Agricultural yield and conflict

Ang, James; Gupta, Satyendra Kumar

2018

Ang, J., & Gupta, S. K. (2018). Agricultural yield and conflict. *Journal of Environmental Economics and Management*, 92, 397-417. doi:10.1016/j.jeem.2018.10.007

<https://hdl.handle.net/10356/136862>

<https://doi.org/10.1016/j.jeem.2018.10.007>

© 2018 Elsevier Inc. All rights reserved. This paper was published in *Journal of Environmental Economics and Management* and is made available with permission of Elsevier Inc.

Downloaded on 26 Apr 2023 18:16:29 SGT

AGRICULTURAL YIELD AND CONFLICT

James B. Ang^{*}

Satyendra Kumar Gupta[#]

This version: October 1, 2018

Abstract: This research establishes that the emergence and persistence of intrastate conflict incidence since 1960 are influenced by regional agro-ecological factors captured by the extent of variation in potential crop yield. Our results based on cross-country and grid-level analysis indicate that higher potential crop yield variability within a country that is exogenous to both human intervention and regional culture increases the likelihood of intrastate conflict. Our findings are robust to the inclusion of various geographical, institutional, and potentially confounding economic development correlates.

JEL Code: E02; F50; Q10

Keywords: Intrastate conflict, potential crop yield, agronomy

^{*} Corresponding author. Department of Economics, Nanyang Technological University, Singapore 637332. E-mail: James.Ang@ntu.edu.sg.

[#] Department of Economics, Indian Institute of Management Rohtak, Haryana, India, 124010. E-mail: satyendra.gupta@iimrohtak.ac.in

Acknowledgements: Helpful comments and feedback received from two referees of this journal, Christopher Paik, Giovanni Ko, and seminar participants of Nanyang Technological University and conference participants at the 2016 WEAI conference are greatly appreciated. Liu Meng and Aatishya Mohanty provided very competent research assistance. We gratefully acknowledge Oded Galor and Ömer Özak for sharing their crop yield data. James Ang acknowledges financial support from the NTU Start-up Grant and Singapore Ministry of Education Academic Research Fund Tier 2.

1 Introduction

Intrastate conflict, a type of political violence that involves sustained conflicts between the state and an armed non-state group, is a profound reality in many parts of the world. In the past 70 years, intrastate violence has been more common than any other types of armed conflict, which includes extrastate, interstate, and internationalized intrastate violence (Allansson et al., 2017). It is phenomenally evident that nearly half of the countries in the world have experienced at least one incidence of it over the last few decades. The resulting loss of human capital and undesirable outcomes associated with the geographical spread of violence have attracted the attention of many economists, social scientists, and psychologists to understand the roots of civil conflicts.

The literature suggests two possible conditions that would give rise to the occurrence of a conflict: (1) when the opportunity cost of engaging in conflict is less than that of peaceful cooperation or negotiation; and (2) when there is an increasing return from violence. The first condition emphasizes that slow economic growth and low per capita income are notable signs of low opportunity cost, and people facing such circumstances are more likely to participate in violence (Collier and Sambanis, 2002; Blattman and Miguel, 2010). Slower growth and per capita income can, in turn, be linked to lower agricultural productivity, which is often induced by variation in rainfall, temperature, and soil quality. In particular, adverse climate conditions may impact agricultural productivity, which reduces the opportunity cost of initiating and engaging in conflicts and civil wars (see, e.g., Collier and Hoeffler, 1998; Collier and Hoeffler, 2004). The second condition suggests that it is possible for the winning group to extract rents during or after the conflict. For example, Deininger (2003) finds that the presence of cash crops, such as coffee plant, increases conflicts during the Ugandan civil war when the winning group expropriated rents from the agricultural produce. In a similar vein, Angrist and Kugler (2008) show that a higher price of cocoa is positively associated with the occurrence of armed conflicts in Colombia.

Recent studies have taken the above arguments further by providing evidence on how natural conditions play an important role in the onset of conflict and ongoing conflict incidence in a region. Natural rainfall was, and still is in many parts of the developing world, the dominant source of water supply for agriculture in the absence of efficient irrigation systems. Thus, several studies have exploited the association between variation in rainfall and agricultural productivity to explain conflicts and rebellions in cross-country and within-

country analysis. For example, Miguel et al. (2004) provide evidence showing that extreme weather conditions are strongly associated with the occurrence and incidence of conflict. They find a positive relationship between extreme rainfall variation on the frequency of rebels and communal conflicts in Africa. Chaney (2013) shows that significant deviation above or below the optimal flood level of the Nile triggered political instability in historical Egypt. Using the incidence of draught as an instrument for population density, Brückner (2010) shows that an expansion in the population size increases the risk of civil conflict in Sub-Saharan Africa.

Other studies have shown that temperature and the occurrence of conflict are strongly related. In particular, Dell et al. (2012) find that the annual variation in temperature is strongly linked to standards of living, where for every one degree Celsius increase in temperature per capita income is predicted to fall by 1.4 percent in poor countries. Similarly, Schlenker and Lobell (2010) find that variation in temperature and precipitation during yield time negatively affects agriculture productivity in African countries. Analyses using data from historical temperate and cold locations conducted by Zhang et al. (2007) show that anomalously cold events during cold epochs are associated with episodes of political instability in dynastic China and feudal Europe. In a similar vein, Hsiang et al. (2011) find that 21% of all the civil conflicts since 1950 could be attributable to the warmer and drier weather in the continental tropics caused by El Nino/Southern Oscillation (ENSO).

This study extends the strand of literature that explores the influence of climate variables on long-term development. We argue that agricultural productivity potential has played a significant role in shaping the direction of human history following the agricultural transition. Focusing on agroecology as the main explanation for conflict is especially relevant since our physical environment (such as temperature, humidity, water supply, soil conditions, sunlight and terrain) may shape the development of human behavior, social norms, and culture, which subsequently determine the existence of peace or conflicts in a society (see, e.g., Anderson, 1987; Van de Vliert et al., 1999; Nunn and Puga, 2012; Alesina et al., 2013; Jimenez-Ayora and Ulubaşoğlu, 2015). The agroecology of a region, until the advent of modern agricultural techniques such as fertilizers, mechanized farming tools and irrigation facilities, determined the level of calories one could get in any region.

We hypothesize that there would be frequent and persistent attempts to conquer and control territories that produce high caloric yield. Higher regional variation in caloric yield

should therefore increase the frequency of these conflicts to control the most valuable resource in pre-industrial societies. Our hypothesis is built upon the literature that studies the relationship between civil war and horizontal inequality (see, e.g., Gurr, 1970; Cederman et al., 2011). Stewart (2008) finds that there are four arenas where horizontal inequalities may thrive, namely, political participation, economic aspect, social aspect and cultural status. Inequality among groups of people in their ability to participate in state politics, gain ownership of financial, livestock or agricultural assets and their cultural status in the society may lead to discontentment. Different groups of people are endowed with different levels of agricultural productivity that may have resulted in unequal economic prosperity during the preindustrial period. Consequently, a feeling of deprivation among the groups endowed with less productive agricultural land may lead to the occurrence of civil wars. This theory of relative deprivation was put forward by Gurr (1970), whose study affirms that the frustration from being unable to attain what one desires leads to collective violence. Economic horizontal inequality arising from spatial variation in agricultural productivity may lead to social comparison, which eventually triggers conflict (Horowitz, 1985).

In principle, individuals endowed with different levels of potential crop yield may behave differently when they observe substantial variation in agricultural productivity across regions. However, the influence of mean potential crop yield on the incidence of conflict in historical societies and low income countries today is unclear. On one hand, higher agricultural productivity can reduce the incidence of conflict through reducing the requirement for land, which suppresses competition over the control of land. On the other hand, the cost of maintaining large armies reduces with the availability of cheap food, which can lead to more conflicts. Thus, unlike how variation of potential crop yield is related to conflict violence, the net effect of mean potential crop yield is theoretically ambiguous (see Iyigun et al., 2017).

Given that the presence of conflict in a country may influence the choice of technologies and investment in agriculture, and therefore may affect the actual crop yield, we exploit the variation in potential (rather than actual) crop yield compiled using agro-climatic conditions that are orthogonal to human intervention. The use of potential crop yield therefore enables us to identify the causal effect of historical crop yield on contemporary intrastate conflict incidence. Specifically, we demonstrate that the variation in agroecology, measured as the standard deviation in potential crop yield (in thousands of kilocalories per

hectare per year) within a country based on the data of Galor and Özak (2016), has a significant positive effect on conflict incidence.¹ Consistent evidence is obtained when simple cross-country, pooled cross-country and grid-cell level data are used. The findings are also robust to alternative measures of conflict incidence – such as, the intensity of conflict, annual frequency of conflict incidence – and the control of various geographic characteristics, contemporary influences, natural endowments and other indicators of early development. In all regressions, we control for the effect of mean potential crop yield. In line with the above discussion, its effect is either insignificant or inconsistent.

This paper is related to a strand of literature that studies the impact of climate change on conflict. In particular, using the data for East Africa from 1990 to 2009, O’Loughlin et al. (2012) demonstrate that an increase in temperature raises the risk of violence. Similarly, Harari and La Ferrara (2018) also show that higher temperature and lower rainfall during growing seasons increase the risk of conflict disproportionately in Africa during the period 1997-2011. In another recent study, Crost et al. (2018) explore how climate change affects civil conflict in the Philippines. Their results show that a shift towards extreme wet or dry seasons will lead to a higher level of civil conflict.

Our work is closely related to that of Galor and Özak (2015), who provide evidence that, in comparison with another commonly used land productivity measure (i.e., agricultural suitability),² mean potential crop yield is more strongly correlated with pre-industrial population density, which determines the path of subsequent development.³ They also provide new evidence showing that pre-industrial agro-climatic characteristics that were favorable to agricultural productivity, proxied by potential crop yield, induced learning processes that have had a persistent effect on the formation of long-term orientated cultures in the modern day.

This study is also complementary to the contribution of Nunn and Qian (2014), who investigated the implication of humanitarian food aid on conflict. They argue that US food

¹ The crop yield index is a composite measure that takes into account the effect of temperature and moisture on the growth of 48 crops. Potential yield estimation for each crop in each agro-climatic grid (with cell size of approximately 100 km²) is provided by Global Agro-Ecological Zones (GAEZ) project of Food and Agriculture Organization (FAO). For detailed description of the crop yield data, see section 2 of this paper.

² The agricultural suitability indices have been used in a number of research on long-term development, including Michalopoulos (2012), Ashraf and Galor (2013), Ang (2015), Ashraf and Michalopoulos (2015) and Olsson and Paik (2016), etc.

³ Other related studies by Depetris-Chauvin and Özak (2015, 2016) show that population density affects the division of labor and economic specialization, which in turn result in the formation of institutions and states.

aid is often stolen by armed rebels or appropriated by the military of the ruling government, and hence an increase in aid may exacerbate civil conflict in recipient countries. Using a novel identification strategy, their results provide strong support for the view that higher US wheat aid tends to increase the incidence and duration of civil conflicts. In a similar vein, Arbatli et al. (2015) demonstrate that genetic diversity has a robust and persistent effect on the frequency, incidence, and onset of civil conflicts. However, unlike Nunn and Qian (2014) and Arbatli et al. (2015) who examine the roles of contemporary wheat aid and genetic diversity, respectively, we focus on whether the variability of pre-industrial agricultural productivity can potentially account for the persistent occurrence of conflict.

While the current paper focuses on explaining civil conflicts since 1960, in the sensitivity checks we show that our hypothesis is equally valid for non-state conflicts where none of the groups participating in the conflicts are associated with the state. All these groups, whether state or non-state, operate under the same institutional framework and try to control the same natural endowment to empower their own group. Our results also show that historical conflict since 1500 can be explained by the variation in potential crop yield. This result is unsurprising given that geographical conditions have not changed much over time. However, examining the link between interstate wars and their differences in potential crop yield variability is beyond the scope of the current study.

The rest of the paper is organized as follows. Section 2 describes the data and construction of variables. Section 3 presents and discusses the main empirical results. The cross-country results indicate that variation in potential crop yield significantly predicts the occurrence of conflicts. We also divide the world into small grids of 2.5 by 2.5 decimal degrees to address potential concerns of endogeneity. The evidence suggests that the conflict incidence in each grid cell over the period 1989-2015 can be explained by variation in potential crop yield in respective grid cells, even after accounting for other geographical characteristics. Some robustness tests are performed in Section 4. They include the use of a wide range of alternative conflict measures and the inclusion of several potential confounders. Our results are robust to these considerations. In section 5, we explore several channels, which may be plausible conduits linking variation in potential crop yield to conflict incidence. We find that the effect of variation in potential crop yield is likely to work through the shaping of masculinity traits. The last section concludes the paper.

2 Data and Construction of Variables

Our dependent variables for the simple cross-country and pooled cross-country estimations are constructed using data over the period 1960-2014. We follow the common practice in the existing literature by focusing on the post-1960 period, given that most of the former European colonies in Sub-Saharan Africa, Middle East, South and East Asia gained independence after 1960. This is to reduce the possibility that the results may be confounded by colonial powers influencing the domestic decision in these countries. There are some challenges in accounting for the changes in borders between nations over the years though. In particular, over the period of our study, some countries dissolved (e.g., Soviet Union and Yugoslavia), some united (e.g., East and West Germany, North and South Vietnam) and others separated (e.g., Bangladesh, South Sudan). For simplicity, we use modern country boundaries that have existed over a decade. For example, we use country-level data for Croatia, Macedonia, and Slovenia instead of former Yugoslavia. Furthermore, as it is the common practice in the existing literature on conflict, we divide the time period of study (1960 to 2014) into eleven non-overlapping 5-year sub-periods. For the grid-cell level analysis, we use data over the period 1989-2015 since grid-level data prior to 1989 are unavailable.

