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The Role of Conflict in Farmers' Crop Choices in North Kivu, Democratic Republic of the Congo

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Abstract

Cropping choices under uncertainty caused by weather, input prices, and ecological conditions have been addressed in contemporary literature. However, uncertainty arising from violent conflict on farming choices lacks substantial academic attention. In this research we address the ramifications of conflict on household cropping choices, building on the notion of "conflict resistant" cropping systems introduced in Kibriya et al. 2014 and King et al. 2013. We argue that farming households' preferences change under conflict as they revert to a cropping system that minimizes losses. This novel concept is solidified by formulating a definition through rational choice theory. The theoretical expectations are verified through data obtained from 2300 smallholder farming households in North Kivu, DRC. A case study and propensity score matching methods are employed to demonstrate that conflict-affected households focus more on low-value crops that are less frequently stolen in order to maximize the probability of survival.

Keywords: conflict resistant farming, North Kivu, farmer adaptation

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Introduction

Researchers have considered how farmers choose crops to hedge against uncertainty caused by weather and prices (e.g. Dercon 1996; and Morduch 1990). Few studies have extended the analysis to uncertainty arising from conflict. Most of the existing literature on violent conflict either addresses ecological (Gillingham et al. 2003; Hocking et al. 2012; and Hill 2000) or human security (Barnett et al. 2007 and Hussein et al. 1997) issues. In case studies by Kibriya et al. (2014), King et al. (2013), and Price et al. (2014), a number of crops and cropping systems were identified as 'conflict resistant'—a term which implies that these crops are less likely to be impacted adversely by conflict (e.g. through theft, destruction, underproduction, lack of markets, etc.). The work suggested the value of a deeper understanding of farmer crop choices with respect to the threat of conflict. Information from farmers about conflict resistant crops and cropping systems can guide extension workers to improve food security in conflict regimes, and guide scientists and policy makers to direct research that improves the conflict resistance of crops and cropping systems or the viability of crops already identified as such. Along the following lines, we investigate the influence of violent conflict on farmers' crop choices in DRC. We argue that farming households' preferences shift under conflict as they revert to a conflict resilient cropping system. We solidify the novel concept of conflict resistant cropping choices and systems by defining it through rational choice theory. Following, we verify our theoretical expectations through a case study and quantitative analysis of a household survey. Our regression results are verified through a propensity score matching method that conclusively shows that cropping choices of conflict-affected households focus more on low value yet high-security products that maximize the probability of survival.

Literature Review and Discussion of Definitions

Although commonly practiced through much of the developing world, the concept of conflict-resistant cropping choices is relatively novel in academia. "War resistant" crops were discussed in Zilverberg's 2007 MS thesis on "Agriculture, Technology, and Conflict," based on his field research in post-conflict Santa Cruz del Quiché, Guatemala. He noted that during times of war, farming households' cropping choices are altered to produce crops that are difficult to be destroyed and can be cultivated without much risk (Zilverberg 2007).

Price observed during fieldwork in DR Congo in 2014 that food acquisition from farmers by guerilla fighters and the regular military occurs in several ways. Fighters typically roam in small groups and may steal clandestinely or at gunpoint. Larger groups may requisition food from village leaders, or order the community to vacate their farms or homes at harvest time so that their crops might be taken. Other groups purchase food but conduct roadblocks or extortion at mining sites. "Conflict resistant" crops are those crops that provide the best return to the farmer under such conditions. More generally, they are crops which best support bare-minimum food security in households that are exposed to armed conflict.

Existing literature on cropping decisions under conflict in North Kivu is limited, but Vlassenroot and Raeymaekers have touched on the subject in extensive work on the history and political economy of eastern DRC. They note for example that in Masisi, North Kivu, during conflict farmers' crop choices demonstrate "a significant shift from extensive to intensive cultivation and from perennial crops to low-risk and seasonal crops" (Vlassenroot 2008). In this context, they describe agricultural decision-making as "increasingly guided by the minimizing of risk rather than the maximizing of profits. In addition, the diversification of crops [is] in accordance with tenure security, which explain[s] the reduction of perennial crops" (Vlassenroot 2008). They go on to note that the disappearance of local support structures which "assist and guide local farmers" (e.g. agronomists) has further negative impacts on farmers' production and their ability to survive on the basis of their agricultural success.[1]

Among the few instances in the literature where farmer decision-making under conditions of conflict is quantified, Rockmore (2014) uses a large dataset from northern Uganda to examine cropping and livestock holdings. He shows that in areas where rebel activity is reported, farmers keep less livestock, with a more pronounced negative effect on large animal holdings (i.e. cows) and a potentially positive effect on pig holdings. He also finds that in areas with rebel activity, fewer households choose to cultivate cassava, beans, and maize, while more households cultivate millet.

Previous work by Kibriya, Partida, King, Price (2012) has laid out a set of crop characteristics which are associated with conflict-resistance. Building upon their work, conflict resistance can be conveyed through a combination of several different properties, including (1) low visibility, (2) harvesting or transport difficulty for looters, (3) production in home gardens or infields as opposed to outfields (4) extensive processing requirements, (5) quick damage recovery, (6) continual production, (7) market complexity, and (8) annual (vs. perennial) growth pattern. Farming households under conflict will tend to forgo crops that are of high nutritional value and are easily marketable, and choose instead to cultivate crops with some combination of these characteristics. Thus we offer a definition of a 'conflict-resistant cropping system' as *the cultivation of a set of crops with some combination of the above characteristics, on the part of a smallholder in response to conditions of widespread active civil conflict*.

