vargas, 2002). This policy was short-lived, as the ecological effects were widely denounced, and a brief manual eradication program ensued. The latter policy was also quickly abandoned, since it subtracted resources from counter-insurgency operations by the Colombian military.

In the late 1970s, drug trafficking shifted from marihuana to cocaine obtained by processing coca leaf harvested in Peru and Bolivia. By the mid-1980s, and following the assassination of then Minister of Justice Rodrigo Lara Bonilla ordered by the trafficker Pablo Escobar, the Colombian government adopted more aggressive policies against all steps in the drug trafficking chain. Aerial fumigation of coca plantations in the Santa Marta mountains was re-authorised, this time with the herbicide glyphosate, commercially known as Roundup, and the *Plan Nacional de Rehabilitación*

(PNR for its Spanish-language acronym) was instituted to provide economic alternatives to illicit crop growers (Camacho, 1999; Zornoza, 1998). Though originally focused on guerrilla fighters demobilised during the 1982–1986 Betancur administration, the PNR was later subsumed into a general program to boost state presence in underserved territories where both armed conflict and illicit crops concentrated (PNR, 1994). The plan was a decentralising force, promoting direct participation through municipal councils, and striving to align government investment with local priorities. By the mid 1990s, the PNR was scrapped, in favour of other programs, which today encompass a range of services from community-building to direct household transfers.

Aggressive international and domestic law enforcement effectively dismantled large cartels and atomised the trafficking business in the 1990s (Thoumi, 1995). In part as a response to these new conditions, illegal drug production, processing and trafficking integrated vertically, and coca cultivation shifted from Peru and Bolivia to forest colonisation fronts in southern Colombia. The Colombian government then stepped up efforts to detect and forcibly destroy illicit crops. Beginning in 1995, the PNR was replaced by the more narrowly targeted illicit crop substitution program the *Plan Nacional de Desarrollo Alternativo* (PLANTE for its Spanish-language acronym). PLANTE operated until 2003 in 10 *departamentos* where illicit crops were grown. At PLANTE sites, the program offered financing for a productive project presented by the community. A technical committee evaluated the project and then decided whether to approve the project based on its perceived viability and the complete eradication of illicit crops.

PLANTE reached 56,391 smallholder households in three broad agroecological regions: Andean, Amazonia, and Orinoco basin (PLANTE, 2002b). The starting point for intervention by PLANTE was a characterisation of the regions as 1) marginal, 2) lacking infrastructure, 3) isolated from markets, 4) lacking sufficient government presence, 5) vulnerable to ecological damage, 6) economically underdeveloped, and 7) affected by armed conflict and violence. The Pacific or Chocó ecological region, comprising at least 10,000 hectares of coca per year during the last few years of PLANTE's operation, and sharing all the characteristics outlined above was excluded from the program.

PLANTE required the eradication of illicit crops in advance, and without guaranteeing financing for the proposed projects. In 1996, for example, the program in the Orinoco basin received almost 5,000 requests for credit, only 127 of which were funded during the first semester because of funding shortfalls (Ramírez & Molano, 1998). As a result of these built-in obstacles to substitution, during the peak of the program's activity in 2001 and 2002, the number of households joining PLANTE increased while the number of crops substituted decreased (Table 1).

Both aerial eradication and crop substitution failed to curb the expansion of coca during in the 1990s (Figure 1). At its peak in the year 2000, the area planted with coca in Colombia reached more than 163,000 hectares, equivalent to 695 tons of cocaine (UNODCCP, 2002). In response to the increasing area under coca cultivation, the Colombian government in cooperation with the

Table 1. Families joining PLANTE and crop substitution, Colombia 2001–2002

Departamento	Families joining PLANTE		Illicit crops substituted (hectares)		Illicit crops substituted per family (hectares)	
Year	2001	2002	2001	2002	2001	2002
Bolívar	1,597	2,015	2,100	3,881	1.3	1.9
Caquetá	2074	2,979	1,540	2,301	0.7	0.8
Cauca	5,796	5,771	4,861	3,823	0.8	0.7
Guaviare	471	1,502	870	700	1.8	0.5
Huila	2,616	1,956	2,831	2,551	1.1	1.3
Meta	375	557	490	448	1.3	0.8
Nariño	995	5,316	555	636	0.6	0.1
N. Santander	1,232	1,050	2,500	2,917	2	2.8
Putumayo	–	16,379	–	10,917	–	0.7
Tolima	920	2,383	1,090	300	1.2	0.1
Total	16,076	39,908	16,837	28,474	1.0	0.7

Source: Compiled by the authors based on PLANTE (2002a).

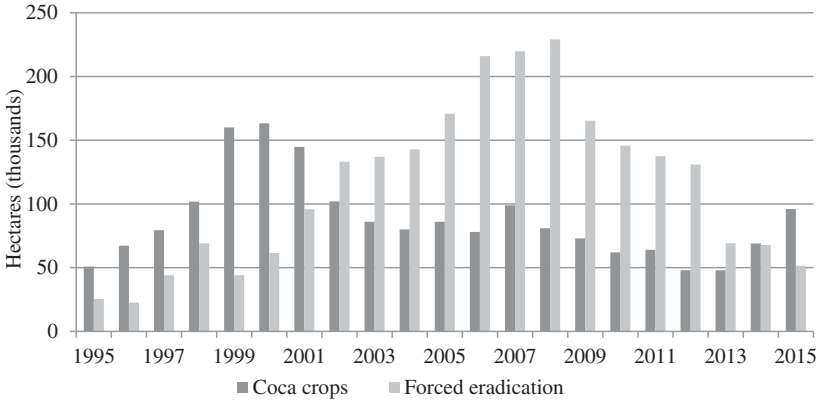

Figure 1. Coca cultivation and forced eradication, Colombia 1995–2015.
Notes: Based on the UNODC (2007b), UNODC (2016b) and UNODC (2016a).

international community implemented *Plan Colombia. Plan Colombia* was a comprehensive strategy for bilateral cooperation between the United States and Colombia to fight against illegal drugs and organised crime. The agreement was launched in 1999 based on the principle of shared responsibility from the demand and supply side of the illegal cocaine market (DNP & DJS, 2006). *Plan Colombia* was divided into four components: 1) fighting drug trafficking and organised crime, including interdiction, forced and voluntary eradication, and strengthening Colombian armed forces to accompany eradication operations; 2) promoting social and economic recovery, through social stability; 3) strengthening democratic institutions; and 4) ending the local armed conflict, by generating spaces for disarmament, demobilisation, and reintegration of illegal armed groups (DNP & DJS, 2006).