2.1 Key outcome measure

Our main source of data for the country-level estimations is the Armed Conflict Dataset (version 4-2015) (Pettersson and Wallensteen, 2015), which is originally from the Uppsala Conflict Data Program (UCDP). UCDP defines conflict as “*a contested incompatibility that concerns government and/or territory where the use of armed force between two parties, of which at least one is the government of a state, results in at least 25 battle-related deaths.*” As a consequence, any conflict episode where the number of battle deaths is less than the prescribed threshold is not recorded in this dataset. The dataset provides an annual binary indicator of whether the threshold of 25 battle-related deaths has been exceeded in that year.

We use intrastate conflict incidence variables from Armed Conflict Dataset. Following the standard approach in the literature (see, e.g., the work of Esteban et al., 2012), our main outcome variable (*confinc*) is defined to take a value of 1 when there is at least one conflict of any intensity in any year within a 5-year sub-period; otherwise, it is 0. This

measure is used in the pooled cross-country analysis. We use the sum of this variable across 11 sub-periods in the simple cross-country study. For the grid-cell level analysis, we use data from the latest version (version 5) of UCDP Georeferenced Event Dataset (Sundberg and Melander, 2013). This dataset provides global conflict events (excluding Syria) over the period 1989-2015. A conflict event is defined as: “*An incident where armed force was by an organized actor against another organized actor, or against civilians, resulting in at least 1 direct death at a specific location and a specific date*”. The reporting unit is an individual event and the dataset contains 128,264 events. Our baseline outcome variable (also labeled as *confinc*) captures whether there was an incidence of conflict in a given grid cell.

We use a number of alternative measures of conflict intensity from other sources to test the robustness of our baseline estimates. These measures are discussed in Section 4.1. The definition of these variables is also given in the Online Appendix.

2.2 Main explanatory variable (variation in potential crop yield)

Data on potential crop yield are taken from Galor and Özak (2016), who construct their dataset from the Global Agro-Ecological Zones (GAEZ) project of the Food and Agriculture Organization (FAO). GAEZ supplies global yield and growth cycle estimates for 48 crops in grids with cells size of 5’x5’ (approximately 100 km²).⁴ The database gives crop yield estimates for each crop based on three alternative levels of input – high, medium and low – and two feasible sources of water supply – rain-fed water supply and irrigation. Our potential crop yield index is constructed using low level of inputs and rain-fed agriculture cultivation methods in order to account for the agricultural conditions that were prevalent during the pre-industrial era. This reflects farming practices prevalent during the early stages of development.

The FAO database supplies two alternative projections of potential crop yield estimates for each crop based on agro-ecological constraints and agro-climatic conditions. Potential crop yield data based on agro-ecological constraints can be affected by human intervention, whereas the estimates based on agro-climatic conditions are arguably unaffected

⁴ These 48 crops and their variants are alfalfa, banana, barley, buckwheat, cabbage, cacao, carrot, cassava, chickpea, citrus, coconut, coffee, cotton, cowpea, dry pea, flax, foxtail millet, greengram, groundnuts, indigo rice, maize, oat, oilpalm, olive, onion, palm heart, pearl millet, phaseolus bean, pigeon pea, rye, sorghum, soybean, sunflower, sweet potato, tea, tomato, wetland rice, wheat, spring wheat, winter wheat, white potato, yams, giant yams, subtropical sorghum, tropical highland sorghum, tropical lowland, sorghum, white yams.

by human intervention. To mitigate concerns of reverse causality, we use data based on agro-climatic conditions under rain-fed low-input agriculture. These estimates account for the effect of temperature and precipitation on the growth of the crop, the impact of pests, diseases and weeds on the yield in addition to climate-related workability constraints. In addition, the FAO database also provides estimates for the growth cycle of crops, which captures the number of days it takes for each crop to grow from seeds to mature plants.

Each crop yield in the GAEZ data (measured in tons per hectare per year) is converted by Galor and Özak (2016) into caloric yield (thousands of kilocalories per hectare per year) to represent the nutritional variation across crops and to compare crop yields among different crops. The USDA National Nutrient Database for Standard Reference provides data on the caloric content of various crops. Using these measures, the estimated average regional crop yield reflects the average regional levels of two variables – crop yield and crop cycle – among crops that indicate the average caloric yield in each cell.⁵ For the cross-country estimates, we take logs on the standard deviation of potential crop yield for all the grids in a country and use it as our measure of variation in potential crop yield.⁶

The potential crop yield data of Galor and Özak (2016) address the limitations of other available weight-based agricultural yield indices. For example, the land productivity index constructed by Ramankutty et al. (2002), does not reflect the fact that equally suitable land can have a large variation in potential crop yield since caloric-intensive crops may not be cultivated in some regions (see Galor and Özak, 2015). As discussed in Nunn and Qian (2011), Europe is more suitable for potato cultivation than other parts of the Old World.

It is also worth highlighting that we use potential crop yield as a proxy for actual crop yield due to the fact that actual crop yield is likely to be affected by human intervention and the incidence of conflicts per se, and this may give spurious estimates. Moreover, GAEZ provides actual crop yield data only for the year 2000, which is not sufficiently far back in time to serve as an exogenous variable. Nevertheless, as a sanity check, we regress variation in actual crop yield on variation in potential crop yield and find that they are significantly

⁵ It is important to account for different crop cycles for each crop because a calorie-rich crop might have a much longer crop cycle and thus provide much lesser caloric yield per year.

⁶ When taking the average across cells, we include cells with zero potential crop yield in the dataset. In principle, the survival of a human society is not feasible in regions with no crop yield. We therefore also check our results by including only cells with positive average potential crop yield. Our results, available upon request, are robust to this consideration. This is not surprising since our measure and the measure that excludes cells with zero crop yield show a strong correlation of 0.93.

correlated, conditioning on the baseline geographic influences. Similarly, the results also indicate that mean potential crop yield significantly predicts mean actual crop yield. The results hold for both cross-country and grid-level data (see Tables A3 and A4 in the Online Appendix).

Figure 1 plots the distribution of variation in potential crop yield for all the countries in the sample. The bottom decile of countries has a variation below 62.60, while the top decile has a variation of over 674.56. Countries in Middle-East Asia and North Africa (e.g., Israel, Qatar, Saudi Arabia, UAE, and Oman) typically have very low levels of variation in potential crop yield whereas some mountainous or geographically large countries such as the U.S., Argentina, Nepal, Bhutan, and China, are at the other end of the spectrum. Figure 2 shows that conflict incidence and variation in potential crop yield display a positive relationship. Table A1 in the Online Appendix lists the country-level data on conflict incidence, mean and variation in potential crop yield.

[Figure 1]

[Figure 2]

2.3 *Baseline control variables*

Mean potential crop yield is included in all regressions. The computation of this variable is similar to the way that variation in potential crop yield is constructed, except for the fact that it represents the mean of potential crop yield over all the cells in a country. Several other control variables which may potentially confound the relationship between variation in potential crop yield and conflict incidence are included in the regressions. This includes terrain ruggedness, absolute latitude, elevation, distance to nearest waterway, precipitation, landlockedness, mean elevation, temperature and the percentage of population living in tropical zones. We also include continent dummies to account for any omitted variable bias of time-invariant continent-specific geographical, cultural and historical characteristics. Summary statistics and the correlations of the variables are given in Table A2 of the Online Appendix. A number of other control variables are also used in the robustness checks performed in Section 4.2. The definition of these variables is also given in the Online Appendix.

3 Empirical Results

3.1 Simple cross-country analysis of intrastate conflict

The section presents evidence using simple cross-country data. We estimate the following OLS regression model to evaluate the influence of variation in potential crop yield on conflict incidence:⁷

$$confinc_i = \alpha + \beta sd_crophyield_i + \gamma avg_crophyield_i + \delta Controls_i + \epsilon_i \quad (1)$$

where $confinc_i$ is the average number of 5-year sub-periods that experience any conflict in country i , $sd_crophyield_i$ is the log of variation in potential crop yield across cells (measured in thousands of kilocalories per hectare per year) in country i , $avg_crophyield_i$ is the log of mean potential crop yield across cells in country i , $Controls_i$ is a vector of control variables included in the regressions to minimize the possibility of getting spurious estimates, and ϵ_i is the error term. We expect β to be positive and statistically significant. Our baseline sample used in the cross-country analysis consists of data for up to 135 countries. Note that we also use several alternative outcome variables in the robustness checks performed in Section 4.1.

Table 1 presents our findings for the influence of variation in potential crop yield on conflict incidence in a cross-section of 135 countries. The analysis here makes use of data on the ongoing conflict incidence dimension of civil conflict over the period from 1960 to 2014. Column (1) uses no control variable and shows that the unconditional influence of variation in potential crop yield on conflict incidence is positive and significant at the 1% level. Measured in a standardized form, a one standard deviation change in (logs) variation in potential crop yield is expected to result in 0.17 standard deviations increase in conflict incidence.

[Table 1]

We introduce mean potential crop yield in column (2) to allow for the possibility that

⁷ Our baseline outcome variable measures the intensity of conflict incidence in a country on an 11-point scale. Moreover, given that our dependent variable takes positive integer values with a large number of zero values, the data are over dispersed (the variance of 10.32 is much larger than the mean value of 2.54). Consequently, we also perform count data analysis, i.e., Poisson and Negative binomial regressions, as suggested by Cameron and Trivedi (1986) and Wooldridge (2010). Our main results, which are available upon request, still prevail when these estimators are used.

individuals endowed with different levels of potential crop yield may behave differently when they observe substantial variation in agricultural productivity across regions. The results show that the influence of variation in potential crop yield on conflict incidence, after accounting for the influence of mean potential crop yield, remains highly statistically significant. The effect of mean potential crop yield, however, is insignificant. We add standard geographic controls in column (3) and the coefficient of potential crop yield variation remains statistically significant. Finally, although we have accounted for various country-level geographical features (including terrain ruggedness, absolute latitude, elevation, distance to nearest waterway, precipitation, landlockedness, temperature and the percentage of population living in tropical zones), there is still possibility that the results may be biased due to the failure to control for other unobserved characteristics. Hence, we include continent fixed effects in column (4) and the results remain robust. In all cases, we do not find any significant effect of average potential crop yield.

The partial regression plot in Figure 3 shows the relationship between conflict incidence and variation in potential crop yield. As expected, the partial regression line shows a positive and statistically significant influence of variation in potential crop yield on conflict incidence, after controlling for other geographical controls and continent fixed effect in column (4) of Table 1.

[Figure 3]

3.2 Pooled cross-country analysis of intrastate conflict

In this section, we exploit the time dimension of conflict incidence using quinquennial repeated cross-country data. A similar regression framework, as shown in Eq. (2), is used except that our outcome variable ($confinc_{it}$) is now a binary variable measuring the potential for an active conflict episode in country i during any given 5-year period.

$$\Pr(confinc_{it}) = \alpha + \beta_1 sd_cropyield_i + \beta_2 avg_cropyield_i + \beta_4 (confinc_{it-1}) + \beta_3 Controls_i + \epsilon_{it} \quad (2)$$

where $sd_cropyield$ is the log of variation of potential crop yield, and $avg_cropyield$ is the log of mean potential crop yield. Note that these variables do not vary over time. We use the same geographic control variables as defined earlier. We also account for intertemporal spillover effect of conflict incidence on contemporary conflict incidence by including a

lagged dependent variable in our regression model.

Table 2 shows the regression results using a logistic estimator with standard errors clustered at the country level. Column (1) reports results for the unconditional influence of variation in potential crop yield on conflict incidence. The effect of variation in potential crop yield is found to be statistically significant at 1% level. The results do not change when we sequentially add mean potential crop yield (column (2)), geographic controls (column (3)), and continent fixed effects (column (4)). In all cases, the effect of variation in potential crop yield remains very precisely estimated at 1% level.

[Table 2]

3.3 *Grid-cell level analysis of intrastate conflict*

In this section, we provide further evidence using data at the grid level. The analysis is performed using a global grid of 2.5 by 2.5 decimal degrees covering from -180 to 180 degrees longitude and from -65 to 85 degrees latitude. To create our outcome variable, we use the latest version (version 5) of UCDP Georeferenced Event Dataset (Sundberg and Melander, 2013). This dataset provides information on global conflict events (excluding Syria) over the period 1989-2015. A conflict event is defined as: “*An incident where armed force was by an organized actor against another organized actor, or against civilians, resulting in at least 1 direct death at a specific location and a specific date*”. The reporting unit is an individual event and the dataset contains 128,264 events. Figure 4 shows the distribution of conflict across grid cells.

[Figure 4]

It should be highlighted that this dataset is compatible with the one used earlier for cross-sectional analysis. Only conflict events involving at least 25 casualties are reported. The best spatial resolution for the conflict events of this dataset is for an individual village or town. Three type of events – state based, non-state, and one sided – are reported in the dataset.

As in previous sections, we focus on state-based events where one party in the conflict is the state. This reduces the number of conflict events in the dataset to 89,943. We match these violent events, using latitude and longitude of the events, with our grid of 2.5 by 2.5 decimal to identify corresponding grid cells for each event over period 1989-2015. Similar to the previous analyses, the outcome variable captures whether there was an

incidence of conflict in a given grid cell.