Hypotheses

The primary objective of this study is to explore the conditions (i.e. the specific categories of conflict) under which crop theft in particular occurs, and how farmers' choices of crops are influenced by the incidence of conflict. We also aim to further clarify attributes that impart conflict resistance to crops and cropping systems. A secondary objective is to learn what factors might moderate the effects of conflict on crop choice, such as ease of converting crops to cash through market access. Standard choice theory[2] infers that farming households' will alter their

[1] See Rockmore 2014 for a particularly extensive review of the literature on agricultural decision-making and exposure to insecurity and violence.

[2] Standard rational choice theory suggests that individuals have preferences among the available choice alternatives that allow them to state which option they prefer. These preferences are based on three axioms: a. completeness (the agent can always say which of two alternatives they consider preferable or that neither is preferred to the other); b. transitive (if option X is preferred over option Y and option Y is preferred over option Z, then X will always be preferred over Z); c. consistency (the agent will follow the same pattern/rationality unless the underlying conditions change). In this research a rational farmer is assumed to take account of available information, probabilities of conflict events, and potential costs and benefits in determining their cropping choices, and act consistently.

cropping behavior due to exposure to violent conflict. This behavior is likely to be facilitated through market access[3] and technology.[4] Our main hypotheses in this study are:

H_1: Conflict-affected farming households revert to conflict-resistant cropping systems.

H_2: Farmers who have better access to markets and technology will be more equipped to practice a conflict-resistant cropping system.

Survey and Sampling Methodology

Data for this study was collected from North Kivu, DRC in August and September of 2014.[5] We randomly chose thirty-six villages from Beni, Lubero and Rushuru regions of North Kivu[6] using a randomized grid-based strategy and interviewed approximately 2200 rural farming households. The sampling methodology was designed to ensure each village in the selected regions has equal selection likelihood. High-resolution maps from the United Nation's Office for the Coordination of Humanitarian Affairs identify villages in each region. For the grid-based sampling methodology, each region was divided into 5kmx5km squares. In order to be included in the sample space, a grid square had to have at least one village in it. We identified 626 populated squares in the three territories considered, and numbered those squares consecutively—Beni 1:190, Lubero 191:462, and Rutshuru 463:626. Gridding methodology is appropriate because population density is not known and cannot be incorporated in the sampling procedure.

R statistical software was used to generate sixty-five random numbers to select squares for village sampling.[7] Squares that could not be surveyed due to geographic, safety or other concerns are replaced with the next number. Village selection uses proportional weighting within each square. One village was chosen at random from each grid square selected. The unit of analysis is the individual farming household. Each household in the selected villages was surveyed, whenever possible. Enumerators were instructed to ask for the individual responsible for farming. If the individual is not available, enumerators proceed to the next house and return later.

The surveyor was prepared to gather specific information on household demography, input availability and usage, crop choices, market access, empowerment and social voice, and conflict within the society. The main dependent variable for this research is the cropping system of farming households. To collect specific information on the household cropping system the surveyor gathered detailed information on the types of crops each household chose and the reasoning behind such choices. Households were asked to categorize between crops grown for home consumption and cash crops. Additionally, they were asked to specify which crops they had ever had stolen

[3] Market access in this specific study refers to be able to access local enterprises to buy or sell crops and inputs. It encompasses communication facilities such as: cell phones, radio, cycles and social cohesion such as: NGO and co-operative assistance.
[4] For this study technology refers to seeds, fertilizer, irrigation facilities, pesticides and herbicides available to farming households.
[5] The survey was validated and approved by the Institutional Review Board.
[6] Safety and logistical considerations eliminated the other territories in North Kivu from initial consideration.
[7] R 10.3 for Mac Maverick, seed set to 2301. The numbers were selected without replacement.

from their fields, and which crops they had *never* had stolen from their fields. Given the regions and villages the households belonged in, we also asked questions on ethnicity and recorded data on the administrative unit (*groupement*) in which the household was located. Market access was determined by their access to credit and local trade. Information on empowerment and social cohesion were acquired through households' connection to village leadership and extent and type of interaction with fellow farmers. We also gathered information on their co-operative membership status and whether they had any contracts with a crop buyer enterprise.

Empirical Strategy

We initiate our analysis through a qualitative understanding of the farming households in the three surveyed regions of North Kivu and a quantitative estimation of their choices. These choices are set within the agroecological and sociopolitical context of each territory. We then explore the prevalence of both conflict and crop theft in each region, including discussion of the correlations between the incidence of each. The first section concludes by illustrating our hypothesis that farmers shift away from high-conflict crops and toward more conflict-resistant crops when local insecurity increases.

In the second section of the empirical study, we focus on a short case study of a subset of the surveyed regions of North Kivu, which introduces and illustrates our quantitative analysis. In the case study, we discuss the agronomic and ecological attributes of specific crops and cropping patterns of the geographical areas in question. The case study also reveals and verifies the choices adopted by farmers by examining the prevalence of conflict and cultivation of different crops in segregated survey areas. While the initial T-tests and the regression and PSM analysis in Section Three provide a measurable understanding of patterns, the case study aims to provide a more intuitive explanation of farmer choices.