The first component of *Plan Colombia* sought to disrupt the productive process of cocaine by targeting the first link on the drug trafficking structure (Appendix 1). Controlling the crops is, at least in theory, the easiest way to tackle drug trafficking because cultivation is relatively fixed (Felbab-Brown, 2009). This leads to the main strategy to control illicit crops: eradication, implemented in three different ways through manual eradication, aerial spraying, and alternative development. The first two types of eradication are forced, while the latter encourages illicit crop growers to eradicate voluntarily and adopt licit activities. Manual eradication implies uprooting and sometimes burning coca bushes. This is a labour-intensive method performed in easily accessible areas without armed conflict. Aerial fumigation involves spraying herbicide over coca plantations larger than two hectares, located in inaccessible areas with active armed conflict (Council, 1994; DNE, 2003). Fumigation using the herbicide glyphosate mixed with a variety of surfactants and adjuvants was conducted in Colombia until September 2015 (ANLA, 2015).

Alternative development programs aim to control illicit crops by promoting legal productivity (Appendix 2). In Colombia, as of 2015, this strategy included two programs, *Programa Proyectos Productivos* (productive projects) and *Programa Familias Guardabosques* (forest ranger families). Both programs require families to voluntarily eradicate their coca crops to become eligible. *Programa Proyectos Productivos* includes long-term agroforestry and agricultural projects such as cocoa, rubber, and palm oil. *Familias Guardabosques* promotes rural tourism and hand-made crafts as a licit livelihood alternatives for Indigenous and Afro-descendent communities located in environmentally vulnerable areas affected by illicit crops (DNE, 2011).

4. Smallholder households

The criterion used by the government to differentiate between coca cultivation by smallholders and commercial coca crops is plantation size. Plantations larger than three hectares are classified as commercial, while smaller ones are attributed to smallholders (PLANTE, 2002b). At the previous

peak of coca production in Colombia – 2000, 40 per cent of the area planted fit the definition of smallholder cultivation (UNODC, 2003), but as a consequence of enhanced surveillance and monitoring, coca production in smallholder plots rose to almost 76 per cent of the area by 2010 (UNODC, 2011a). By 2013, small coca fields accounted for more than 60 per cent of the total area under coca cultivation, providing a focus for coca control strategies (UNODC, 2014).

Smallholder households are family farms practising subsistence agriculture in which most of the labour comes from within. Smallholder households that undertake illicit cultivation are motivated by the stability and security of income from illicit crops, but not necessarily by undue profits. The estimated annual gross income for a coca-growing family of four people in 2010 was $6,950 USD (UNODC, 2011b), while the gross domestic product per capita in the same period was $5,630 USD. According to both the United Nations Office of Drug Control and the Colombian government, the higher income of coca growing families does not translate into a higher standard of living, as cost of living is higher and infrastructure poorer in coca-growing regions (UNODC, 2006, 2011b; UNODC & DNE, 2010).

Most coca growers are migrants attracted to the agricultural frontier by the promise of land ownership, productive booms in rubber, timber, gold, oil or illicit crops, or displaced by armed conflict from their area of origin (Dávalos et al., 2016; Ramírez & Molano, 1998). The largest state-sponsored mass migrations to the frontier took place in the 1960s and 1970s under a policy authorised by the government through the 'Directed Colonisation Project' law of 1961 ('Ley 135 de 1961', 1961). By opening the forested frontier, this policy relieved political pressure to break the large landholdings or *latifundios* in the Andes and northern lowlands. By the 1980s, productive booms at the frontier were as attractive to the rural and urban unemployed as the promise of landholding (Zornoza, 1998). Finally, a floating population of coca leaf collectors (*raspachines*) emerged in the 1990s and has become a regular feature of the rural economy in coca-growing regions (García, 2006).

An important factor to analyse the decision-making of smallholder households to cultivate coca is their freedom to choose between coca cultivation and alternative legal activities. The survey used in this analysis did not include this question, but previous studies reported that 98 per cent of the farmers interviewed were not forced to cultivate coca (Ibanez & Klasen, 2017). We argue that smallholder households that grow coca face two alternatives: 1) they can plant a legal crop in untreated soil without technical assistance or assured buyers knowing that transportation and commercialisation will be costly in time and resources, or 2) they can plant coca from seeds provided by the trafficker, applying multiple herbicides, chemical fertilisers and pesticides afforded by the higher value of this crop, and knowing with near-complete certainty that there will be a buyer (UNODC, 2013; UNODC & Acción Social, 2008, 2010). Additionally, the coca cultivars in Colombia are native to the Andes or Amazonian lowlands, adapted to many local conditions and produce an average of 4.3 annual harvests (range: 2.5–6.0) (UNODC, 2007a). As a result, illicit crops provide smallholder families with access to the cash economy but fail to solve the lack of basic infrastructure, education, health care, justice, or environmental management of their regions.

5. Data

This article analyses agricultural units located in the Northeast and South Bolivar, Colombia. The data were obtained from the 2008 version of the *Encuesta de Costos de las Unidades de Producción Agropecuaria*; a survey conducted during the second half of 2008 by the Illicit Crops Monitoring Global Program of the United Nations Office of Drugs and Crime in Colombia. The random sample was selected using the area sampling frame technique. First, based on the 2007 Coca Survey, the Northeast and South Bolivar regions of Colombia were divided into one-kilometre square grids. Then, the area in the grids was classified into different strata; areas with the same land use formed a stratum. Following this procedure, the grids were numbered in a serpentine order, starting in the northeast of the region. Finally, 110 grids were selected using a systematic selection process after a random start.