The potential crop yield data are extracted from a global raster file provided by Galor and Özak (2016). Since we define our unit of analysis as grid cells with a size of 2.5×2.5 decimal degrees, the construction of the potential crop yield variables is based on the use of smaller grid-cell units with a size of 5×5 arc minutes. Accordingly, the variation in potential crop yield and mean potential crop yield are calculated as the standard deviation and average of the crop yield values, respectively, across the 5×5 arc-minute grid cells within the larger grid cells with a size of 2.5×2.5 decimal degrees. The grid-level geographic data are obtained from Michalopoulos (2012).

The results for using grid-level data are reported in Table 3. As is evident, variation in potential crop yield is found to have a positive effect on conflict. In all cases, the effect is found to be statistically significant at least at the 5% level, regardless of whether control variables and continent fixed effects are included.

[Table 3]

3.4 The effects of temperature and precipitation: a discussion

It is interesting to note that our results consistently suggest temperature but not precipitation has an effect on conflict incidence (see the results in Tables 1 to 3). Hence, this finding is consistent with the results of Zhang et al. (2007), Hsiang et al. (2011) and Dell et al. (2012) but is inconsistent with the results of Miguel et al. (2004) and Brückner (2010). It is plausible that precipitation may serve as an imperfect proxy for potential crop yield (their correlation coefficient is 0.43), which renders its effect insignificant. But when we remove mean potential crop yield or variation in potential crop yield or both variables from the model specification, the effect of precipitation remains insignificant at the 5% level, regardless of which dataset we use. This result is consistent with Sarsons (2015), who argues that the relevance of precipitation in explaining conflict incidence may have been over-emphasized in the literature.

3.5 Potential effects of climate change on the yield-conflict relationship

In this sub-section, we discuss how our results can potentially be affected by climate change, but leave a careful empirical analysis on this issue to a future exercise.

Increasingly harmful effects of climate change that damage the natural environment can polarize the agricultural yield of different regions, resulting in a wider gap in crop yield across regions. Ray et al. (2015) study how fluctuations in precipitation and temperature affect the variability in crop yield. Their study finds that variability in climate accounts for about 60% of the variation in crop yield globally (see also Osborne and Wheeler, 2013).⁸ Larger crop yield variability is likely to adversely affect the stability of agricultural production, induce fluctuations in crop prices, and decrease the income of farmers. This therefore poses a serious problem for the sustainability of agriculture and food security (Wheeler and von Braun, 2013; Matiu et al., 2017). Coupled with the fact that the demand for food will continue to rise due to the projected increase in global population over the next few decades, the survival of human civilization will be threatened, and this may result in more conflicts.

As the process of climate change accelerates, variation in agroecological conditions is likely to have an aggravated effect on conflict. In other words, the effect of crop yield variation is likely to be more pronounced in places with heightened vulnerability to climate stresses. There are several ways in which this can happen. First, how people in each area are affected by climate change depends on the extent to which they are dependent on agricultural activity, the sensitivity of their crops to climate change, and their ability to adapt to climate change. In particular, farmers who lack access to efficient irrigation systems and practice subsistence agriculture that grows crops which are not weather-resistant tend to be more vulnerable to climate change. In this case, we expect climate change to impact people in these regions, which typically have low crop yield, more severely than others, and this may amplify the effect of crop yield variation on conflict.

Second, climate change may influence human societies in many different ways, including desertification, rising sea-levels, water shortage, and the spread of disease vectors in long term. It may also lead to increased frequency and severity of natural disasters (such as flooding and hurricanes), lesser availability of natural resources, the loss of biodiversity and mass migration out of climate change affected areas in the short term (Hoegh-Guldberg et al., 2007; Salehyan, 2008). Given that these impacts of climate change on different societies are likely to be uneven, the agricultural productivity of some regions will deteriorate more than

⁸ A number of studies also show that climate change affects the level of crop yield. Fischer et al. (2005), for example, show that extreme climactic variations can damage water resources and arable land, which in turn affects average crop yield (see also Lobell et al., 2011; Leng et al., 2016; Zhao et al., 2017).

the others, thus intensifying the effect of crop yield variation on conflict.

Third, the production of major crops around the world largely depends on temperature and precipitation (Ray et al., 2015). Dramatic changes in these climatic factors will influence crop yield, which may result in the shifting of cultivation areas. Some of the production, for example, may be moved to areas with higher altitude to provide a more favourable growing condition for crops (Challinor et al., 2014). In this case, differences of crop yield across regions will be widened, which exacerbates conflict incidence.

4 Robustness Checks

4.1 Robustness to alternative measures of conflict

A. Simple cross-country analysis

An implicit assumption of our analysis is that the natural endowments of a region have not changed much over time and hence our results can explain the occurrence of conflicts in the past over a long duration and the current level of conflict should be correlated with the historic level of conflict. To check the validity of this assumption, we use the total number of historical internal conflicts compiled by Brecke (1999). When we use the total number of conflict since 1500AD (*confinc_hist*) as the outcome variable in column (1) of Table 4, the results indicate that the influence of variation in potential crop yield on conflict over the last five centuries remains consistent.

[Table 4]

We have used the number of conflict incidence with at least 25 battle-related deaths within a year as our outcome variable in Table 1. There could be some concerns regarding the way conflict intensity is defined (i.e., the number of 5-year periods that has at least one conflict over the period 1960-2014). For instance, a country that has experienced only one incidence of conflict in a particular five-year period will be regarded as having the same extent of conflict intensity as another country having experienced conflicts every year over the same period. To address this concern, we use the fraction of years that had an incidence of conflict over the period 1960-2014 (*confinc_frac*) to mitigate the concern that the intensity of conflicts is smoothed out over a five-year period. Our results shown in column (2) are not affected by this consideration.

Further, there are other ways to count the existence of a conflict in a country based on alternative thresholds for the number of deaths in a conflict. We use *confinc_mid* and

confinc_war as alternative measures of conflict incidence, where the former captures medium conflict (less than 1000 battle-related deaths in a given year but at least cumulative 1000 battle-related deaths since the beginning of conflict) and the latter captures major conflict (at least 1000 battle-related deaths in a given year), as defined earlier. The estimation results for using *confinc_mid* and *confinc_war* as outcome variables are presented in columns (3) and (4), respectively. The results indicate that the influence of variation in potential crop yield on medium conflict incidence (column 3) and major conflict incidence (column 4) is statistically highly significant in both cases. Notice that the value of the adjusted R^2 in column (4) drops substantially. One possible explanation is that the occurrence of major conflicts is likely to be largely determined by idiosyncratic shocks not captured by our model. For this reason, we believe that our baseline measure (*confinc*), the measure of conflict incidence that includes low-intensity conflict with at least 25 but less than 1000 battle-related deaths in a year, is a more appropriate outcome measure for the purpose of our study.

Next, we perform additional robustness checks by using two measures on the onset of new conflicts as our alternative outcome variables. We create two new variables using the Conflict Onset and Incidence Dataset. These variables, labeled as *onset2* and *onset5*, take a value of 1 if a new episode of conflict starts after 2 and 5 years of ‘peace’, respectively, in each of the five-year periods. We take the aggregate values over the eleven periods. These measures, however, suffer from the problem that they cannot fully distinguish between new episodes of conflict and ongoing conflict when battle-related deaths exceed the threshold of 25 in a given year. Bearing this limitation in mind, we prefer our baseline approach to focus on the frequency of new conflict. Columns (5) and (6) present the results of estimating the influence of variation in potential crop yield on the frequency of the onset of new conflict using *onset2* and *onset5* as the dependent variable, respectively. In both cases, the effect of variation in potential crop yield is still statistically significant at 1% level.

As all civil conflicts are generally not ethnic-driven, using the UCDP dataset, Wimmer et al. (2009) have created a unique conflict dataset that focuses only on ethnic conflicts. They coded the aim of each rebel organization and indicated whether they pursued ethno-nationalist aims and recruited along ethnic lines. They identify “ethnic” as aiming to achieve ethnonational self-determination, a more favorable ethnic balance-of-power in government, ethno-regional autonomy, the end of ethnic and racial discrimination, language and other cultural rights, and the likes. In ethnic wars, armed organizations also recruit

fighters predominantly among their leaders' ethnic group and forge alliances on the basis of ethnic similarity. We use the latest version of their dataset covering the period from 1960 to 2010 to obtain a measure of new ethnic conflict. In column (7), we present the results for regressing the onset of new ethnic conflict (*onset_eth*) on the variation of potential crop yield. It is evident that the results are qualitatively very similar to what we obtained earlier.

All the alternative definitions and different thresholds of minimum battle-related deaths that have been considered so far are based on the data where one side of the conflict is the government or the state forces, fighting against one or more internal armed opposition groups. These conflict incidences are more severe and prevalent in the conflict data. However, government or state forces may not be involved in all intrastate conflicts. In many countries, people give preference to members of their own political party, ideology, tribe, religion, and ethnicity. Even when these groups are not fighting against the state, there are many intergroup conflicts where two or more groups fight with each other and such conflict is recorded as non-state conflicts when the threshold of twenty-five battle-related deaths is crossed. Consequently, we use the UCDP non-state conflict dataset, Version 2.5-2014, 1989-2013 (Sundberg et al. 2012), to obtain a measure of non-state conflict incidence.⁹ The influence of variation in potential crop yield on the incidence of non-state conflicts (*confinc_ns*) where none of the sides involved in the conflict is a state, is tested in column (8). The results again remain largely intact to this alternative outcome measure.

B. Pooled cross-country analysis

The various outcome variables that we have employed so far reflect the extensive margin effect of variation in potential crop yield on intrastate conflict events as they use a binary measure depending on a threshold number of the battle-related deaths in a year. This is potentially an issue since taking the average over 55 years may not necessarily reflect the intensity of conflict in a country. We can overcome this limitation by using a pooled cross-sectional framework in which the duration of each period is given as five years. Hence, we employ both ordinal and continuous measures of conflict incidence that capture the severity

⁹ For example, conflict between paramilitary United Self-Defense Forces of Colombia (AUC) and the guerrilla Revolutionary Armed Forces of Colombia (FARC) in Colombia, or between the competing rebel groups National Patriotic Front of Liberia (NPFL) and United Liberation Movement of Liberia for Democracy (ULIMO) in Liberia; clashes between supporters of the All Nigeria People's Party and supporters of the People's Democratic Party in Nigeria; between groups that define themselves along identity lines, be it ethnic, clan, religious, national, or tribal identities. Fighting between these types of groups captures what is commonly referred to as a communal conflict, such as the Hindu-Muslim riots in India.

of intrastate conflict to establish the influence of variation in potential crop yield on the intensive margin of conflict.

The first measure of conflict of intensity that we employ is a non-binary measure of conflict intensity, *confinc_int*, which is based on UCDP armed conflict dataset. Following Esteban et al. (2012), we categorize *confinc_int* into three distinct intensity level – 0, 1, and 2 in any year. When a country is at “Peace”, *confinc_int* is assigned a zero value. Conflict incidence satisfying *confinc* but not *confinc_war* is assigned a value of 1 whereas conflict incidence satisfying *confinc_war* criteria is assigned a value of 2.

Our second measure of conflict intensity is based on the Major Episodes of Political Violence (MEPV), 1946-2014 dataset (Marshall, 2014). Major episodes of conflicts, according to this database, involve “at least 500 directly-related fatalities and reach a level of intensity in which political violence is both systematic and sustained (a base rate of 100 directly-related deaths per annum)”. For each episode of conflict, the MEPV dataset provides the “magnitude score” of the destructive impact, or magnitude of the violent episode of the directly-affected areas on a scale of 1 (smallest) to 10 (greatest). We employ data on the total intrastate conflict that includes civil violence, civil conflict, ethnic violence and ethnic war. These data are reported at the country-year level and to convert them into quinquennial intervals, we create our outcome variable by using the maximum level of conflict intensity from any year in each of the 5-year periods.

Our third measure of the intensity of conflict is a continuous index of social conflict (ISC) computed by the Cross-National Time-Series (CNTS) Data Archive (Banks, 2011). The data are taken from Esteban et al. (2012). The period of this conflict severity is limited to between the years 1960 and 2008, or only ten sub-periods of the 5-year interval (we used eleven sub-periods of 5-year interval earlier). The results in Table 5 show that the influence of variation in potential crop yield on conflict is still statistically significant even when these alternative measures of conflict are used.

[Table 5]

C. Grid-cell level analysis

As an alternative measure to *confinc*, we use a similar approach by dividing the whole period 1989-2015 into six 5-year sub-periods (the last sub-period covers only 2 years). We indicate conflict intensity as 1 if there is at least one event of conflict in that grid cell in the 5-

year window and 0 otherwise. The aggregate number is our second measure and we label it as “*frequency of conflict incidence*”. The results reported in Table 6 indicate that the coefficients of variation in potential crop yield are still statistically significant across different specifications, although they are less precisely estimated.

[Table 6]

4.2 Robusness to controlling for other effects

In this section, we check whether our main results are driven by some potential confounders, including some early development, contemporary influences, natural endowment and additional geographic effects emphasized in the literature. The checks are performed for all three layers of analysis, and the results are reported in Table 7 for simple cross-country, Table 8 for pooled cross-country and Table 9 for grid-cell level estimations. The full set of estimates is reported in Tables A5 to A7, respectively, in the Online Appendix.