In the third section, we perform a regression analysis that will quantify the consequence of conflict on cropping system choice. Given the cross-sectional nature of our dataset, we cannot control for unobserved heterogeneity within households, nor can we find a suitable and valid instrument that would be partially correlated with our explanatory variables, but uncorrelated with unobserved heterogeneity. To mitigate any bias this might introduce and in order to capture at least some heterogeneity across groups of households, we include ethnic and *groupement* fixed effects instead and estimate the following equation:

$$(1)\; crop\_choice_{ij} = \alpha + \beta_1\, VAR_{ij} + \beta_2\, groupment_j + \boldsymbol{X}'\beta_3 + \varepsilon_{ij}$$

Where $crop\_choice_{ij}$ refers to the cropping decision of household i belonging to *groupement* j; for the *groupement* fixed effect. For this estimation we divided the cropping choices into three groups: a. conflict resistant food crops; b. conflict resistant cash crops and c. crop diversification. The conflict resistant food and cash crops refer to each household's responses on the crops they deemed most unlikely to be stolen and their propensity to produce them. The crop diversity variable is derived from the number of crops individual households chose to produce. X is a vector of the mentioned control variables, referring to: conflict incidence, education, income, social cohesion, access to technology, co-operative membership and access to market. ε_{ij} refers to the innovation term. In all regressions, we used robust standard errors. Since the dependent variable is categorical and ordinal, an ordered probit model was used to estimate the main equation.

While the randomly selected population and categorical regression analysis may eliminate bias, the incidence of conflict or crop choice may be correlated with the other variables which we consider controls. A randomized controlled trial would be ideal but impossible to implement since “conflict” cannot be inserted as a treatment. In this situation, the best empirical setup will be a quasi-experimental design. OLS estimations may produce overestimates of the impact of conflict on crop choices. Overestimation of the effects may occur because many attributes that create conflict may be the same characteristics that do not allow farmers to cultivate certain crops. Therefore, we also chose to employ Propensity Score Matching (PSM) to isolate the effect of conflict on different cropping choices.

Matching methods group and match individual observations based on a single variable (Dehejia and Wahba 1999; Dehejia and Wahba 2002). By matching pairs of farming households with the same characteristics from control and treatment groups, we can make a comparison between treatment and control groups while reducing selection bias. For our quasi-experimental estimation, we use PSM as proposed by Rosenbaum and Rubin (1983). PSM refers to the conditional probability (given a vector of covariates X) of being assigned to treatment. Propensity score accounts for the multidimensional covariates and compresses them into a single dimension, facilitating the matching process (Abadie and Imbens 2009). Hence, the key advantage of PSM is that by using a linear combination of covariates for a single score, it balances treatment and control groups on a large number of covariates without losing a large number of observations. The pair-matched individuals in control and treatment groups with the same propensity score are essentially comparable since their only difference is whether they have been assigned to the treatment or the control group.

More intuitively, a propensity score is the probability of a unit (i.e., farming household choosing crops that are conflict resistant) being assigned to a particular treatment (i.e., experiencing conflict), given a set of observed variables, such as household demographics and access to different facilities. Propensity scores reduce selection bias by equating groups based on the selected variables. In the case of a binary treatment T (T=1 if experienced conflict, and 0 otherwise), an outcome Y (specific cropping choices), and background variables X, the propensity score is defined as the conditional probability of treatment given background variables. The treatment assignment is, then, (conditionally) unconfounded if potential outcomes are not dependent on the treatment, conditional on background variables. In technical terms, we obtain the average treatment effect (ATE) as the mean difference in outcome between the treated and the control households, and the average treatment effect on the treated (ATT) which is the average effect from treatment for those who actually experienced conflict. To check the robustness of the PSM estimation, several matching algorithms are implemented: nearest neighbor, radius (‘caliper’), and kernel (Caliendo and Kopeining 2008; Imbens 2015).

In the nearest neighbor matching method, each conflict-affected household is matched with a conflict-free household with the closest propensity score. The propensity score is the probability of a household experiencing conflict given a set of specified control variables. The radius approach matches each conflict-affected household with all non-conflict-affected households whose propensity score falls in a predefined neighborhood. In kernel matching, each conflict-affected household is matched with a weighted average of all conflict-free households, with weights declining with the distance between propensity scores.

Results– Part I

There is considerable agroecological and sociopolitical heterogeneity across the province of North Kivu, though individual territories can be characterized as somewhat unique from each other. The eastern reaches of all three territories considered are endowed with rich soil (with volcanic derivatives in the south and young fertile Mollisols in the north), while the low-altitude western regions have more acidic and nutrient-poor soils. Three staple crops, beans, cassava, and maize, are the most commonly cultivated crops across all three territories, though they are present in varying relative proportions across the territories (See Table 2).

Beni territory is lower-altitude than the other two territories (generally less than 1200m), with localized rebel activity which increased significantly in the period immediately following the completion of the fieldwork for this study. Households grow more bananas than either of the other territories considered, along with cocoa, coffee and oil palm as cash crops. The territory is relatively ethnically homogenous, being populated largely by the Nande ethnic group.

Lubero territory is generally high-altitude (above 1200m - though the sparsely-populated western expanse of the territory is found at a lower altitude), and also has localized rebel activity, primarily in the southern region. In addition to the primary three staple crops, farmers grow rice, vegetables and a significant amount of potatoes. The territory is very ethnically homogenous, with the city of Butembo along the northern border of the territory being recognized as a traditional Nande stronghold.