A survey team from the United Nations Office of Drugs and Crime in Colombia visited each of the 110 grids, located in 25 municipalities, and selected a coca field in each of them. The survey team

searched for two agricultural units growing coca crops and two agricultural units without coca crops around each selected field inside the grid. In total, the survey team conducted 220 interviews with coca farmers and 220 interviews with non-coca farmers. The final dataset consists of a random sample of 440 cross-sectional units – coca growing and non-coca growing farms – representative of the agricultural units located in Northeast and South Bolivar, Colombia. The area of study encompasses nine *departamentos*, including 601 municipalities. Figure 2 illustrates the geographic location of the area of study.

The survey asked questions related to the characteristics of the head of the household, the household, and the agricultural unit. This analysis includes all three types of variables. The main characteristics of the head of the household are captured in five variables based on his or her answers to the survey questions (Table 2). The poverty variable was created based on the answer by the head of the household to the survey question about his or her level on the *Sistema de Identificación y Clasificación de Potenciales Beneficiarios para Programs Sociales* (SISBEN for its Spanish-language acronym) – System for

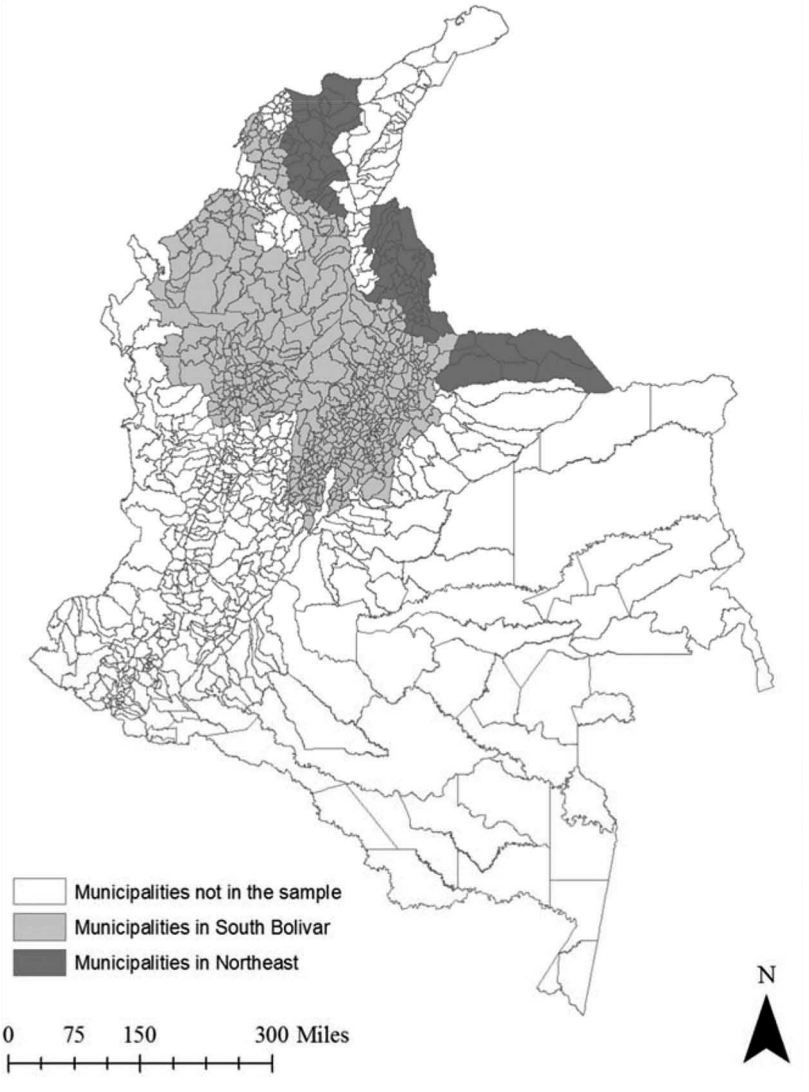

Figure 2. Smallholder households survey Northeast and South Bolivar, Colombia 2008.

Table 2. Descriptive statistics agricultural units with and without coca crops and data sources, Northeast and South Bolivar, Colombia 2007–2008

Type	Short name	Units	Description	Source(s)	Agricultural units with coca crops N = 220		Agricultural unit without coca crops N = 220	
					Mean	Std.	Mean	Std.
Head of household characteristics	Woman		Dichotomous variable coded one if the head of the household is a woman, zero otherwise	UNODC	0.04	0.20	0.05	0.21
	Age	Years	Continuous variable describing how old the head of the household is	UNODC	41.59	12.54	43.66	11.69
	Literacy		Dichotomous variable coded one if the head of the household knows how to read and write, and zero otherwise	UNODC	0.89	0.32	0.85	0.35
	Education	Years	Continuous variable describing the number of years of education completed by the head of the household	UNODC	4.18	2.98	3.63	2.95
	Poor		Dichotomous variable coded 1 if the head of the household is poor, and zero otherwise.	UNODC	0.08	0.27	0.09	0.28
	Extremely poor		Dichotomous variable coded 1 if the head of the household is extremely poor, and zero otherwise.	UNODC	0.85	0.35	0.81	0.39
Household characteristics	Size household	People	Number of people living in the household	UNODC	4.44	2.13	4.67	1.77
	Work force	People	Percentage of people in the household older than ten years old	UNODC	80.37	19.91	81.79	19.25
	Percentage males	Percentage	Percentage of males living in the household	UNODC	57.65	20.69	56.96	17.62
	Percentage children 5 years old or younger	Percentage	Percentage of people in the household who are 5 years old or younger	UNODC	10.79	15.41	10.15	14.15
	Percentage people who read and write	Percentage	Percentage of people in the household who knows how to read and write	UNODC	79.75	23.64	79.74	21.53
	Electricity		Dichotomous variable coded one if the household has electricity, zero otherwise	UNODC	0.38	0.49	0.45	0.50