[Table 7]

[Table 8]

[Table 9]

First, consider how our results can potentially be confounded by some early development influences. Ahlerup and Olsson (2012) show that the duration of human settlement since prehistoric time (*Origtime*) affects the level of ethnolinguistic diversity of current populations. Similarly, Ashraf and Galor (2013) show that the migratory distance from East Africa explains current income levels. Since the literature also suggests that ethnolinguistic diversity and income are closely related to conflict (see, e.g., Fearon and Laitin, 2003; Miguel et al., 2004; Collier and Hoeffler, 2005; Esteban et al., 2012; Dube and Vargas, 2013), we control for *Origtime* and migratory distance in columns (1) and (2), respectively.

Depetris-Chauvin (2015) shows that areas which have longer state history are less likely to experience conflicts induced by agricultural shocks since the local governments have greater bureaucratic capability. The timing of agricultural transition and biogeography are other dimensions of early development which are closely correlated to agricultural productivity (see Olsson and Hibbs, 2005 and Putterman, 2008 for a discussion). We account for these effects in columns (3) to (5). Lastly, we also control for the effect of early development using a more generic measure – population density in 1500 AD (logged) – in

column (6). The Online Appendix provides detailed description of these variables.

As is evident, the coefficients of these indicators are found to be either insignificant or weakly significant at the 10% level whereas the coefficients of variation in potential crop yield remain very precisely estimated in all cases (see Tables A5 to A7 in the Online Appendix for statistical significance of these estimates). These results suggest that variation in potential crop yield is a more important root of conflict, compared to other dimensions of early development highlighted in the literature.

Next, we consider potential influences of other effects. In column (7), we augment the baseline specification by adding executive constraints, autocracy, democracy, and real GDP per capita. As highlighted by Gurr (2000) and Fearon and Laitin (2003), political systems such as democracy and autocracy are strongly related to conflict. We include real GDP per capita as a proxy for the opportunity cost of engaging in intrastate conflict. Moreover, we also control for the effects of colonial legacy, following the results of Posner (2003). Controlling for the influence of colonial legacies is important since they may play an important role in stabilizing political institutions in newly independent states, especially given the fact that colonizers arbitrarily defined ethnic groups for administrative purposes and sometimes followed ethnically biased policies. Accordingly, we use colonial history dummies for British, French, Spanish, Portuguese and other major European colonizers. However, there may be some residual influence of legal systems originating from European colonizers, with large differences between those originating from English common law and those originating from Roman civil law. Hence, we also use dummy variables for British Common Law, French civil law, Socialist law, German civil law, and Scandinavian law to capture the major categories of legal origins, as suggested by La Porta et al. (1998).

In column (8), we include five natural resource variables, including oil exports as a fraction of total exports, mineral wealth, diamond production, timber wealth and natural gas wealth, to capture their potential effects on conflict. Several studies have shown that natural resources are important determinants of wars and conflicts. Collier and Hoeffler (2004) find that countries that are heavily dependent on the export of primary commodities have a higher risk of civil wars. Similarly, Fearon and Laitin (2003) emphasize that oil revenues are a key incentive to consolidate state power and oil producing states often have higher risks of entering into civil conflicts. According to Ross (2004), higher resource wealth in oil, non-fuel minerals and drugs is causally linked to conflict. Similarly, Berman et al. (2017) also study

the impact of control over mines in exacerbating the conflict in Africa. More recently, Adhvaryu et al. (2018) also argue that both economic growth and conflicts are driven by natural resources in Africa since natural resources not only empower groups to fight more but also increase the benefits from expropriation. A number of African nations, including Angola, Nigeria, Ethiopia, Somalia, Algeria, Chad, Sudan and Congo, have experienced conflicts due to gas and oil (Fairhead, 2000).¹⁰ Similarly, the Cambodian (1978-97) and Burmese (1983-95) civil wars in Asia were linked to timber and gems (Ross, 2004).

While we control for the effect of colonial origins in column (7), Olsson (2009) emphasizes the importance of the temporal dimension of colonial rule on institutions due to the fact that colonizers needed time to establish institutions. Hence, we allow for this effect in column (9).

Letendre et al. (2010) find that the disease burden of a country can provide potential ground for higher levels of conflict. we control for this effect using the settler mortality data of Albouy (2012) in column (10) since higher mortality rate can reduce the opportunity cost for individuals to indulge in a civil war (Cervellati et al., 2011). The results (not reported) are also consistent when we use the disease burden data of Murray and Schaller (2010).

Furthermore, we also control for several diversity measures which have been shown to influence some development outcomes in the existing literature. These variables are the ethnic fractionalization index of Fearon (2003) (column (11)), the religion fractionalization index of Alesina et al. (2003) (column (12)), and the fractionalization, polarization and Greenberg Gini indices of Esteban et al. (2012) (column (13)).

In columns (14) and (15), we control for some additional country-specific geographical characteristics. Fearon and Laitin (2003) find that the mountainous terrain and non-contiguous region at a distance from the center of political power provides a safe haven for rebel groups and it facilitates the emergence and perpetuation of civil war. Hence, we include these variables in column (14). A recent study by Michalopoulos (2012) highlights that

¹⁰ Sierra Leone has witnessed conflicts over diamonds, gold, rutile and timber while Congo has faced political emergencies due to diamonds, minerals, gas oil and timber (Fairhead, 2000). Control over diamond mines, or 'Blood Diamonds' as they are commonly termed, has been a recurrent source of conflict in Africa since they are small, can be easily smuggled and have a high value in the international market (Bannon and Collier, 2003; Lujala et al., 2005). Lujala et al. (2005) find that there is a strong relationship between easily exploitable and 'lootable' secondary diamonds and the onset of civil wars. In particular, Sierra Leone and Angola have witnessed long and violent civil wars over diamonds. The struggle for revenue from diamonds has been intertwined with ethnic and religious hostilities as well as weak and corrupt political institutions (Klare, 2001).

diversity in a society may originate from some geographical features of the region. He shows that geographical features, such as variation in elevation and soil quality, can explain ethnolinguistic diversity. Larger countries may tend to have higher variation in potential crop yield and hence we also control for this effect in column (15).

Reassuringly, including these variables does not change our results in any significant fashion (see columns (7) to (15), Tables 7 to 9). Essentially, the effect of variation of potential crop yield remains highly significant, suggesting that our results are not driven by these potential omitted influences. Our results also indicate that income and settler mortality are negatively correlated with conflict for the country-level analyses. This finding is consistent with our prediction. For the grid-level estimation, we find that both autocracy and democracy are negatively correlated with conflict, suggesting that both autocratic and democratic regimes suppress violent behavior. The magnitude of the democracy estimate, however, is larger. In all estimations, we find that polarization drives conflict whereas the Greenberg-Gini index of ethnic difference reduces conflict. These results are consistent with the theoretical prediction of Esteban et al. (2012). Moreover, non-contiguity is found to be positively correlated with conflict, a result that supports the argument of Fearon and Laitin (2003) since a non-contiguous region at a distance from the center of political power provides ideal conditions for the rebel groups to survive. Finally, we also find some evidence that abundance of natural resources does not seem to trigger conflict. The coefficients of mineral wealth are weakly significant for two cases and the coefficient of timber wealth is significant for one case. While the finding that natural resources are not a curse to peace and development seems to be against conventional wisdom, it is compatible with the results of Brunnschweiler and Bulte (2009).

5 Potential Channels of Influence

Our results have so far established a positive reduced-form association between variation in potential crop yield and conflict incidence. However, it is unlikely that the agroecology of a country represented by variation in potential crop yield directly affects conflict incidence. That is, the effect of variation of agroecological factors on conflict incidence can also occur via other channels independent of agricultural productivity. We propose that the cultural traits of a society that can be influenced by agroecology of a region country can plausibly be a channel that transmits the influence of agroecology on conflict

incidence.

Let us consider the following two international territorial disputes to understand the role of culture in interstate conflicts. In the first instance, two less masculine nations – Finland and Sweden – solved the problem of ownership of the pro-Swedish Åland archipelago amicably and transferred the ownership to Finland. Today, a large number of Swedish tourists visit the islands and the Åland has a thriving economy. In another instance, two highly masculine nations – the United Kingdom and Argentina – have not been able to solve the ownership problem of a small Falkland Island where about 1800 poor sheep farmers live. Both countries fought in 1982 and lost around one thousand soldiers from both sides. The conflict is still not resolved and Falkland Island survives on British subsidy and a large military presence.

Accordingly, we hypothesize that variation in historical crop yield induces a cultural shift towards a paradigm that supports the formation of a masculine culture, which in turn influences the level of conflict today. Societies place the means of violence/weapons in the hands of man and this is evident from the fact that most of the world armies are predominantly male dominated. Societies prefer males to be assertive, aggressive and control the dominance of power. Most of the conflicts are to achieve dominance of power over people from another ethnicity, religion, race or gender in order to control lands with high crop yield potential.

We test the above hypothesis by including an index of masculinity using the data of Hofstede et al. (2010). If the effect of variation in potential crop yield works through masculinity, including masculinity in the specification would render the effect of variation in potential crop yield insignificant. We also regress the masculinity index on the variation in crop yield, conditioning on other influences, to assess their direct association. Hofstede (2001, p. 297) defines masculinity as a preference for society with a clearly distinct role for different genders. Men are supposed to be assertive, tough and focused on material success and heroism. Its opposite, femininity, stands for a preference for cooperation, modesty, caring for the weak and quality of life. Data on masculinity is available for 101 countries. It is indexed between zero and one hundred with a mean and standard deviation of, 47.6 and 18.6, respectively. Sweden has the lowest masculinity index of five and Slovakia has the highest masculinity index of a 100. Figure 5 shows that the distribution of the masculinity index is concentrated around the mean.

[Figure 5]

We also consider several other variables which could potentially serve as a channel of influence. They include income inequality (gini coefficients of Solt, 2016), ethnolinguistic diversity (the ethnic fractionalization index of Fearon (2003), income per capita and night lights per capita. As discussed earlier, these variables are likely to be associated with the occurrence of intrastate conflict. Since most of these data are observable only at the country level, we perform only cross-country analysis in this section. Table 10 presents the findings. It is evident that the coefficient of variation in potential crop yields is only statistically significant when masculinity is used as the dependent variable (column (1)), suggesting that masculinity is an effective channel of influence.

[Table 10]

6 Summary and Conclusions

Agroecology in general, and geography and climate in particular, has become an important topic of research in economics as part of a broader agenda to understand the origin of both, intrastate and interstate conflict. Nevertheless, there is an ambiguity in identifying the specific aspect of geography and climate that have a significant influence over the likelihood of conflict incidence. Recent studies indicate that available resources in a region and the opportunity cost of the people to participate in violence play a key role in the onset and persistence of conflict incidence.

This study contributes to this growing literature by identifying the role of potential crop yield (measured in thousands of kilocalories per hectare per year) variation as an important source of conflict. Most of the conflicts were initiated to achieve dominance of power over people from another ethnicity, religion, race or gender in order to control lands with high crop yield potential. There can be various plausible mediating channels to explain this relationship. As different groups settle in different parts of a country, their economic prosperity should be positively influenced by the agricultural productivity in that region. Consequently, a country with higher variation in potential crop yield is expected to have higher ethnic inequality, and this in turn induces more conflicts. Similarly, the formation of cultures of aggression and violence is also likely to occur when societies depend on agriculture for survival and when there is a significant disparity in agricultural productivity across regions. This culture of violent behavior may escalate into full-fledged armed conflict,

which explains how variation in potential crop yield is linked to intrastate conflict today.

Our empirical findings provide support for this hypothesis. Specifically, we find a variation in potential crop yield to have a significant effect on conflict incidence. These findings are robust to the use of alternative outcome variables, measures of conflict, the inclusion of a number of possible confounders, and alternative empirical regression methods. The results are also consistent when grid cell level data are used. When attempting to uncover a plausible channel that transmits the influence of variation in crop yield on conflict incidence, our results indicate that the effect of crop yield variation on conflict is most likely to work through cultural masculinity.

The results of this paper are related to a large body of research which demonstrates that climate change will continue to have dramatic impacts on our ecological and social systems, including social disruption and violent conflict. Our analysis suggests that the effect of crop yield variability on conflict incidence will be exacerbated by climate change. The consequences of future climate change are likely to be worse than what have been recognized in the literature, which emphasizes the impacts on health risks, water availability, food security and biodiversity. Our results therefore have some implications for the costs of future climate change and the formulation of climate policy, suggesting that policies aimed at alleviating the effect of climate change on agricultural yield could also benefit the economy by dampening conflict incidents.