Rutshuru territory is a mix of middle and higher altitudes, and has much more widespread rebel activity than either of the northern territories, in large part due to an influx of refugees and armed groups following the genocide in Rwanda in 1994, along with a complicated history of population flows from neighboring regions dating back at least to the Belgian colonial era. In addition to the three staple crops, farmers grow soy, sorghum, fruits and vegetables. The territory is ethnically diverse, with a mix comprising primarily the Hutu, Nande and Tutsi ethnic groups.

Over the past five years conflict has generally spread northward from Rutshuru territory.[8] Among the many armed groups active in the province, the FDLR are particularly significant. An ethnically Hutu militia previously localized to Rutshuru territory, the FDLR's activities have spread into southern Lubero and possibly further north. A variety of ethnically Nande local defense groups have sprung up in the areas where the FDLR is active.

[8] The many layers of conflict in the eastern provinces of the Democratic Republic of Congo are complex and rooted in a combination of historical, political, ethnic and geographical factors which lie beyond the scope of this paper. For an in-depth historical perspective see Hochschild 1999; for a nuanced discussion of recent events see Stearns 2012.

Table 1. Prevalence of conflict per territory

Prevalence of	Beni	Lubero	Rutshuru	"Sub-Region 12"
Community-level conflict	19.8%	22.6%	27.8%	42.5%
Conflict attributed to rebel groups	6.6%	5.1%	11.4%	27.6%
(Correlation coefficient)	0.046	0.240	0.178	0.289

Table 2. Prevalence of crop cultivation per territory

Prevalence of Cultivation	Beni	Lubero	Rutshuru	"Sub-Region 12"
Bananas	55.1%	30.4%	37.8%	4.7%
Beans	85.6%	64.3%	78.8%	52.0%
Cassava	85.3%	70.8%	76.3%	59.1%
Maize	80.0%	68.4%	83.1%	59.1%

Of the twenty-nine crops covered in the survey, only four registered consistently high rates of theft across all regions surveyed: maize, beans, cassava and bananas (See Table 3).[9] On average, theft is substantially more common in Rutshuru territory as compared to Beni or Lubero territories, though maize theft is relatively high everywhere.

Conflict is categorized as "community-level", reported either as conflict with neighbors or family members or "attributed to rebel groups." (See Table 1) In Beni territory, conflict and theft are both low and unpredictable: community-level conflict is not highly correlated with rebel activity, and no conflict is consistently correlated with crop theft (See Table 4). In Lubero, conflict and theft are both relatively localized in the southern sub-region, and there is a high level of correlation between different kinds of conflict, and between conflict and theft across all crops (except bananas, which are not common in Lubero) (See Table 5). In Rutshuru, conflict and theft are both more widespread and generally correlated with each other. (See Table 6).

Table 3. Prevalence of crop theft per territory

Prevalence of Theft:	Beni	Lubero	Rutshuru	"Sub-Region 12"
Bananas	17.2%	10.7%	37.8%	4.7%
Beans	15.4%	17.2%	78.8%	54.3%
Cassava	19.1%	15.9%	76.3%	32.3%
Maize	35.5%	45.8%	83.1%	77.2%

[9] Defined as greater than 10% of households overall reporting theft of the crop at any point. Note that 'bananas' includes both plantain (more prevalent) and sweet bananas.

Table 4. Test statistics for mean rates of theft by incidence of conflict (Beni Territory)

Beni Territory	Bananas	Beans	Cassava	Maize
Community-level conflict	-9.3209***	2.3523	0.9215	0.7972
Conflict attributed to rebel groups	-1.7270*	1.2547	-3.3226***	-0.0028
N	679	679	679	679

Note. Test statistics are reported for the mean rate of theft for each crop for households not reporting the specified type of conflict as compared with the mean rate of theft for that crop for households who do report the specified type of conflict. *Refers to 10% significance level while ** and *** refer to significance levels of 5 and 1 percent, respectively.

Table 5. Test statistics for mean rates of theft by incidence of conflict (Lubero Territory)

Lubero Territory	Bananas	Beans	Cassava	Maize
Community-level conflict	-1.7563*	-6.3762***	-2.9170***	-2.6656***
Conflict attributed to rebel groups	1.1159	-8.7130***	-4.0566***	-2.0812**
N	679	679	679	679

Note. Test statistics are reported for the mean rate of theft for each crop for households not reporting the specified type of conflict as compared with the mean rate of theft for that crop for households who do report the specified type of conflict. *****Refers to 10% significance level while ** and *** refer to significance levels of 5 and 1 percent, respectively.

Table 6. Test statistics for mean rates of theft by incidence of conflict (Rutshuru Territory)

Rutshuru Territory	Bananas	Beans	Cassava	Maize
Community-level conflict	1.4503	-3.4542***	-3.9476***	-3.7789***
Conflict attributed to rebel groups	1.8929	-3.2135***	0.3442	0.5043
N	894	894	894	894

Note. Test statistics are reported for the mean rate of theft for each crop for households not reporting the specified type of conflict as compared with the mean rate of theft for that crop for households who do report the specified type of conflict. *Refers to 10% significance level while ** and *** refer to significance levels of 5 and 1 percent, respectively.