(*continued*)

Table 2. (*Continued*)

Type	Short name	Units	Description	Source(s)	Agricultural units with coca crops N = 220		Agricultural unit without coca crops N = 220	
					Mean	Std.	Mean	Std.
Agricultural unit characteristics	Size agricultural unit	Hectare	Size of the agricultural unit	UNODC	25.01	26.92	28.79	37.70
	Access to credit		Dichotomous variable coded one if the agricultural unit has some sort of credit to support agricultural production, zero otherwise	UNODC	0.02	0.13	0.08	0.27
	Cattle	Number	Number of cows in the agricultural unit	UNODC	4.24	10.26	12.56	33.28
	Crop lost		Dichotomous variable coded one if the agricultural unit lost seasonal and/or perennial crops, zero otherwise	UNODC	0.11	0.32	0.12	0.33
	Area planted seasonal crops	Hectare	Area planted in seasonal crops	UNODC	1.02	1.69	1.66	3.29
	Cash payment licit crops		Dichotomous variable coded one if the payment was made in cash, zero otherwise	UNODC	0.16	0.37	0.25	0.44
	Cash payment cattle		Dichotomous variable coded one if the payment was made in cash, zero otherwise	UNODC	0.10	0.29	0.21	0.41
	Cash payment non-cattle		Dichotomous variable coded one if the payment was made in cash, zero otherwise	UNODC	0.01	0.10	0.05	0.22

Notes: This table presents descriptive statistics for 440 agricultural units representative of agricultural units located in Northeast and South Bolivar, Colombia. The survey was conducted in the second half of 2008 by the United Nations Office on Drugs and Crime.

Identification of Potential Beneficiaries of Social Programs.[3] SISBEN index ranges from zero to 100, divided into six brackets from the poorest to the richest (Castañeda, 2005). There are six levels in SISBEN. Level I groups people with the worst socioeconomic conditions, classified as extremely poor. Their living conditions are similar to those living below the poverty line. Level II includes people with living conditions similar to those close to the poverty line, usually classified as poor. National social programs target only poor and extremely poor people classified in SISBEN levels I and II (Vélez, Castaño, & Deutsch, 1998). As a result, the level of SISBEN is a good proxy to capture poverty conditions in Colombia. Finally, the household is characterised by six variables. Table 2 summarises the descriptive statistics of the variables included in the analysis.

6. How do municipalities located in the Northeast and South Bolivar regions differ?

In terms of rural population and poverty rate, municipalities located in the Northeast and South Bolivar are alike. On average, rural population is about half of the whole population in both regions, and the percentage with unsatisfied basic needs ranges between 64 and 66 per cent. In contrast to these structural similarities, on average, the number of hectares sprayed in municipalities located in South Bolivar is more than four times that in municipalities located in Northeast. The number of victims of all kind of human right violations per 1,000 inhabitants in Northeast is more than three times that in South Bolivar, and arrival of displaced people per 1,000 inhabitants is almost double. In addition, municipalities located in South Bolivar have more area covered by rainforest and receive, on average, 742 mm more rainfall per year compared to municipalities located in Northeast. Therefore, all these factors are included as control variables in the analysis. Table 3 summarises the descriptive statistics of the variables included in the analysis by municipality.

7. Empirical model

To establish the main factors that motivate smallholder households to grow coca crops, we estimate a linear probability model. The dependent variable has a binary distribution. To control for-time invariant unobservable municipal differences, for instance, institutional factors and cultural attitudes towards crime, the regression model includes municipal fixed effects. The basic econometric model is presented in Equation 1. To control for arbitrary correlation within a municipality, the model is estimated using Huber-White standard errors clustered by municipality.

Equation 1. Linear probability model assessing the probability of growing coca crops

$$\Pr(y_i = 1|x_i, w_i, z_i) = \gamma_0 + \gamma_1 x_i + \gamma_2 w_i + \gamma_3 z_i + \alpha_j$$

where $i = 1, \ldots, 440$ and $j = 1, \ldots, 25$

The outcome variable is the chance of growing coca crops for agricultural unit i, and x, w, and z are vectors of regressors. The chance that an agricultural unit grows coca crops is a function of head of household individual characteristics, x, household variables, w, and different agricultural unit attributes, z. To capture time-invariant municipal-specific characteristics, the model also includes municipal fixed effects (α_j).

There are three assumptions implicit in the model. First, the household is aware of the actions of the Colombia government to forcibly eradicate and substitute illicit crops. Second, soil quality is homogenous based on the high adaptability of coca bushes. Third, the probability of forced eradication for a single smallholder household is exogenous, as individual smallholders cannot affect decisions by policy-makers.

In general, coefficients on human capital accumulation (literacy, years of education) are expected to be negative. That is the probability of growing coca crops will decrease as the head of household and/or the members of the household are more educated. As for household variables, coefficients on size of the household and the percentage of children 5-years old and younger are expected to be

Table 3. Descriptive statistics municipalities in Northeast and South Bolivar, Colombia 2007–2008

Type	Short name	Units	Description	Source(s)	Agricultural units Northeast N = 200		Agricultural units South Bolivar N = 240	
					Mean	Std.	Mean	Std.
Strategies to control illicit crops	Manual eradication	Hectare	Number of hectares manually eradicated throughout the year in each municipality in 2006	UNODC	272.23	385.85	438.42	676.25
	Aerial eradication	Hectare	Number of hectares sprayed throughout the year in each municipality in 2006	DIRAN from UNODC	414.69	351.82	1708.46	2093.22
	Alternative development	Families	Number of families joining alternative development projects that require voluntary eradication in 2006	Acción Social (2011)	140.22	194.77	66.53	258.36
Demographic characteristics	Rural population	Percentage	Percentage of rural population in 2006	DANE	55.60	18.77	53.03	17.97
	Forced migration	Number of people	Arrival of displaced people per 1,000 inhabitants in 2006	RUV	41.44	21.73	23.09	27.04
Socioeconomic characteristics	UBN	Percentage	Percentage of population with unsatisfied basic needs in 2005	DANE	65.83	24.63	63.73	12.34
	Conflict	Number of people	Victims of all kind of human rights violations per 1,000 inhabitants in 2006	CINEP	0.97	0.53	0.25	0.40
	Fiscal performance	Rank from 0 to 100	Municipal fiscal performance, where values over 80 mean that the municipality is solvent and values below 40 that has low savings capacity, difficulties to cover its operation expenses, and relies on national transfers in 2006	DNP	62.07	5.20	58.37	5.07