REFERENCES

- ADHVARYU, A., FENSKE, J.E., KHANNA, G. & NYSHADHAM, A. (2018). 'Resources, Conflict, and Economic Development in Africa', NBER Working Paper No. 24309.
- AHLERUP, P. & OLSSON, O. (2012). 'The Roots of Ethnic Diversity', *Journal of Economic Growth* 17, 71-102.
- ALBOUY, D.Y. (2012). 'The Colonial Origins of Comparative Development: An Empirical Investigation: Comment', *American Economic Review* 102, 3059-3076.
- ALESINA, A., DEVLEESCHAUWER, A., EASTERLY, W., KURLAT, S. & WACZIARG, R. (2003). 'Fractionalization', *Journal of Economic Growth* 8, 155-194.
- ALESINA, A., GIULIANO, P. & NUNN, N. (2013). 'On the Origins of Gender Roles: Women and the Plough', *Quarterly Journal of Economics* 128, 469-530.
- ALLANSSON, M., MELANDER, E. & THEMNER, L. (2017). 'Organized Violence, 1989-2016', *Journal of Peace Research* 54, 574-587.
- ANDERSON, C.A. (1987). 'Temperature and Aggression: Effects on Quarterly, Yearly, and City Rates of Violent and Nonviolent Crime', *Journal of Personality and Social Psychology* 52, 1161-1173.
- ANG, J.B. (2015). 'What Drives the Historical Formation and Persistent Development of Territorial States?' *Scandinavian Journal of Economics* 117, 1134-1175.
- ANGRIST, J.D. & KUGLER, A.D. (2008). 'Rural Windfall or a New Resource Curse? Coca, Income, and Civil Conflict in Colombia', *Review of Economics and Statistics* 90, 191-215.
- ARBATLI, C.E., ASHRAF, Q.H. & GALOR, O. (2015). 'The Nature of Conflict', NBER Working Papers 21079.
- ASHRAF, Q. & GALOR, O. (2013). 'The "Out of Africa" Hypothesis, Human Genetic Diversity, and Comparative Economic Development', *American Economic Review* 103, 1-46.
- ASHRAF, Q. & MICHALOPOULOS, S. (2015). 'Climatic Fluctuations and the Diffusion of Agriculture', *Review of Economics and Statistics* 97, 589-609.
- BANKS, A.S. (2011). Cross-National Time-Series Data Archive, 1815-2011.
- BANNON, I. & COLLIER, P. (2003) *Natural Resources and Violent Conflict: Options and Actions* (Washington D.C.: World Bank).
- BERMAN, N., COUTTENIER, M., ROHNER, D. & THOENIG, M. (2017). 'This Mine Is Mine! How Minerals Fuel Conflicts in Africa', *American Economic Review* 107, 1564-1610.
- BLATTMAN, C. & MIGUEL, E. (2010). 'Civil War', *Journal of Economic Literature* 48, 3-57.
- BOCKSTETTE, V., CHANDA, A. & PUTTERMAN, L. (2002). 'States and Markets: The Advantage of an Early Start', *Journal of Economic Growth* 7, 347-369.
- BRECKE, P. (1999). 'The Conflict Dataset: 1400 AD - Present', Georgia Institute of Technology.
- BRÜCKNER, M. (2010). 'Population Size and Civil Conflict Risk: Is there a Causal Link?' *Economic Journal* 120, 535-550.
- BRUNNSCHWEILER, C.N. & BULTE, E.H. (2009). 'Natural Resources and Violent Conflict: Resource Abundance, Dependence, and the Onset of Civil Wars', *Oxford Economic Papers* 61, 651-674.
- CAMERON, A.C. & TRIVEDI, P.K. (1986). 'Econometric Models Based on Count Data. Comparisons and Applications of Some Estimators and Tests', *Journal of Applied Econometrics* 1, 29-53.
- CEDERMAN, L.-E., WEIDMANN, N.B. & GLEDITSCH, K.S. (2011). 'Horizontal Inequalities and Ethnonationalist Civil War: A Global Comparison', *American Political Science Review* 105, 478-495.
- CERVELLATI, M., SUNDE, U. & VALMORI, S. (2011). 'Disease Environment and Civil Conflicts', IZA Working Paper 5614.
- CHALLINOR, A.J., WATSON, J., LOBELL, D.B., HOWDEN, S.M., SMITH, D.R. & CHHETRI, N. (2014). 'A Meta-Analysis of Crop Yield under Climate Change and Adaptation', *Nature Climate Change* 4, 287-291.

- CHANEY, E. (2013). 'Revolt on the Nile: Economic Shocks, Religion, and Political Power', *Econometrica* 81, 2033-2053.
- COLLIER, P. & HOEFFLER, A. (1998). 'On Economic Causes of Civil War', *Oxford Economic Papers* 50, 563-573.
- _____. (2004). 'Greed and Grievance in Civil War', *Oxford Economic Papers* 56, 563-595.
- _____. (2005). 'Resource Rents, Governance, and Conflict', *Journal of Conflict Resolution* 49, 625-633.
- COLLIER, P. & SAMBANIS, N. (2002). 'Understanding Civil War: A New Agenda', *Journal of Conflict Resolution* 46, 3-12.
- CROST, B., DUQUENNOIS, C., FELTER, J.H. & REES, D.I. (2018). 'Climate Change, Agricultural Production and Civil Conflict: Evidence from the Philippines', *Journal of Environmental Economics and Management* 88, 379-395.
- DEININGER, K. (2003). 'Causes and Consequences of Civil Strife: Micro-level Evidence from Uganda', *Oxford Economic Papers* 55, 579-606.
- DELL, M., JONES, B.F. & OLKEN, B.A. (2012). 'Temperature Shocks and Economic Growth: Evidence from the Last Half Century', *American Economic Journal: Macroeconomics* 4, 66-95.
- DEPETRIS-CHAUVIN, E. (2015). 'State History and Contemporary Conflict: Evidence from Sub-Saharan Africa', Available at SSRN: <https://ssrn.com/abstract=2679594>.
- DEPETRIS-CHAUVIN, E. & ÖZAK, Ö. (2015). 'Population Diversity, Division of Labor and the Emergence of Trade and State', Available at SSRN: <https://ssrn.com/abstract=2679382>.
- _____. (2016). 'The Origins and Long-Run Consequences of the Division of Labor', Available at SSRN: <https://ssrn.com/abstract=2827328>.
- DUBE, O. & VARGAS, J.F. (2013). 'Commodity Price Shocks and Civil Conflict: Evidence from Colombia', *Review of Economic Studies* 80, 1384-1421.
- EASTERLY, W.R. (2001). 'Global Development Network Growth Database'.
- ESTEBAN, J., MAYORAL, L. & RAY, D. (2012). 'Ethnicity and Conflict: An Empirical Study', *American Economic Review* 102, 1310-1342.
- FAIRHEAD, J. (2000) *The Conflict over Natural and Environmental Resources*, in *War, Hunger, and Displacement: Volume 1*, eds. E. W. Nafziger, F. Stewart and R. Väyrynen (Oxford: Oxford University Press),
- FEARON, J.D. (2003). 'Ethnic and Cultural Diversity by Country', *Journal of Economic Growth* 8, 195-222.
- FEARON, J.D. & LAITIN, D.D. (2003). 'Ethnicity, Insurgency, and Civil War', *American Political Science Review* 97, 75-90.
- FISCHER, G., SHAH, M., N. TUBIELLO, F. & VAN VELHUIZEN, H. (2005). 'Socio-Economic and Climate Change Impacts on Agriculture: An Integrated Assessment, 1990–2080', *Philosophical Transactions of the Royal Society B: Biological Sciences* 360, 2067-2083.
- GALLUP, J.L., MELLINGER, A.D. & SACHS, J.D. (2010). 'Geography Datasets', Centre for International Development, Harvard University.
- GALOR, O. & ÖZAK, Ö. (2015). 'Land Productivity and Economic Development: Caloric Suitability vs. Agricultural Suitability', Brown University, Department of Economics Working Papers 2015-5.
- _____. (2016). 'The Agricultural Origins of Time Preference', *American Economic Review* 106, 3064-3103.
- GILMORE, E., GLEDITSCH, N.P., LUJALA, P. & ROD, J.K. (2005). 'Conflict Diamonds: A New Dataset', *Conflict Management and Peace Science* 22, 257-272.
- GURR, T.R. (1970) *Why Men Rebel* (Princeton: Princeton University Press).
- _____. (2000). 'Ethnic Warfare on the Wane', *Foreign Affairs* 79, 52-64.
- HARARI, M. & LA FERRARA, E. (2018). 'Conflict, Climate, and Cells: A Disaggregated Analysis', *Review of Economics and Statistics*, forthcoming (https://doi.org/10.1162/rest_a_00730).
- HOEGH-GULDBERG, O., MUMBY, P.J., HOOTEN, A.J., STENECK, R.S., GREENFIELD, P., GOMEZ, E., HARVELL, C.D., SALE, P.F., EDWARDS, A.J., CALDEIRA, K., KNOWLTON, N., EAKIN, C.M.,

- IGLESIAS-PRIETO, R., MUTHIGA, N., BRADBURY, R.H., DUBI, A. & HATZIOLOS, M.E. (2007). 'Coral Reefs Under Rapid Climate Change and Ocean Acidification', *Science* 318, 1737-1742.
- HOFSTEDE, G. (2001) *Culture's Consequences: Comparing Values, Behaviors, Institutions, and Organizations across Nations* (Beverly Hills, CA: Sage Publication).
- HOFSTEDE, G., HOFSTEDE, G.J. & MINKOV, M. (2010) *Cultures and Organizations: Software of the Mind. Revised and Expanded 3rd Edition* (New York: McGraw-Hill USA).
- HOROWITZ, D.L. (1985) *Ethnic Groups in Conflict* (Berkeley: University of California Press).
- HSIANG, S.M., MENG, K.C. & CANE, M.A. (2011). 'Civil Conflicts are Associated with the Global Climate', *Nature* 476, 438-441.
- IYIGUN, M., NUNN, N. & QIAN, N. (2017). 'The Long-Run Effects of Agricultural Productivity on Conflict, 1400-1900', NBER Working Paper No. 24066.
- JIMENEZ-AYORA, P. & ULUBAŞOĞLU, M.A. (2015). 'What Underlies Weak States? The Role of Terrain Ruggedness', *European Journal of Political Economy* 39, 167-183.
- KLARE, M. (2001) *Resource Wars: The New Landscape of Global Conflict* (New York: Metropolitan books).
- LA PORTA, R., LOPEZ-DE-SILANES, F., SHLEIFER, A. & VISHNY, R.W. (1998). 'Law and Finance', *Journal of Political Economy* 106, 1113-1155.
- LANGE, G.-M., HAMILTON, K., RUTA, G., CHAKRABORTI, L., DESAI, D., EDENS, B., FERREIRA, S., FRAUMENI, B., JARVIS, M., KINGSMILL, W. & LI, H. (2010) *The Changing Wealth of Nations: Measuring Sustainable Development in the New Millennium* (Washington D.C.: World Bank).
- LENG, G., ZHANG, X., HUANG, M., ASRAR, G.R. & LEUNG, L.R. (2016). 'The Role of Climate Covariability on Crop Yields in the Conterminous United States', *Scientific Reports* 6, 33160.
- LETENDRE, K., FINCHER, C.L. & THORNHILL, R. (2010). 'Does Infectious Disease Cause Global Variation in the Frequency of Intrastate Armed Conflict and Civil War?' *Biological Reviews* 85, 669-683.
- LOBELL, D.B., SCHLENKER, W. & COSTA-ROBERTS, J. (2011). 'Climate Trends and Global Crop Production Since 1980', *Science* 333, 616-620.
- LUJALA, P., GLEDITSCH, N.P. & GILMORE, E. (2005). 'A Diamond Curse? Civil War and a Lootable Resource', *Journal of Conflict Resolution* 49, 538-562.
- MARSHALL, M.G. (2014). 'Major Episodes of Political Violence (MEPV) and Conflict Regions, 1946–2013', Center for Systematic Peace.
- MARSHALL, M.G., GURR, T.R. & JAGGERS, K. (2015). 'Polity IV Project: Political Regime Characteristics and Transitions, 1800-2015 Dataset'.
- MATI, M., ANKERST, D.P. & MENZEL, A. (2017). 'Interactions Between Temperature and Drought in Global and Regional Crop Yield Variability During 1961-2014', *PLOS ONE* 12, e0178339.
- MCEVEDY, C. & JONES, R. (1978) *Atlas of World Population History* (New York: Facts on File).
- MICHALOPOULOS, S. (2012). 'The Origins of Ethnolinguistic Diversity', *American Economic Review* 102, 1508-1539.
- MIGUEL, E., SATYANATH, S. & SERGENTI, E. (2004). 'Economic Shocks and Civil Conflict: An Instrumental Variables Approach', *Journal of Political Economy* 112, 725-753.
- MONFREDA, C., RAMANKUTTY, N. & FOLEY, J.A. (2008). 'Farming the Planet: 2. Geographic Distribution of Crop Areas, Yields, Physiological Types, and Net Primary Production in the Year 2000', *Global Biogeochemical Cycles* 22.
- MURRAY, D.R. & SCHALLER, M. (2010). 'Historical Prevalence of Infectious Diseases within 230 Geopolitical Regions: A Tool for Investigating Origins of Culture', *Journal of Cross-Cultural Psychology* 41, 99-108.
- NUNN, N. & PUGA, D. (2012). 'Ruggedness: The Blessing of Bad Geography in Africa', *Review of Economics and Statistics* 94, 20-36.
- NUNN, N. & QIAN, N. (2011). 'The Potato's Contribution to Population and Urbanization: Evidence From A Historical Experiment', *Quarterly Journal of Economics* 126, 593-650.
- _____. (2014). 'US Food Aid and Civil Conflict', *American Economic Review* 104, 1630-1666.