Tables 7 and 8 provide further emphasis for the point that conflict of both categories across North Kivu as a whole is correlated with higher rates of crop theft. Table 7, in particular, indicates that higher rates of community-level conflict are correlated with increased crop theft in beans, cassava, and maize.

Banana theft is difficult to assess in part because the crop is not cultivated as widely, so the comparison between territories is difficult. In addition, the banana plant has a number of characteristics which confer some degree of conflict-resistance (as defined at the beginning of this paper), potentially confounding analysis which treats it as a conflict-prone crop. Those characteristics include the fact that the banana corm continues to produce new stalks and new bunches even if the farmer is dislocated due to conflict; the relative difficulty in transporting the fruit when harvested (given its bulky nature); and the fact that a farmer's banana field is often near the homestead. As a result, the analysis that follows does not explicitly categorize bananas as either conflict-resistant or conflict-prone. (Cf. beans, cassava, and maize, which are all categorized as conflict-prone.)

Table 7. Test statistics (and significance) comparing community-level conflict to theft

Incidence of Community - Level Conflict	Theft of: Bananas	Beans	Cassava	Maize
Household level (incidence vs. no incidence)	-4.8284***	-5.3351***	-4.7456***	-4.1990***
Sub-regional level (20-40% vs. <20%)	0.9404	5.7629	7.4434	5.4317
Sub-regional level (41-60% vs. <20%)	-9.2244***	-1.511	-2.3398**	-2.8087***
Sub-regional level (61-80% vs. <20%)	1.2880	-7.0820***	-8.7767***	-4.9856***

Test statistics are reported for the mean rate of theft for each crop for households for the conflict incidence comparison specified. "Household level" is identical to the t-test run in Tables 4–6. "Sub-regional level" describes the overall percentage of households in an individual survey location which report community-level conflict, and compares mean theft in areas with the prevalence rates specified. **Note.*** refers to 10% significance level while ** and *** refer to significance levels of 5 and 1 percent, respectively.

Table 8. Test statistics (and significance) comparing rebel conflict to theft

Incidence of Conflict Attributed to Rebel Groups	Theft of: Bananas	Beans	Cassava	Maize
Household level (incidence vs. no incidence)	0.8459	-6.4475***	-4.0148***	-1.9883**
Sub-regional level (20-40% vs. <20%)	3.1510	-11.6012***	-5.6008***	-4.0334***
Sub-regional level (41-60% vs. <20%)	0.2498	-3.7996***	-7.6261***	-2.5378**

Note. Test statistics are reported for the mean rate of theft for each crop for households for the conflict incidence comparison specified. "Household level" is identical to the t-test run in Tables 4–6. "Sub-regional level" describes the overall percentage of households in an individual survey location which report conflict attributable to rebel activities, and compares mean theft in areas with the prevalence rates specified. ***Refers to 10% significance level while ** and *** refer to significance levels of 5 and 1 percent, respectively.

Case Study

In mid-April, 2012 parts of Lubero territory started to come under control of the FDLR (Van Damme 2012; see Raeymaekers 2008 for background). This control was localized in the area just south of "Sub-Region 12", around the town of Luofu in southwestern Lubero territory. This area is otherwise substantially similar to the rest of the heavily-populated eastern portion of Lubero territory, with similar rainfall (in the range of 1,200–1,800 mm/yr), altitude (1,600–2,000 m), history, market access and ethnic composition. This basic similarity allows us to assess the current conditions (post-FDLR incursion) as a natural experiment, in which the rest of eastern Lubero territory (substantially unaffected by the incursion) is taken as a control region.

The uptick in rebel-related and another conflict in Sub-Region 12 is evident in respondents' answers to questions about their experience of conflict in the past 12 months (as of August 2014) (summarized in Table 9). We also see a particularly high incidence of theft[10] in this Sub-Region in comparison to the rest of Lubero territory (see Table 11). Upon further inspection, we note evidence of changing preferences among farmers with regard to crop choice: Across eastern Lubero territory, maize *(Zea mays)*, beans *(Phaseolus vulgaris)* and cassava *(Manihot esculenta)* are the most commonly cultivated crops, but fewer farmers in Sub-Region 12 choose to cultivate maize, beans, and cassava, and more cultivate finger millet *(Eleusine coracana)*, taro *(Colocasia esculenta)* and peas *(Pisum sativum)* (see Table 10).

Table 9. Prevalence of conflict by source, in Sub-Region 12 vs. Control Region

Prevalence of Conflict (by source)	Family and Neighbors	Local Chiefs	Government Forces	Rebel Groups
Sub-region 12	42.5%	42.5%	6.3%	27.6%
Eastern Lubero Territory	20.3%	20.8%	0.8%	0.0%
test statistic	-5.050***	-4.896***	-3.669***	-11.840***
N	497	497	497	497

Note. Test statistics are reported comparing the prevalence of conflict for households between the regions specified. *Refers to 10% significance level while ** and *** refer to significance levels of 5 and 1 percent, respectively.

Table 10. Prevalence of cultivation by crop, in Sub-Region 12 vs. Control Region

Prevalence of Cultivation	Beans	Cassava	Maize	Millet	Taro	Peas
Sub-Region 12	52.0%	59.1%	59.1%	37.0%	49.6%	26.8%
Eastern Lubero Territory	67.8%	67.8%	65.1%	0.3%	36.2%	3.8%
test statistic	3.238***	1.799**	1.228	-14.367***	-2.676***	-8.029***
N	497	497	497	497	497	497

Note. Test statistics are reported comparing the rate of theft for each crop for households between the regions specified. *Refers to 10% significance level while ** and *** refer to significance levels of 5 and 1 percent, respectively.