(*continued*)

Table 3. (*Continued*)

Type	Short name	Units	Description	Source(s)	Agricultural units Northeast N = 200		Agricultural units South Bolivar N = 240	
					Mean	Std.	Mean	Std.
Physical environment	Forest	Percentage	Percentage of area in the municipality covered by forest in 2005	Calculated from IGAC 2005 by Armenteras, Rodríguez, Retana, and Morales (2011)	31.19	9.32	36.47	19.11
	Road density	Km of road per 100 sq. km of land	Density of road in each municipality in 2005	Calculated from IGAC 2005 by Armenteras, Cabrera, Rodríguez, and Retana (2013)	1.57	0.72	1.06	0.79
	Elevation	metre	Altitude above sea level	IGAC 2005 from Armenteras et al. (2013)	591.54	437.66	410.57	263.32
	Precipitation	millimetre	Total annual precipitation in 2005	Worldclim 2005 from Armenteras et al. (2013)	2532.03	402.02	3274.27	962.32

Notes: This table presents descriptive statistics of municipalities in North East and South Bolivar in which the 440 agricultural units were located.

positive, since their economic burden is greater. In contrast, agricultural unit attributes, like access to credit and cash payments, are expected to be negative, as resources to invest on the farm are likely to increase legal productivity and reduce the attractiveness of coca cultivation.

8. Results

To determine what motivates smallholders to cultivate coca, we regress the decision of growing or not growing coca crops on head of household individual characteristics, household variables, and agricultural unit attributes. Table 4, columns (1) through (5), presents lineal probability estimates of equation 1. Column (6) reports marginal effects on logit estimates controlling for municipal fixed effects. Results reported in column (1) through (4) are baseline estimations to illustrate consistency. Column (1) reports coefficients on head of household characteristics. Column (2) presents results including household variables. Column (3) shows coefficients on agricultural unit attributes. Column (4) also reports estimates controlling for municipal characteristics. Results in columns (5) and (6) include municipal fixed effects regressors not shown. Numbers in parentheses are Huber-White standard errors clustered by municipality.

Results are consistent throughout all the models. Coefficients on age are statistically significant and display a negative relationship. The probability of growing coca crops decreases, at a decreasing rate, as the head of household ages. The older the head of household, the less likely the household is to grow coca. Based on the sample, this relationship reverses around 48 years of age. This result differs from the traditional aggregate age crime curve or inverted U curve, in which the peak of crime ranges from 18 to 24 years old (Donohue & Levitt, 2001). Here, the chances of growing coca crops decline until 47 years of age, and then start increasing as farmers get older (see Appendix 3). It might be that older farmers have more experience avoiding forced eradication, and thus are less risk averse.

Another relevant characteristic of the head of household is poverty. The coefficient on extreme poverty is always positive and statistically significant. The poorer the head of the household, the more likely the household is to grow coca. This result for households supports several previous studies of aggregate data in which poverty measures displayed a significant relationship with coca crops (Dávalos et al., 2011; Dion & Russler, 2008; Moreno-Sanchez, Kraybill, & Thompson, 2003; Rincón Ruiz, Pascual, & Romero, 2013).

Among the household characteristics analysed, the coefficient on electricity is consistently negative and significant. Households connected to the grid are less likely to grow coca. This result connects the *energy poverty* concept to the discussion on coca cultivation. Indeed, previous studies in developing countries have established the nexus between electricity, poverty, income, academic achievement, and agricultural productivity (Bridge, Adhikari, & Fontenla, 2016; Ingwe, 2014; Ringel, 2004). All these variables relate to coca cultivation, as poverty appears to be one of the main motivations to grow coca, and low agricultural productivity is one of the reasons licit crops fail to compete with illicit ones.

As expected, losing a crop, either a seasonal or permanent crop, because of fumigation, pests, or bad weather also increases the probability of growing coca crops. In contrast, the availability of land has a positive relationship with growing coca crops. As predicted, having more cattle, planting more seasonal crops, having access to credit, and cash payments for licit crops decrease the likelihood of growing coca. These last two attributes are key to design strategies appealing to farmer needs in coca-growing areas. As previous studies suggested, access to credit is a successful means to overcome poverty (Yunus, 1998; Yunus & Jolis, 1999), and the success of some alternative development projects in Colombia are contingent on cash transfers (Rozo, Gonzalez, Morales, & Soares, 2015). Therefore, banking alternatives for farmers in coca-growing areas and cash payments for their licit crops might be a way to promote legal crops.

Results in columns (5) and (6) include municipal fixed effects regressors to control for municipal characteristics that may vary across municipalities but do not vary in time. These municipal fixed effects control for municipal context. Columns (5) and (6) also report results for regional differences.