- O'LOUGHLIN, J., WITMER, F.D.W., LINKE, A.M., LAING, A., GETTELMAN, A. & DUDHIA, J. (2012). 'Climate Variability and Conflict Risk in East Africa, 1990–2009', *Proceedings of the National Academy of Sciences* 109, 18344-18349.
- OLSSON, O. (2009). 'On the Democratic Legacy of Colonialism', *Journal of Comparative Economics* 37, 534-551.
- OLSSON, O. & HIBBS, D.A., JR. (2005). 'Biogeography and Long-Run Economic Development', *European Economic Review* 49, 909-938.
- OLSSON, O. & PAIK, C. (2016). 'Long-Run Cultural Persistence: Evidence from the Neolithic Revolution', *Journal of Development Economics* 122, 197-213.
- OSBORNE, T.M. & WHEELER, T.R. (2013). 'Evidence for a Climate Signal in Trends of Global Crop Yield Variability Over the Past 50 Years', *Environmental Research Letters* 8, 024001.
- PETTERSSON, T. & WALLENSTEEN, P. (2015). 'Armed Conflicts, 1946–2014', *Journal of Peace Research* 52, 536-550.
- POSNER, D.N. (2003). 'The Colonial Origins of Ethnic Cleavages: The Case of Linguistic Divisions in Zambia', *Comparative Politics* 35, 127-146.
- PUTTERMAN, L. (2006). 'Agricultural Transition Year Country Data Set', Brown University.
- _____. (2008). 'Agriculture, Diffusion and Development: Ripple Effects of the Neolithic Revolution', *Economica* 75, 729-748.
- _____. (2012). 'State Antiquity Index (Statehist) Version 3.1 (http://www.econ.brown.edu/fac/louis_putterman/)'.
- RAMANKUTTY, N., FOLEY, J.A., NORMAN, J. & MCSWEENEY, K. (2002). 'The Global Distribution of Cultivable Lands: Current Patterns and Sensitivity to Possible Climate Change', *Global Ecology and Biogeography* 11, 377-392.
- RAY, D.K., GERBER, J.S., MACDONALD, G.K. & WEST, P.C. (2015). 'Climate Variation Explains a Third of Global Crop Yield Variability', *Nature Communications* 6, 5989.
- ROSS, M.L. (2004). 'How Do Natural Resources Influence Civil War? Evidence from Thirteen Cases', *International Organization* 58, 35-67.
- SALEHYAN, I. (2008). 'From Climate Change to Conflict? No Consensus Yet', *Journal of Peace Research* 45, 315-326.
- SARSONS, H. (2015). 'Rainfall and Conflict: A Cautionary Tale', *Journal of Development Economics* 115(C), 62-72.
- SCHLENKER, W. & LOBELL, D.B. (2010). 'Robust Negative Impacts of Climate Change on African Agriculture', *Environmental Research Letters* 5, 014010.
- SOLT, F. (2016). 'The Standardized World Income Inequality Database', *Social Science Quarterly* 97, 1267-1281.
- STEWART, F. (2008) Horizontal Inequalities and Conflict: An Introduction and some Hypotheses, in *Horizontal Inequalities and Conflict: Understanding Group Violence in Multiethnic Societies*, ed. F. Stewart (London: Palgrave Macmillan), 3-24.
- SUNDBERG, R., ECK, K. & KREUTZ, J. (2012). 'Introducing the UCDP Non-State Conflict Dataset', *Journal of Peace Research* 49, 351-362.
- SUNDBERG, R. & MELANDER, E. (2013). 'Introducing the UCDP Georeferenced Event Dataset', *Journal of Peace Research* 50, 523-532.
- VAN DE VLIERT, E., SCHWARTZ, S.H., HUISMANS, S.E., HOFSTEDE, G. & DAAN, S. (1999). 'Temperature, Cultural Masculinity, and Domestic Political Violence A Cross-National Study', *Journal of Cross-Cultural Psychology* 30, 291-314.
- WDI (2017) *World Development Indicators 2017 Database* (Philadelphia: World Bank).
- WHEELER, T. & VON BRAUN, J. (2013). 'Climate Change Impacts on Global Food Security', *Science* 341, 508-513.
- WIMMER, A., CEDERMAN, L.-E. & MIN, B. (2009). 'Ethnic Politics and Armed Conflict: A Configurational Analysis of a New Global Dataset', *American Sociological Review* 74, 316-337.
- WOOLDRIDGE, J.M. (2010) *Econometric Analysis of Cross Section and Panel Data* (Cambridge, MA: MIT Press).

- ZHANG, D.D., BRECKE, P., LEE, H.F., HE, Y.-Q. & ZHANG, J. (2007). 'Global Climate Change, War, and Population Decline in Recent Human History', *Proceedings of the National Academy of Sciences* 104, 19214-19219.
- ZHAO, C., LIU, B., PIAO, S., WANG, X., LOBELL, D.B., HUANG, Y., HUANG, M., YAO, Y., BASSU, S., CIAIS, P., DURAND, J.-L., ELLIOTT, J., EWERT, F., JANSSENS, I.A., LI, T., LIN, E., LIU, Q., MARTRE, P., MÜLLER, C., PENG, S., PEÑUELAS, J., RUANE, A.C., WALLACH, D., WANG, T., WU, D., LIU, Z., ZHU, Y., ZHU, Z. & ASSENG, S. (2017). 'Temperature increase reduces global yields of major crops in four independent estimates', *Proceedings of the National Academy of Sciences* 114, 9326-9331.

Figure 1: Histogram of variation in potential crop yield

Notes: The horizontal axis measures variation in potential crop yield across the globe, as measured in thousands of kilo calories per hectare per year, based on the crops that were available after Colombian exchange (source: Galor and Özak, 2016).

Figure 2: The relationship between conflict incidence and variation in potential crop yield

Notes: Conflict incidence is the number of five year sub-periods, between 1960 and 2014, that had at least one ongoing conflict of any intensity. The x-axis measures variation in potential crop yield across the globe, as measured in thousands of kilo calories per hectare per year, based on the crops that were available after Colombian exchange. The number of countries included is 135 (source: Galor and Özak, 2016).

Figure 3: Relationship between conflict incidence and potential crop yield variation

Notes: The partial regression line in the diagram illustrates the influence of variation in potential crop yield on conflict incidence while partialing out the effects of all other control variables, including mean crop yield, rugged terrain, absolute latitude, elevation, distance to waterways, precipitation, landlockedness, temperature, and fraction of population in tropical zones (see column (4) of Table 1). The number of observations is 135.

Figure 4: Conflict data for grid cells of 2.5 by 2.5 decimal degrees

Notes: Longitude extends from -180 to 180 degree, and latitude extends from -65 to 85 degree. Dots represent individual conflict events during the period 1989-2015. The Conflict events data are taken from Sundberg and Melander (2013).

Figure 5: Histogram of masculinity index for 101 countries

Source: Hofstede et al. (2010). Masculinity is defined as a preference for society with a clearly distinct role for different genders (see Hofstede, 2001, p. 297).

Table 1: Cross-country regression results

	(1)	(2)	(3)	(4)
	(Baseline)			
Dependent variable:	Conflict incidence (<i>confinc</i>)			
Variation in potential crop yield, log	0.17*** (2.67)	0.20** (2.52)	0.34*** (3.46)	0.47*** (4.71)
Mean potential crop yield, log		-0.07 (-1.06)	-0.07 (-0.71)	-0.08 (-0.86)
Rugged terrain			0.04 (0.35)	-0.02 (-0.13)
Absolute latitude			0.52* (1.79)	0.08 (0.26)
Elevation			0.14 (0.97)	-0.00 (-0.00)
Distance to waterways			0.29** (2.60)	0.23* (1.69)
Precipitation			0.14 (0.84)	0.07 (0.44)
Landlockedness			-0.25*** (-2.78)	-0.24*** (-2.73)
Temperature			0.80*** (3.10)	0.57** (2.14)
% pop in tropical zones			0.15 (0.94)	0.16 (1.04)
Observations	135	135	135	135
Adjusted R-squared	0.02	0.02	0.20	0.30
Continent dummies	No	No	No	Yes

Notes: This table presents standardized beta coefficients of the reduced-form effect of variation in crop yield on conflict incidence using an OLS estimator. The continent dummies are Africa, Asia, Europe, North America, South America, with Oceania as the excluded group. An intercept is included in all the regressions but not reported for brevity. Robust t-statistics are given in parentheses. *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table 2: Pooled cross-country results

Dependent variable	(1)	(2)	(3)	(4)
	Conflict incidence (<i>confinc</i>)			
Variation in potential crop yield, log	0.56*** (2.89)	0.77*** (3.25)	1.27*** (3.42)	1.68*** (4.39)
Mean potential crop yield, log		-0.47** (-2.29)	-0.54 (-1.43)	-0.69* (-1.69)
Rugged terrain			0.69* (1.70)	0.70 (1.64)
Absolute latitude			1.35 (1.55)	0.78 (0.83)
Elevation			0.24 (0.51)	-0.19 (-0.37)
Distance to waterways			1.33*** (3.62)	1.21*** (2.94)
Precipitation			0.26 (0.62)	0.18 (0.38)
Landlockedness			-1.04*** (-2.98)	-0.97*** (-2.73)
Temperature			2.47*** (3.29)	2.07** (2.36)
% pop in tropical zones			0.55 (0.96)	0.72 (1.37)
Conflict incident, lagged	2.93*** (14.10)	2.92*** (14.01)	2.64*** (12.71)	2.48*** (12.01)
Continent FE	No	No	No	Yes
Observations	1120	1120	1120	1120
Pseudo R^2	0.29	0.29	0.33	0.34

Notes: This table presents standardized beta coefficients of the reduced-form effect of variation in crop yield on conflict incidence using a logistic estimator. The continent dummies are Africa, Asia, Europe, North America, South America, with Oceania as the excluded group. An intercept is included in all the regressions but not reported for brevity. Robust z-statistics are given in parentheses. *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table 3: Grid-level analysis

	(1)	(2)	(3)	(4)
Dependent variable	Conflict incidence (<i>confinc</i>)			
Variation in potential crop yield, log	0.27*** (4.96)	0.21** (2.50)	0.14** (2.01)	0.14** (2.03)
Mean potential crop yield, log		0.07 (0.66)	0.17* (1.80)	0.18* (1.88)
Rugged terrain			0.02 (0.47)	0.02 (0.48)
Absolute latitude			0.36 (1.49)	0.34 (1.45)
Elevation			0.44** (2.26)	0.45** (2.38)
Distance to sea			-0.06 (-1.17)	-0.06 (-1.18)
Precipitation			0.07 (1.28)	0.07 (1.21)
Landlockedness			0.02 (0.90)	0.03 (1.00)
Temperature			1.15* (1.87)	1.17* (1.95)
% pop in tropical zones			-1.20 (-1.23)	-1.31 (-1.30)
Baseline controls	No	No	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Continent FE	No	No	No	Yes
Observations	1827	1827	1827	1827
Number of clusters	130	130	130	130

Notes: This table presents standardized beta coefficients of the reduced-form effect of variation in crop yield on conflict incidence using a Poisson estimator. The continent dummies are Africa, Asia, Europe, North America, South America, with Oceania as the excluded group. An intercept is included in all the regressions but not reported for brevity. Robust z-statistics are given in parentheses. *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table 4: Robustness to alternative measures of conflict for cross-country regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. Var. =	<i>confinc_hist</i>	<i>confinc_frac</i>	<i>confinc_mid</i>	<i>confinc_war</i>	<i>onset2</i>	<i>onset5</i>	<i>onset_eth</i>	<i>confinc_ns</i>
Var. in potential	0.24***	0.46***	0.39***	0.29**	0.41***	0.43***	0.33***	0.46***
crop yield, log	(2.71)	(4.25)	(3.28)	(2.49)	(3.76)	(4.14)	(2.90)	(4.64)
Mean potential	-0.01	-0.08	-0.04	0.05	-0.01	-0.06	0.09	-0.04
crop yield, log	(-0.09)	(-0.91)	(-0.42)	(0.69)	(-0.15)	(-0.58)	(1.05)	(-0.41)
Observations	135	135	135	135	135	135	131	135
Adjusted R ²	0.10	0.23	0.16	0.09	0.22	0.22	0.19	0.25
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Continent FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents standardized beta coefficients of the reduced-form effect of variation in crop yield on conflict incidence using an OLS estimator. *confinc_hist* (columns (1)) is the total number conflicts during the period 1500-2010; *confinc_frac* (columns (2)) is the fraction of years that had incidence of conflict over the period 1960-2014. *confinc_mid* (columns (3)) is the number of five year sub-periods, between 1960 and 2014, that had at least one ongoing conflict and where battle-related deaths were less than one thousand in a single year but cumulative battle-related deaths exceeded one thousand since the beginning of the episode of conflict in any year within a 5-year sub-period; *confinc_war* (columns (4)) is the number of five year sub-periods, between 1960 and 2014, that had at least one ongoing conflict and where battle-related deaths exceeded one thousand in a single year in any year within the 5-year sub-period; *onset2* (columns (5)) and *onset5* (columns (6)) are the number of five-year sub-periods, between 1960 and 2014, that had at least one onset of a new conflict episode after two and five years of continuous peace, respectively; *onset_eth* (columns (7)) is the aggregate of new ethnic conflicts between 1960 and 2010; *confinc_ns* (columns (8)) is the number of five year sub-periods, between 1960 and 2014, that had at least one ongoing non-state conflict. Absolute latitude, elevation, distance to sea, average precipitation, average temperature, ruggedness, landlockedness, and % population in tropical zones are included as additional controls in all regressions. The continent dummies are Africa, Asia, Europe, North America, South America, with Oceania as the excluded group. An intercept is included in all the regressions but not reported for brevity. Robust t-statistics are given in parentheses. *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively. The results can be benchmarked against the baseline estimates reported in Table 1.