[10] Note that the prevalence of crop theft is higher than the prevalence of cultivation in some cases. Farmers were asked to specify which crops they cultivated in the previous two growing seasons (approximately 12 months), but the question about theft asked farmers to list crops which had *ever* been stolen from their fields.

Table 11. Prevalence of theft by crop, in Sub-Region 12 vs. Control Region

Prevalence of Theft	Beans	Cassava	Maize	Millet	Taro	Peas
Sub-Region 12	54.3%	32.3%	77.2%	0.0%	0.5%	0.8%
Eastern Lubero Territory	12.2%	13.8%	40.0%	0.0%	0.4%	0.3%
test statistic	-10.824***	-4.725***	-7.625***	–	-0.613	-0.793
N	497	497	497	497	497	497

Note. Test statistics are reported comparing the rate of theft for each crop for households between the regions specified. *Refers to 10% significance level while ** and *** refer to significance levels of 5 and 1 percent, respectively.

Smallholders in North Kivu tend to devote their largest fields to their staple crops - most commonly a combination of beans, maize and cassava - and these fields are often far from the family home. Maize, in particular, is easily harvested and ready for consumption, while beans are the most widespread basic protein source in the region and are ready for cooking at harvest. Two general categories of cassava—'sweet' cassava and 'bitter' cassava, with varying cyanide content—are grown in the region, usually planted together in the same fields. For the rural population the differences between varieties of this staple crop are common knowledge, so 'sweet' cassava is a ready target for foragers and thieves while 'bitter' cassava, with dangerous levels of cyanide and requiring substantial processing (soaking, fermentation, drying, etc.) before consumption, is largely ignored by thieves and foragers.[11]

Peas in North Kivu are prepared in a manner similar to beans, where they are boiled (either fresh or dried), seasoned with oil and salt and served with a carbohydrate such as maize, cassava, taro or rice. They are seen as a rather 'particular' crop, susceptible to both insects and disease, so farmers in the region prefer to plant less and watch the crop closely, leading them to plant the crop in smaller fields close to home. In the presence of conflict, when farmers face greater risk visiting outlying fields, peas planted in fields closer to the home have the potential to take the place of extensive (and risky) bean production as the household's primary protein source. In addition, peas in the high-altitude areas of eastern Lubero are harvested fresh to minimize the risk of insect damage, then sold fresh or dried, so the period from planting to harvest is less than four months, while beans in the same area are harvested after 4–5 months.

Like 'bitter' cassava, taro root contains toxins which require considerable processing (usually peeling and sun-drying) before the root can be consumed safely. In addition, taro is traditionally cultivated on more marginal fields, so farmers who resort to cultivating closer to home in smaller patches of more difficult terrain may choose taro as a culturally appropriate option.

As a small-seeded grain, millet requires considerable investment in drying, threshing and winnowing the harvested crop before it can be consumed, all of which would tend to dissuade potential thieves from the effort of stealing the crop from the field. In addition, millet is an uncommon staple crop in

[11] Unfortunately the survey did not differentiate between 'sweet' and 'bitter' cassava when measuring cultivation and theft.

the diet of the region, so unfamiliarity with cooking and preparing the grain could be an additional impediment to its theft.[12]

Considering these agronomic and cultural factors, a shift away from easily-prepared and readily-consumed crops such as maize, beans and 'sweet' cassava, and toward millet, taro and peas make sense. As noted in Table 11, though rates of theft are higher in sub-region 12 even for taro and peas, those rates are substantially lower than the rates of theft for the primary staple crops mentioned. In this natural experiment, we see that farmers in areas exposed to higher-than-average rates of conflict act as rational actors: They choose to switch away from conflict-prone staple crops and to diversify their portfolio with crops which are more conflict-resistant.

Results– Part II

Table 12. Regression estimations on the relationship between cropping system choice and conflict

Dependent Variable	**Conflict Resistant Food Crops**		**Conflict Resistant Cash Crops**		**Crop Diversification**	
Variables	(1)	(2)	(3)	(4)	(5)	(6)
Conflict Level	0.156***	0.13***	0.07***	0.08***	0.47***	0.44***
Low Market Access	-0.299***	-0.08	-0.26***	-0.10*	-1.48***	-0.82***
Contract with Farmer	-0.406***	-0.19**	0.01	0.01	-1.3***	-0.63**
Empowerment	-0.706***	-0.90***	-0.11	-0.06	-1.99***	-2.0***
Social Cohesion	0.0950	0.08	0.10	0.12**	0.30*	0.37**
Cooperative Membership	0.196	-0.06	-0.16***	-0.10*	0.14	0.86*
Household Size	0.478	0.08	0.01	-0.01	0.1***	0.14***
Income	-3.93^{-10}	$-1.10^{-.09}$	$-1.2^{-.09}$	$1.69^{-.09}$	$8.03^{-.09}$	$1.33^{-.08}$
Education	0.01	0.01	0.01	0.01	-0.01	0.01
Access to Technology	0.280	0.16**	0.22**	0.08	0.78	0.40**
Constant	2.816	1.7***	0.70***	0.69	5.3***	4.49***
Observations	1440	1440	1440	1440	1440	1440
R-squared	.2	.3	.15	.35	.25	.45
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Groupement FEs	No	Yes	No	Yes	No	Yes

Note.*Refers to 10% significance level while ** and *** refer to significance levels of 5 and 1 percent, respectively.