Table 4. Regression determining the probability of growing coca

	Agricultural unit growing coca crops											
	(1)		(2)		(3)		(4)		(5)		(6)	
Head of household characteristics												
Woman	−0.02	(0.12)	−0.03	(0.12)	−0.01	(0.12)	−0.01	(0.12)	−0.01	(0.12)	−0.01	(0.13)
Age	−0.02*	(0.01)	−0.02*	(0.01)	−0.02*	(0.01)	−0.02*	(0.01)	−0.02*	(0.01)	−0.02*	(0.01)
Age squared	0.00*	(0.00)	0.00*	(0.00)	0.00*	(0.00)	0.00*	(0.00)	0.00*	(0.00)	0.00*	(0.00)
Literacy	0.00	(0.09)	0.02	(0.11)	0.04	(0.11)	0.04	(0.11)	0.04	(0.12)	0.05	(0.13)
Education	0.01	(0.01)	0.01	(0.01)	0.01	(0.01)	0.01	(0.01)	0.01	(0.01)	0.01	(0.01)
Poor	0.07	(0.09)	0.09	(0.08)	0.04	(0.09)	0.05	(0.09)	0.08	(0.09)	0.09	(0.10)
Extremely poor	0.11	(0.07)	0.12*	(0.06)	0.12*	(0.07)	0.12*	(0.07)	0.15**	(0.06)	0.17**	(0.07)
Household characteristics												
Size household			−0.01	(0.02)	−0.01	(0.02)	−0.01	(0.02)	−0.01	(0.02)	−0.01	(0.02)
Work force			−0.00	(0.00)	−0.00	(0.00)	−0.00	(0.00)	−0.00*	(0.00)	−0.00	(0.00)
Percentage males			0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	−0.00	(0.00)	−0.00	(0.00)
Percentage children 5 years old or younger			−0.00	(0.00)	−0.00	(0.00)	−0.00	(0.00)	−0.00	(0.00)	−0.00	(0.00)
Percentage people who read and write			0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	−0.00	(0.00)	−0.00	(0.00)
Electricity			−0.11**	(0.04)	−0.11*	(0.06)	−0.11	(0.07)	−0.17*	(0.09)	−0.20**	(0.09)
Agricultural unit characteristics												
Size agricultural unit					0.00*	(0.00)	0.00*	(0.00)	0.00*	(0.00)	0.00**	(0.00)
Access to credit					−0.20**	(0.09)	−0.21**	(0.09)	−0.26**	(0.10)	−0.30**	(0.12)
Cattle					−0.00**	(0.00)	−0.00**	(0.00)	−0.00**	(0.00)	−0.01**	(0.00)
Crop lost					0.05	(0.05)	0.06	(0.06)	0.10	(0.06)	0.12*	(0.07)
Area planted seasonal crops					−0.02***	(0.01)	−0.02**	(0.01)	−0.02**	(0.01)	−0.04*	(0.02)
Cash payment licit crops					−0.14**	(0.07)	−0.16*	(0.08)	−0.21**	(0.09)	−0.23**	(0.10)
Cash payment cattle					−0.15*	(0.07)	−0.15*	(0.08)	−0.20**	(0.08)	−0.20**	(0.09)
Cash payment non-cattle					−0.20	(0.15)	−0.21	(0.15)	−0.26	(0.16)	−0.33*	(0.17)
Municipal characteristics												
Agricultural unit located in Northeast region							−0.04	(0.04)	0.22**	(0.10)	0.26***	(0.09)
Manual eradication							−0.00	(0.00)				
Aerial eradication							−0.00*	(0.00)				
Alternative development							0.00	(0.00)				
Conflict							0.04	(0.04)				
Poverty							0.00	(0.00)				
Fiscal performance							0.00	(0.00)				
Intercept	0.86***	(0.30)	1.08***	(0.37)	1.11***	(0.38)	1.13***	(0.39)	1.17**	(0.47)		

(*continued*)

Table 4. (*Continued*)

	Agricultural unit growing coca crops					
	(1)	(2)	(3)	(4)	(5)	(6)
Observations	440	440	440	440	440	440
R-squared/Pseudo R-squared	0.02	0.03	0.11	0.12	0.14	0.12
Clusters	25	25	25	25	25	25

Notes: This table presents the results of the specification established in Eq. (1) by Linear probability model (LPM), columns (1) to (5), and marginal effects from a Logit regression, column (6). The outcome variable used in this analysis is defined as agricultural unit growing coca crops = 1, 0 otherwise. The sample includes 440 agricultural units located in Northeast and South Bolivar, Colombia. Huber–White standard errors clustered by municipality in parentheses. Municipal fixed effects regressors not shown in columns (5) and (6). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Based on our results, agricultural units located in the Northeast are more likely to cultivate coca compared to agricultural units located in South Bolivar.

9. Discussion

The household survey analysed here, encompassing a greater diversity of households and regions than any previous survey of coca growers, provides insights into smallholder decision-making and illuminates efforts to control coca cultivation. Our results suggest as long as the goal of reducing coca cultivation is in place, social investment offers a range of public policy interventions to discourage farmers from growing coca. Although municipal-level analyses had already identified poverty and underdevelopment as important covariates of coca cultivation (Dávalos et al., 2011; Dion & Russler, 2008; Ibañez & Carlsson, 2010; Moreno-Sanchez et al., 2003), individual households in coca-growing areas are not uniformly prone to coca cultivation. First, poorer households within already poor and underserved areas are more likely to grow coca than others. Second, the negative relationship between connection to the electric grid and coca cultivation suggests rural electrification is a key intervention to boost legal productivity and reduce the appeal of coca cultivation. Third, boosters of legal productivity, from credit assistance to enhancing legal crop management may play a key role in steering growers away from coca. In contrast, and as observed at larger geographic scales, crop loss including loss from aerial fumigation instigates further coca production. Finally, the relationship between coca cultivation and the age of the head of the household is U-shaped, suggesting a peak in risk-aversion, the importance of experience to successfully growing coca, and/or difficulties in switching away from coca for older households.

If the main goal of all the eradication efforts is to reduce the area under coca cultivation (DNP & DJS, 2006; USAID, 2009), the strategies used to deter farmers from growing coca crops should be tailored to answer their needs. In general, anti-drug strategies should aim to reduce poverty and promote social development (Davalos, 2016). Although unsurprising, finding household poverty is a covariate of coca cultivation is important for shaping future policy. Previous municipal-level analyses have revealed coca is disproportionately located in developing regions with poor social indicators, but even within regions, it is the poorest farmers the ones who adopt coca. This suggests that tactics complementary to boosting local development, investment and support, need to target specifically the poorest households in the region, and not just seek to improve access and conditions in general. As previous studies suggested, specific policies can be more effective that generalised country strategies (Rincón-Ruiz, Correa, León, & Williams, 2016).