Table 5: Robustness to alternative measures of conflict for pooled cross-country regressions

Dependent variable	(1) <i>confinc_int</i>	(2) Major Episodes of Political Violence (MEPV)	(3) Index of Social Conflict (ISC)
Variation in potential crop yield, log	1.02*** (3.92)	0.24*** (3.13)	0.11*** (3.22)
Mean potential crop yield, log	-0.24 (-0.89)	-0.06 (-0.66)	0.02 (0.64)
Conflict intensity, lagged	Yes	Yes	Yes
Baseline controls	Yes	Yes	Yes
Continent FE	Yes	Yes	Yes
Observations	1,451	1,278	1,035
Pseudo R^2	0.32	0.27	0.39

Notes: This table presents standardized beta coefficients of the reduced-form effect of variation in crop yield on conflict incidence using ordered logit in columns (1) and (2), and OLS in column (3). Absolute latitude, elevation, distance to sea, average precipitation, average temperature, ruggedness, landlockedness, and % population in tropical zones are included as additional controls in all regressions. The continent dummies are Africa, Asia, Europe, North America, South America, with Oceania as the excluded group. An intercept is included in all the regressions but not reported for brevity. Robust z-statistics are given in parentheses. *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively. The results can be benchmarked against the baseline estimates reported in Table 2.

Table 6: Robustness to an alternative measure of conflict for grid-level regressions

Dependent variable	(1)	(2)	(3)	(4)
	<i>Presence of conflict incidence (Yes = 1)</i>			
Variation in potential crop yield, log	0.90*** (3.32)	1.17* (1.65)	0.81* (1.88)	0.85** (1.97)
Mean potential crop yield, log		-0.33 (-0.31)	-0.01 (-0.01)	-0.09 (-0.18)
Rugged terrain			0.02 (0.13)	0.06 (0.35)
Absolute latitude			2.39** (2.19)	2.20** (2.15)
Elevation			1.76*** (3.25)	1.81*** (3.67)
Distance to sea			0.15 (0.45)	0.17 (0.53)
Precipitation			0.38 (1.08)	0.36 (1.00)
Landlockedness			0.07 (0.46)	0.15 (0.92)
Temperature			5.17*** (2.62)	5.33*** (2.90)
% pop in tropical zones			0.60 (0.15)	-0.95 (-0.22)
Baseline controls	No	No	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Continent FE	No	No	No	Yes
Observations	1337	1337	1337	1337
Number of clusters	57	57	57	57
Pseudo R^2	0.47	0.47	0.50	0.51

Notes: This table presents standardized beta coefficients of the reduced-form effect of variation in crop yield on conflict incidence using a probit estimator. The continent dummies are Africa, Asia, Europe, North America, South America, with Oceania as the excluded group. An intercept is included in all the regressions but not reported for brevity. Robust z-statistics are given in parentheses. *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively. The results can be benchmarked against the baseline estimates reported in Table 3.

Table 7: Robustness to omitted covariates for cross-country regressions

Dependent Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	Conflict incidence (<i>confinc</i>)														
Variation in crop yield, log	0.42 ⁺ (4.34)	0.47 ⁺ (4.61)	0.39 ⁺ (3.81)	0.46 ⁺ (4.45)	0.37 ⁺ (3.89)	0.46 ⁺ (4.55)	0.39 ⁺ (4.19)	0.45 ⁺ (4.27)	0.33 [#] (2.31)	0.35 [*] (2.24)	0.47 ⁺ (4.77)	0.46 ⁺ (4.42)	0.40 ⁺ (3.91)	0.41 ⁺ (3.87)	0.46 ⁺ (3.96)
Mean crop yield	-0.06 (-0.62)	-0.07 (-0.71)	-0.08 (-0.88)	-0.06 (-0.63)	-0.08 (-0.96)	-0.10 (-0.96)	-0.13 (-1.10)	-0.08 (-0.76)	-0.15 (-1.07)	-0.15 (-1.09)	-0.09 (-0.87)	-0.07 (-0.64)	-0.16 (-1.54)	-0.08 (-0.83)	-0.11 (-0.75)
Origtime															
Migratory distance from East Africa		✓													
State history up to 1500 AD			✓												
Years since agricultural transition				✓											
Biogeography					✓										
Population density in 1500 AD (log)						✓									
Executive constraints							✓								
Autocracy							✓								
Democracy							✓								
GDP per capita, log							✓								
Colonial history (<i>F</i> -statistic)							✓								
Legal origin (<i>F</i> -statistic)							✓								
% Oil export in total export								✓							
Minerals								✓							
Production of diamonds								✓							
Timber								✓							
Natural gas								✓							
Duration of colonial experience									✓						
Settler mortality, log										✓					
Ethnic fractionalization (Fearon, 2003)											✓				
Religion fractionalization (Alesina et. al., 2003)												✓			
Fractionalization (Esteban, 2012)													✓		
Polarization (Esteban, 2012)														✓	
Greenberg Gini index (Esteban, 2012)															✓
Mountainous terrain															✓
Non-contiguous															✓
Variation in elevation															✓
Mean land quality (soil-based)															✓
Land area (1000 km ²)															✓
Observations	128	130	123	126	121	128	135	123	75	70	135	133	118	135	130
Adj. R-squared	0.31	0.31	0.30	0.30	0.31	0.31	0.34	0.31	0.36	0.24	0.30	0.29	0.39	0.33	0.29
Baseline control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Continent FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents standardized beta coefficients of the reduced-form effect of variation in crop yield on conflict incidence using OLS. Absolute latitude, elevation, distance to sea, average precipitation, average temperature, ruggedness, landlockedness, and % population in tropical zones are included as additional controls in all regressions. The continent dummies are Africa, Asia, Europe, North America, South America, with Oceania as the excluded group. An intercept is included in all the regressions but not reported for brevity. Robust t-statistics are given in parentheses. *, # and + indicate significance at the 10%, 5% and 1% levels, respectively. The results can be benchmarked against the baseline estimates reported in Table 1. ✓ indicates that the corresponding variable(s) are controlled in the regression. Refer to the Online Appendix for the full set of estimates.

Table 8: Robustness to omitted covariates for pooled cross-country regressions

Dependent variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	Conflict incidence (<i>confinc</i>)														
Variation in crop yield, log	1.56 ⁺ (3.46)	1.89 ⁺ (4.04)	1.53 ⁺ (3.87)	1.89 ⁺ (3.99)	1.38 ⁺ (3.24)	1.81 ⁺ (3.97)	1.68 ⁺ (3.48)	1.34 ⁺ (3.12)	1.22 [#] (2.32)	1.09 [#] (2.22)	1.71 ⁺ (3.96)	1.68 ⁺ (3.79)	1.29 ⁺ (2.70)	1.48 ⁺ (3.45)	1.99 ⁺ (4.05)
Mean crop yield	-0.57 (-1.31)	-0.81 ⁺ (-1.83)	-0.64 ⁺ (-1.78)	-0.83 ⁺ (-1.86)	-0.59 (-1.54)	-0.83 ⁺ (-1.83)	-0.88 ⁺ (-1.87)	-0.40 (-0.91)	-0.91 ⁺ (-1.92)	-0.73 ⁺ (-1.74)	-0.74 ⁺ (-1.81)	-0.68 (-1.60)	-0.75 ⁺ (-1.74)	-0.65 (-1.57)	-1.25 [#] (-2.25)
Oritime	✓														
Migratory distance from East Africa		✓													
State history up to 1500 AD			✓												
Years since agricultural transition				✓											
Biogeography					✓										
Population density in 1500 AD (log)						✓									
Executive constraints							✓								
Autocracy							✓								
Democracy							✓								
GDP per capita, log							✓								
Colonial history (F-statistic)							✓								
Legal origin (F-statistic)							✓								
% Oil export in total export								✓							
Minerals								✓							
Production of diamonds								✓							
Timber								✓							
Natural gas								✓							
Duration of colonial experience									✓						
Settler mortality, log										✓					
Ethnic fractionalization (Fearon, 2003)											✓				
Religion fractionalization (Alesina et. al., 2003)												✓			
Fractionalization (Estabén, 2012)													✓		
Polarization (Estabén, 2012)														✓	
Greenberg Gini index (Estabén, 2012)															✓
Mountainous terrain															✓
Non-contiguous															✓
Variation in elevation															✓
Mean land quality (soil-based)															✓
Land area (1000 km ²)															✓
Conflict incidence, lagged	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Continent FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Baseline control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1068	1086	1045	1067	1033	1074	1076	1053	684	654	1116	1104	1023	1116	1086
Pseudo R-squared	0.35	0.35	0.35	0.36	0.37	0.35	0.36	0.36	0.33	0.29	0.35	0.35	0.38	0.35	0.35

Notes: This table presents standardized beta coefficients of the reduced-form effect of variation in crop yield on conflict incidence using a logistic estimator. Absolute latitude, elevation, distance to sea, average precipitation, average temperature, ruggedness, landlockedness, and % population in tropical zones are included as additional controls in all regressions. The continent dummies are Africa, Asia, Europe, North America, South America, with Oceania as the excluded group. An intercept is included in all the regressions but not reported for brevity. Robust z-statistics are given in parentheses. *, # and + indicate significance at the 10%, 5% and 1% levels, respectively. The results can be benchmarked against the baseline estimates reported in Table 2. ✓ indicates that the corresponding variable(s) are controlled in the regression. Refer to the Online Appendix for the full set of estimates.

Table 9: Robustness to omitted covariates for grid-level regressions

Dependent variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	<i>Conflict incidence (confinc)</i>														
Variation in crop yield, log	0.30 ⁺ (3.44)	0.29 ⁺ (3.68)	0.29 ⁺ (3.40)	0.31 ⁺ (3.84)	0.31 ⁺ (3.63)	0.28 ⁺ (3.25)	0.21 ⁺ (1.92)	0.26 ⁺ (2.81)	0.21 [#] (2.54)	0.25 ⁺ (2.93)	0.28 ⁺ (3.17)	0.22 [#] (2.46)	0.30 ⁺ (3.57)	0.22 [#] (2.55)	0.22 [#] (2.57)
Mean crop yield	0.00 (0.01)	-0.10 (-1.18)	-0.05 (-0.50)	-0.10 (-1.07)	0.01 (0.06)	-0.08 (-0.84)	-0.04 (-0.30)	0.01 (0.11)	-0.12 (-1.29)	-0.15 (-1.43)	-0.03 (-0.31)	0.13 (1.26)	-0.13 (-1.37)	-0.02 (-0.23)	0.00 (0.03)
Oritime	✓														
Migratory distance from East Africa		✓													
State history up to 1500 AD			✓												
Years since agricultural transition				✓											
Biogeography					✓										
Population density in 1500 AD (log)						✓									
Executive constraints							✓								
Autocracy							✓								
Democracy							✓								
GDP per capita, log							✓								
Colonial history (F-statistic)							✓								
Legal origin (F-statistic)							✓								
% Oil export in total export								✓							
Minerals								✓							
Production of diamonds								✓							
Timber								✓							
Natural gas								✓							
Duration of colonial experience									✓						
Settler mortality, log										✓					
Ethnic fractionalization (Fearon, 2003)											✓				
Religion fractionalization (Alesina et. al., 2003)												✓			
Fractionalization (Estaben, 2012)													✓		
Polarization (Estaben, 2012)														✓	
Greenberg Gini index (Estaben, 2012)															✓
Mountainous terrain															✓
Non-contiguous															✓
Variation in elevation															✓
Mean land quality (soil-based)															✓
Land area (1000 km ²)															✓
Continent FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Baseline control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1814	1827	1792	1820	1806	1826	1755	1690	897	1007	1818	1824	1689	1818	1827
Pseudo R-squared	0.36	0.40	0.36	0.37	0.39	0.35	0.39	0.39	0.28	0.31	0.34	0.37	0.36	0.37	0.36

Notes: This table presents standardized beta coefficients of the reduced-form effect of variation in crop yield on conflict incidence using a Poisson estimator. Absolute latitude, elevation, distance to sea, average precipitation, average temperature, ruggedness, landlockedness, and % population in tropical zones are included as additional controls in all regressions. The continent dummies are Africa, Asia, Europe, North America, South America, with Oceania as the excluded group. An intercept is included in all the regressions but not reported for brevity. Robust z-statistics are given in parentheses. *, # and + indicate significance at the 10%, 5% and 1% levels, respectively. The results can be benchmarked against the baseline estimates reported in Table 3. ✓ indicates that the corresponding variable(s) are controlled in the regression. Refer to the Online Appendix for the full set of estimates.