[12] These findings substantially corroborate those reported by Rockmore (2014), who also found that in areas with rebel activity, fewer households choose to cultivate cassava, beans and maize, while more households cultivate millet.

The first two columns of Table 12 refer to conflict resistant food crops as the dependent variable with and without the *groupement*-specific effects. Table 13 lists and describes all correlates used in the analysis. In both the columns, we find conflict incidence positively affecting households' cropping choices at the 99% confidence level. Households that have lower market access have a statistically significant negative association with producing less conflict resistant food crops. Contract levels of farmers are found to be negatively related to households' choice of conflict resistant crops with 1% statistical significance: Farmers have more incentive to produce profit maximizing crops as opposed to hedging against conflict if they have an existing contract and will be producing more cash crops.

Table 13. Regression variables

Variable Name	**Description**
Conflict Resistant Food Crops	Crops which are both cultivated by the farmer as food crops for home consumption *and* reported as infrequently stolen
Conflict Resistant Cash Crops	Crops which are both cultivated by the farmer as cash crops *and* reported as infrequently stolen
Crop Diversity	Number of crops each farmer produced
Conflict Level	Number of incidences of conflict each farmer experienced
Low Market Access	From a composite score of farmer's access to local markets
Contract with Farmers	If the farmer had a formal contract with a buyer
Empowerment	Composite score on farmer's voice and influence in his/her village
Social Cohesion	Composite score of farmer's social standing
Co-operative Membership	If the farmer is a member of a co-operative
Household Size	Number of people in the household
Income	Total income in the last two cropping seasons
Education	Number of years of schooling
Access to technology	Composite score on farmers' access to agricultural technology
Groupement	The specific *groupement* in which the farmer is located

Empowerment also appears negatively and significantly related to conflict resistant food crops in both columns. As a household gains more power in the society, it appears that households get more confident and produce less conflict resistant crops. Income, education, size and co-operative memberships do not appear to be statistically significant with any of the conflict resistant food crops. Columns 3 and 4 show the estimates of conflict resistant cash crops as dependent variables with and without *groupement* fixed effects. Similar to conflict resistant food crops we find that conflict incidences are positively related at 1% significance levels. Low market access also depicts comparable results with the first two columns. Surprisingly, contracts with buyers do not have any statistical significance in the choice of conflict resistant cash crops. We attribute this non-significance to the lack of variation in the data as most of the farmers who produced cash crops have some kind of contract with buyers. Empowerment had similar effects because most farmers who practiced cash cropping had some influence on their respective councils and societies. We again fail to find any significant relationship between conflict resistant cash crop and household size, income and education.

Columns 5 and 6 show the estimates of crop diversification. Conflict incidences are again found to be statistically significant and positively related to crop diversification at 99% confidence intervals. Contracts and low market access are negatively but statistically significantly related to crop diversification at a 1% significance level. Farmers who have contracts with buyers and low market access try to specialize in certain crops. Empowerment has a statistically significant negative relationship while social cohesion has a significant and positive association with crop diversification. Household size contradicts the results of previous columns showing a significant positive relationship with crop diversification. Surprisingly yet consistently, income and education appear inconsequential in terms of households' choice of diversifying agricultural crops—possibly because while it is generally accepted that higher-educated farmers tend to specialize and invest more in fewer crops, under conditions of conflict those same farmers may tend to diversify their cropping choices.

Using Propensity Score Matching, the impact of conflict on farmers' cropping choice remains significant at the 5% level under the nearest neighbor regression method, and at the 1% level under the other methods (caliper=0.005 and kernel) (see Table 14). Figure 1 shows that the density curve for propensity scores of the treated and the control groups align well. Table 15 details the variables used in the PSM estimation.

Table 14. PSM estimations on the relationship between cropping system choice and conflict

Estimation Method	**Nearest Neighbor**	**Caliper (0.005)**	**Kernel**
Coefficient on outcome variable ('Conflict resistant crops')	0.076**	0.083***	0.085***
Number of treated	879	879	879
Number of controls	945	945	945

Note. ** Refers to 5% significance level while *** refers to 1% significance level.

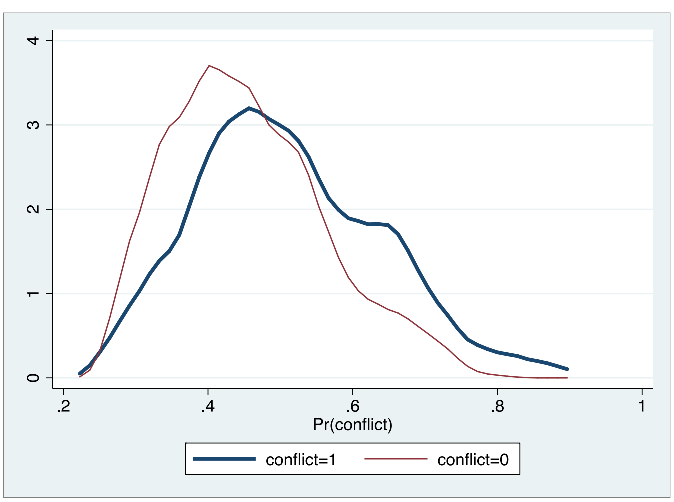

Figure 1. Estimated propensity score density over groups (treated vs. control)