Prior to these analyses, rural electrification has not specifically been evaluated as part of anti-coca strategies despite being part of general development plans. Even after controlling for income, access to electricity is an important factor in avoiding coca cultivation. This implies expansion of access to electricity can change agricultural decision-making away from coca. Fortunately, off-grid solutions to providing electricity are increasingly feasible, as is the expansion of the energy grid to which many of the surveyed households were connected. Options for electrification in remote areas include micro hydropower generators, biomass gasifier systems, small wind electric generators, or solar power systems (El Bassam, Maegaard, & Schlichting, 2013; Kanase-Patil, Saini, & Sharma, 2010; Nouni, Mullick, & Kandpal, 2008). Thus, a diversity of geographically appropriate approaches could henceforth become part of anti-coca strategy.

The survey analysed reveals that having the means to enhance legal productivity is an important factor in decision-making. Enhancements to legal productivity can take several different forms: credit, technical support, or even contracts on harvests before planting (effectively what the traffickers provide). Although alternative development projects focus on providing licit market options, but they also must ensure cash payments for their products and access to credit, as previous program failures and partial or in-kind payments discourage farmers from joining new projects.[4] Conversely, crop losses – independent of their ultimate source – are an important driver of coca cultivations. Programs to buffer crop losses are therefore important to limiting the downside of smallholders, preventing the spread of coca. Another alternative is crop insurance, which could be made part of illicit crop control strategies.

As a final implication of our results, communication strategies, productive projects, and training programs should factor the age of the head of the household in their methods. Farmers in their prime, mid-twenties to mid-forties, are less likely to grow coca crops. People in this age range can easily be retrained and shift production activities, but their older counterparts find these changes more challenging (Bailey Iii & Hansson, 1995; Hendricks, 1984; Super, 1990). Therefore, policy-makers need to better understand the contextual factors that make some crops or career changes especially problematic for each target population in order to design more effective policies.

There are, however, alternative scenarios and limitations to consider when interpreting these results. First, if social investment increases the opportunity cost of coca cultivation, according to the economic theory of crime, more farmers are going to opt for legitimate alternatives. In time, there will be a shortage of labour to cultivate coca, a reduction in the area under coca cultivation, and an increase in the price of coca leaf. Under this scenario, social investment will be a successful strategy to deter farmers from coca cultivation. However, as a response to the shortage of labour to cultivate coca, there may be an increase in the price of labour. The wages of coca farmers could grow and become a greater portion of cost production. This increase could persist for as long as the price of cocaine in the market increases. Since cocaine price has decreased consistently since 2001, this wage increase would be limited.[5] Ultimately, a benefit maximising firm – the traffickers – will always choose to reduce wage costs and if necessary, relocate to other areas with lower wages.

Second, previous studies have already established a link between coca cultivation and institutional factors (Camacho, 1999; Ramírez & Molano, 1998; Sarmiento, 1990; Thoumi, 2002, 2003, 2005; Tokatlian & Bagley, 1990). This analysis does not identify the channels through which institutional factors foster coca cultivation, but places with weak rule of law and scarce state presence are prone to criminal activities, including coca cultivation (Diaz & Sanchez, 2004).

Third, the data used in this analysis were collected in 2008 and might be outdated. However, illicit crops still remain a major economic, social, and environmental problem in Colombia. As 2017, Colombia reached an historical number of 171,000 hectares under coca cultivation. Since the survey used in this analysis is the only representative survey of agricultural units located in the Northeast and South Bolivar regions of Colombia, it provides valuable insights into the factors associated with cultivation in those regions.

Finally, decisions of cultivating coca could be motivated by non-monetary factors. Previous studies, following the behavioural theory of crime (Sutherland & Cressey, 1960) found that religion believes, supporting the authorities and the law, and normative factors have a significant effect on the decision of growing coca (Ibañez & Carlsson, 2010; Ibanez & Klasen, 2017). This study, however, does not include morality or legitimacy of the authority and the law in its analysis because the survey used did not include questions about these factors. Therefore, the analysis of non-monetary factors remains material for future research.

10. Conclusions

Crime prevention can be achieved through many different crime control strategies, and law enforcement is just one means to prevent crime (Sherman et al., 1998). In some cases, as in coca cultivation, social investment is an effective complement to coercive eradication (Davalos, 2016). In general, addressing social development issues increases the opportunity cost of committing crime, but social investment in coca-growing areas specifically increases the opportunity cost of growing coca crops. All the results presented in this study support public policy approaches to prevent crime as options besides law enforcement. Most of the statistically significant variables address social development issues: poverty, electrification, and access to banking services. These results could guide new public policies that integrate social development programs as apart from crime prevention strategies to control illicit crops.

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Notes

1. Smallholder households are family farms that practise subsistence agriculture in which most of the labour comes from the household (Arias, Hallam, Krivonos, & Morrison, 2013; Netting, 1993).
2. The area under coca cultivation declined by 52 per cent since 2001, from 144,800 to 69,000 hectares in 2014, (author's estimates based on UNODC (2008) and UNODC (2016b)).
3. The SISBEN index is a *proxy means* index including information on socioeconomic characteristics of the individual, characteristics of his/her home, the size of the household, education, health, employment, and income. For more details about the methodology, visit: https://www.sisben.gov.co/Inicio.aspx.
4. In 1996, for example, the crop substitution program in the Orinoco basin received almost 5,000 requests for credit to improve irrigation, crop processing, and other activities related to legal crop production, only 127 were funded during the first semester because of insufficient resources (Ramírez & Molano, 1998).
5. Cocaine price decreased from COP 5,393/kg in 2001 to COP 3,204/kg in 2017 (UNODC, 2007a, 2018). Price in constant Colombian pesos.

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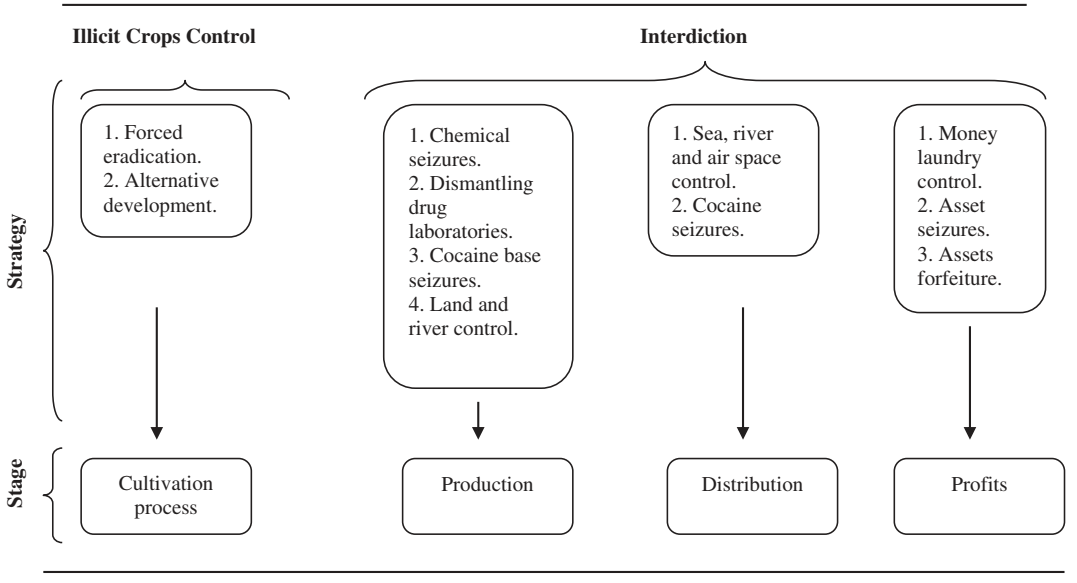
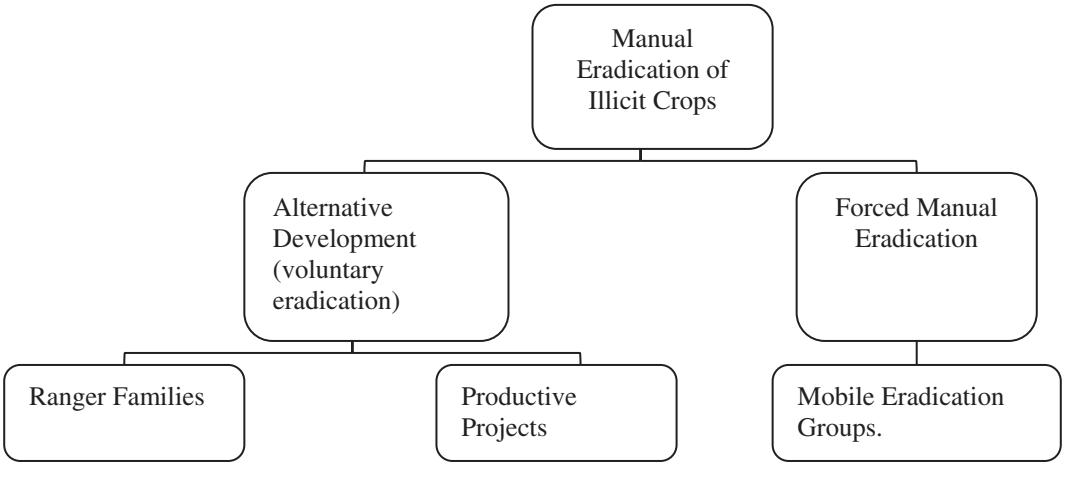
Appendices

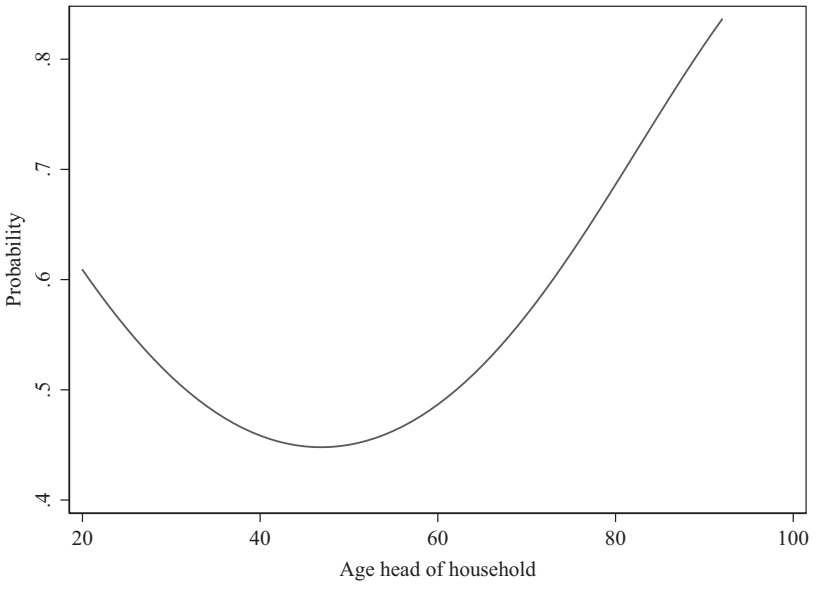


Notes: Based on DNE (2003).

Appendix 1. Comprehensive strategy to control drug trafficking.
Notes: Based on DNE (2003).



Appendix 2. Structure manual eradication of illicit crops.
Source: Based on Acción Social (2011).



Appendix 3. Chances of growing coca as head of household age, results model (6).
Notes: Based on estimations model (6). Chances of growing coca crops decline until 47 years of age, and then start increasing as farmers age.