Table 15. PSM regression variables

Variable Name	Description
Conflict Resistant Crops	Defined on the basis of the cropping system identified in the case study results, as the cultivation of at least one of millet, taro or peas in the previous cropping period.
Treatment Variable	
Conflict	Farmer reports exposure to conflict during the six months preceding the survey.
Control Variables	
Low Market Access	From a composite score of farmer's access to local markets
Contract with Farmers	If the farmer had a formal contract with a buyer
Empowerment	Composite score on farmer's voice and influence in his village
Social Cohesion	Composite score of farmer's social standing
Co-operative Membership	If the farmer is a member of a co-operative
Education	Years of schooling of the most highly educated family member
Access to technology	Composite score on farmers' access to agricultural technology
Sub-Region	The sub-region in which the farmer is located.

Discussion

In Part I, we see that in a 'natural experiment' where rebel forces enter a sub-region of a relatively homogenous territory, increased rebel activity is associated with increases in community-level conflict, and that both are associated with increased incidence of crop theft. We also see evidence in the case study that when confronted by increased levels of conflict, farmers make the rational choice to cultivate less of the common, easily-looted maize, beans, and sweet cassava, and more conflict-resistant crops—characterized in this case by crops with a combination of a short, annual growth pattern, being cultivated in gardens or fields close to the home and/or close to population centers, and having extensive processing requirements (drying/threshing for millet, poison removal in the case of taro). The case study clearly indicates that households make rational choices about crop choice when faced with conflict, and choose to cultivate crops which are less prone to theft.

In Part II, we find that the main independent correlate, conflict incidence, positively influences farmer cropping choice for both conflict-resistant cash and food crops and diversification decisions. Table 16 summarizes the signs of associated correlates used in the regression analysis. We conclude that being prone to conflict alters behavior and hedging mechanisms of farming households. Households in North Kivu tend to diversify their crop choice when exposed to conflict incidents. Access to technology appears to provide farmers an advantage in producing more conflict resistant crops, while better market access makes households more inclined to produce crops that are conflict resistant. Social empowerment also appears to have the same effect on conflict-resistant food cropping and crop diversification. However, empowerment and contracts appear to have no effect on cash cropping, mainly due to lack of variation. Social cohesion does not affect the conflict-resistant food crop choices, though it affects the choice of cash crops and diversification—implying that better-connected farmers alter their cash-cropping behavior due to conflict, but not their cropping behavior for home consumption. A rather surprising finding of this research is that income and education levels do not affect farmer crop choices. We feel that the lack of dispersion in the data due to low-income levels and education across most of the surveyed households contributed to this significant yet perplexing discovery. It is also possible that the well-accepted tendency among higher-educated and higher-earning farmers to specialize in fewer crops confounds our analysis since those same farmers are likely to act rationally under conflict conditions. Access to farmer co-operatives only appears to reduce alteration in behavior in cash cropping. These findings are further corroborated by a Propensity Score Matching approach, demonstrating a strong case for a causal relationship between conflict incidence and the choice to cultivate a set of crops with strong conflict resistance.[13]

These findings cannot necessarily be extrapolated to profit-oriented farming enterprises, given the subsistence nature of the majority of the sample studied—for example, just over 7% of the sample has any sort of contract with a buyer for the purchase of their crops. As noted previously, cropping decisions through much of North Kivu are "guided by the minimizing of risk rather than the maximizing of profits."

Table 16. Summary of results

Explanatory / Dependent	Food Crops	Cash Crops	Diversification
Conflict	+	+	+
Market Access	–	–	–
Contract	–	N/A	–
Empowerment	–	N/A	–
Cohesion	N/A	+	+
Co-op	N/A	–	N/A
Income	N/A	N/A	N/A
Size	N/A	N/A	+
Technology	+	+	+
Education	N/A	N/A	N/A

Note. + Refers to statistically significant positive relationship while refers to a statistically significant negative relationship. N/A implies no association due to lack of statistical significance.

[13] Issues of reverse causality are extremely unlikely in this case: A causal relationship between the cultivation of millet, taro and peas, and the incidence of rebel activity, would be difficult to substantiate.

Conclusion

Although the study of cropping behavior under extreme conditions is in its infancy, our unique approach and results provide significant insight into farmer behaviors in North Kivu, DRC. The case study using the natural experiment in Sub-Region 12 of Lubero territory lends support to our primary hypothesis, that conflict changes farmer perceptions and cropping behavior. Our secondary results imply that farmers that have better market access will be able to adapt more towards conflict resistant cropping systems. Cohesion in general also increased shock resiliency through adaptation towards more conflict resilient cropping systems. Although household size increased crop diversification, it did not contribute to coping mechanisms through cropping systems. The policy implications that can be drawn from this study are that improving access to markets and information as well as increasing social cohesion can help farming households in conflict-prone agrarian societies such as North Kivu to adopt conflict-resistant farming practices. This, in turn, might help them to cope better with the adverse effects of long-term conflict and social unrest that has become an integral part of their lives and livelihoods. Finally, a better understanding of farmers' cropping choices under conditions of conflict could aid practitioners, policymakers, and potentially even crop breeders and other researchers to better serve the needs of populations under conditions of long-term conflict.

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