Table 10: Accounting for potential channels (cross-country regressions)

	(1)	(2)	(3)	(4)	(5)
Dependent variable:	Masculinity	Income inequality	Ethnic fractionalization	Income per capita, log	Night lights per capita
Variation in potential crop yield, log	0.43** (2.61)	-0.15 (-1.36)	-0.06 (-0.50)	0.07 (1.10)	0.05 (0.55)
Mean potential crop yield, log	-0.11 (-0.71)	0.17 (1.64)	0.03 (0.24)	-0.26*** (-3.32)	-0.47*** (-3.17)
Rugged terrain	0.21 (1.15)	-0.10 (-0.68)	-0.31** (-1.99)	0.06 (0.65)	-0.05 (-0.43)
Absolute latitude	-0.54 (-1.02)	-0.03 (-0.09)	-0.78** (-2.38)	-0.27 (-1.18)	0.21 (0.75)
Elevation	-0.54** (-2.06)	0.39** (2.02)	0.25 (1.40)	-0.39*** (-3.56)	-0.18* (-1.84)
Distance to waterways	-0.08 (-0.66)	-0.06 (-0.43)	0.08 (0.77)	-0.24*** (-3.00)	-0.14 (-1.50)
Precipitation	-0.27 (-0.94)	0.19 (1.20)	-0.01 (-0.05)	-0.13 (-1.22)	-0.04 (-0.34)
Landlockedness	0.36** (2.21)	-0.06 (-0.49)	-0.09 (-1.00)	-0.06 (-0.92)	-0.03 (-0.49)
Temperature	-0.09 (-0.21)	0.20 (0.68)	-0.23 (-0.77)	-0.65*** (-3.30)	-0.43** (-2.34)
% pop in tropical zones	-0.11 (-0.36)	-0.34* (-1.80)	-0.13 (-0.74)	-0.11 (-1.02)	0.16 (1.18)
Observations	86	131	135	135	135
Adjusted R-squared	0.08	0.12	0.31	0.69	0.59
Continent dummies	Yes	Yes	Yes	Yes	Yes

Notes: This table presents standardized beta coefficients of the effect of variation in crop yield on some potential channels. The continent dummies are Africa, Asia, Europe, North America, South America, with Oceania as the excluded group. An intercept is included in all the regressions but not reported for brevity. Robust t-statistics are given in parentheses. *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

ONLINE APPENDIX FOR “AGRICULTURAL YIELD AND CONFLICT”

I. DATA DESCRIPTION

A. Conflict measures (outcome variables)

I. Simple cross-country analysis

Our baseline measure is labelled as *confinc*. This variable takes a value of one when there is at least one ongoing conflict of any intensity, as reported in the Armed Conflict Dataset, version 4-2015 (Pettersson and Wallensteen, 2015), in any year within a 5-year sub-period; otherwise it is zero. We use the sum of this variable across 11 sub-periods in the simple cross-country study.

We include the following eight alternative measures of conflict in the robustness checks reported in Table 4: (1) *confinc_hist*: This variable is defined as the total number conflicts during the period 1500-2010 (source: Brecke, 1999); (2) *confinc_frac*: This variable is defined as the fraction of years that had incidence of conflict over period 1960-2014 (source: Pettersson and Wallensteen, 2015); (3) *confinc_mid*: This variable takes the value one when there is at least one ongoing conflict episode having battle-related deaths exceeding one thousand since the beginning of the conflict episode, as reported in the Armed Conflict Dataset, version 4-2015 (Pettersson and Wallensteen, 2015), in any year within a 5-year sub-period; otherwise it is zero. We use the sum of this variable across 11 sub-periods in the cross-section study; (4) *confinc_war*: This variable takes the value one when there is at least one ongoing conflict episode having battle-related deaths exceeding one thousand in a single year, as reported in the Armed Conflict Dataset, version 4-2015 (Pettersson and Wallensteen, 2015), in any year within a 5-year sub-period; otherwise it is zero. We use the sum of this variable across 11 sub-periods in the cross-section study; (5) *onset2* and (6) *onset5*: These variables take the value one when a new conflict episode starts, as reported in the Conflict Onset and Incidence Dataset (Pettersson and Wallensteen, 2015), after two and five years of ‘peace’, respectively, in any year within a 5-year sub-period; otherwise it is zero. We use the aggregate value of these variables across 11 sub-periods in the cross-section study; (7) *onset_eth*: This variable takes the value one when a new conflict, that has an ethnic origin, starts in any year; otherwise it is zero. We use the aggregate value of this variable over the period of study. We construct this variable using updated data from Wimmer et al. (2009); and (8) *confinc_ns*: This variable is constructed similar to *confinc* defined above, but, unlike the above, no side in the conflict is government or state forces. This variable is constructed using the non-state conflict dataset, Version 2.5-2014, 1989-2013 (source: Sundberg et al., 2012).

II. Pooled cross-country analysis

Our baseline measure is labelled as *confinc*. This variable takes a value of one when there is at least one ongoing conflict of any intensity, as reported in the Armed Conflict Dataset, version 4-2015 (Pettersson and Wallensteen, 2015), in any year within a 5-year sub-period; otherwise it is zero.

We include the following three alternative measures of conflict in the robustness checks reported in Table 5: (1) *confinc_int*: This variable indicates the intensity of conflict on a scale of zero to three. When a country is at “Peace”, *confinc_int* is assigned a zero value, conflict incidence satisfying *confinc* but not *confinc_war* is assigned a value of 1 whereas conflict incidence satisfying *confinc_war* criteria are assigned a value of 2; (2) *Major Episodes of Political Violence (MEPV)*: This variable indicates the intensity of conflict on a scale of one (smallest) to ten (highest). We use a maximum of this variable in any year within a 5-year sub-period based on the Major Episodes of Political Violence, 1946-2014 dataset (source: Marshall, 2014); and (3) *Index of Social Conflict (ISC)*: This variable indicates the intensity of conflict as computed by the Cross-National Time-Series Data Archive for the period from 1960 to 2008 (source: Esteban et al., 2012).

III. Grid-cell level analysis

The analysis is performed using a global grid of 2.5 by 2.5 decimal degrees covering from -180 to 180 degrees longitude and from -65 to 85 degrees latitude. We use the latest version (version 5) of UCDP Georeferenced Event Dataset (Sundberg and Melander, 2013). This dataset provides information on global conflict events (excluding Syria) over the period 1989-2015. A conflict event is defined as: “*An incident where armed force was by an organized actor against another organized actor, or against civilians, resulting in at least 1 direct death at a specific location and a specific date*”. The reporting unit is an individual event and the dataset contains 128,264 events. Our baseline outcome variable (labeled as *confinc*) captures whether there was an incidence of conflict in a given grid cell.

For the robustness checks reported in Table 6, we use an approach similar to the above by dividing the whole period 1989-2015 into six 5-year sub-periods (the last sub-period covers only 2 years). We indicate conflict intensity as 1 if there is at least one event of conflict in that grid cell in the 5-year window and 0 otherwise. The aggregate number is our second measure and we label it as “*frequency of conflict incidence*”.

B. Potential crop yield (main explanatory variables)

Data on potential crop yield are taken from Galor and Özak (2016), who construct their dataset from the Global Agro-Ecological Zones (GAEZ) project of the Food and Agriculture Organization (FAO). GAEZ supplies global yield and growth cycle estimates for 48 crops in grids with cells size of 5'x5' (approximately 100 km²). Each crop yield in the GAEZ data (measured in tons per hectare per year) is converted by Galor and Özak (2016) into caloric yield (thousands of kilocalories per hectare per year) to represent the nutritional variation across crops and to compare crop yields among different crops. The USDA National Nutrient Database for Standard Reference provides data on the caloric content of various crops. Using these measures, the estimated average regional crop yield reflects the average regional levels of two variables – crop yield and crop cycle – among crops that indicate the average caloric yield in each cell. Our potential crop yield index is constructed based on agro-climatic conditions under rain-fed low-input agriculture. We take logs on the standard deviation of potential crop yield for all the grids in a country and use it as our measure of variation in potential crop yield. Mean potential crop yield is calculated as the average crop yield across all grid cells within the country.

For the grid-cell level analysis, the potential crop yield variables are constructed in a similar way. Here, we define the unit of analysis as grid cells with a size of 2.5x2.5 decimal degrees. Hence, their variation in potential crop yield and mean actual crop yield are calculated as the standard deviation and average of the potential crop yield values, respectively, across the 5x5 arc-minutes grid cells within the larger grid cells.

C. Baseline geographic controls

Ruggedness: The calculation for ruggedness takes a point on the earth's surface and measures the difference in elevation between this point and each of the eight major directions of the compass (north, northeast, east, southeast, south, southwest, west, and northwest). The index at the central point is given by the square root of the sum of the squared differences in elevation between the central point and the eight adjacent points (source: Nunn and Puga, 2012).

Latitude: The absolute value of latitude of a country's centroid, as reported on <http://gothos.info/resources>.

Elevation: The average elevation of a country, in thousands of kilometers above sea level, calculated using geospatial data at a 1-degree resolution from the Geographically based Economic data (G-ECON) project.

Distance to waterways: The distance, in thousands of km, from a GIS grid cell to the nearest ice-free coastline or sea-navigable river, averaged across the grid cells of a country (source: Harvard University's CID Research Datasets on General Measures of Geography).

Precipitation: The average precipitation of a country, in a unit of 10 millimeters per month over the period from 1961-1990, calculated using geospatial data at a 1-degree resolution from the Geographically based Economic data (G-ECON) project.

Landlockedness: This dummy variable indicates whether a country is landlocked or not (source: Global Development Network Growth Database).

Temperature: The average temperature of a country, in a unit of 10 degree Celsius per month over the period from 1961-1990, calculated using geospatial data at a 1-degree resolution from the Geographically based Economic data (G-ECON) project.

% of population living in tropical zones: The percentage of a country's population in 1995 that resided in areas classified as tropical by the Koppen-Geiger climate classification system (source: Harvard University's CID Research Datasets on General Measures of Geography).

D. Other controls

Origtime: The historical duration of human settlement (in million years) (source: Ahlerup and Olsson, 2012).

Migratory distance from East Africa: The 'Haversine' distance from Addis Ababa to a particular country's modern capital city along a land-restricted route forced through at least one of the five stopping points, including Cairo, Istanbul, Phnom Penh, Anadyr, and Prince Rupert. The variables are rescaled so that a higher value indicates greater proximity (source: Ashraf and Galor, 2013).

State history up to 1500 AD: An index of state history covering the period from 1 AD to 1500 AD, scaled to take values between 0 and 1. The dataset was originally introduced by Bockstette et al. (2002), but the current paper uses its latest version, v3.1. (source: Putterman, 2012).

Years since agricultural transition: The number of years elapsed, in 2000 AD, since the transition to agriculture was estimated to occur (in thousand years) (source: Putterman, 2006).

Biogeography: The first principal component of the standardized numbers of domesticable wild plants and animals (source: Olsson and Hibbs, 2005).

Population density in 1500 AD (log) : The population in 1500 AD divided by land area (source: McEvedy and Jones, 1978; WDI, 2017).

Legal origins: A classification of a country's legal tradition into British common law, French civil law, German civil law, Scandinavian law or Socialist law (source: La Porta et al., 1998).

Colonial history: A classification of a country's colonial origin into British, French, Portuguese, Spanish, or other European origins (i.e., Dutch, Belgian, and Italian) since 1700. For countries ruled by several colonial powers, the most recent one is taken provided that it was ruled for ten years or longer (source: Nunn and Puga, 2012).

Executive constraints: An index from the Polity IV project that reflects the degree of constraints on executives. The variable is measured on a scale of 1 to 7, where 7 indicates the largest amount of constraints (source: Marshall et al., 2015).

Autocracy: An index from the Polity IV project that reflects the degree of institutionalized autocracy. The variable is measured on a scale of 0 to 10, where 10 indicates the largest degree of autocracy (source: Marshall et al., 2015).

Democracy: An index from the Polity IV project that reflects the degree of institutionalized democracy. The variable is measured on a scale of 0 to 10, where 10 indicates the largest degree of democracy (source: Marshall et al., 2015).

GDP per capita (log): GDP per capita data at constant price (2005 US\$) (source: WDI, 2017).

Oil export: A dummy variable indicating whether the proportion of export revenues from oil is larger than 1/3. The data are taken from Fearon and Laitin (2003) and are extended by the authors using data from WDI (2017) .

Mineral wealth: Mineral wealth is calculated as the present value of rents from extraction of minerals, discounted at 4 percent, and over the exhaustion time of the resource. There are ten minerals covered: bauxite, copper, lead, nickel, phosphate, tin, zinc, gold, silver, and iron ore. The data are available for 1995, 2000 and 2005. We divide them by the population size and take the average over the available years (source: Lange et al., 2010).

Diamond production: A dummy variable indicating countries with primary and secondary diamond production (source: Gilmore et al., 2005).

Timber wealth: Timber wealth is calculated as the present discounted value of rents from round wood and fuelwood production, discounted at 4 percent and over the time to exhaustion of the forest (if unsustainably managed). The data are available for 1995, 2000 and 2005. We divide them by the population size and take the average over the available years (source: Lange et al., 2010).

Natural gas wealth: Natural gas wealth is calculated as present value of rents from extraction of gas, discounted at 4 percent, and over the exhaustion time of the resource. The data are available for 1995, 2000 and 2005. We divide them by the population size and take the average over the available years (source: Lange et al., 2010).

Duration of colonial history: This is measured as time spent under colonial rule in hundreds of years, i.e. year of independence minus year of colonization, divided by 100 (source: Olsson, 2009).

Settler mortality (log): European settler mortality rates in the 19th century (source: Albouy, 2012).

Ethnic fractionalization: This is defined as the probability that two randomly selected individuals in a country will be from different ethnic groups (source: Fearon, 2003).

Religion fractionalization: This variable is computed as one minus Herfindahl index of religious group shares. It reflects the probability that two randomly selected individuals from the population belong to different religious groups (source: Alesina et al., 2003).

Fractionalization: This index is constructed as: $F = \sum_{i=1}^m n_i(1 - n_i)$, where n_i is the population share of group i and m is the number of groups (source: Esteban et al., 2012).

Polarization: This index is constructed as: $\sum_{i=1}^m \sum_{j=1}^m n_i^2 n_j k_{ij}$, where $k_{ij} = 1 - s_{ij}^{0.5}$ and s_{ij} is the degree of similarity between two languages, i and j , given the ratio of the number of common branches to the maximum possible number of 15 for the entire tree. n_i is the population share of group i and m is the number of groups (source: Esteban et al., 2012).

Greenberg Gini index: This index is constructed as: $G = \sum_{i=1}^m \sum_{j=1}^m n_i n_j k_{ij}$, where $k_{ij} = 1 - s_{ij}^{0.5}$ and s_{ij} is the degree of similarity between two languages, i and j , given by the ratio of the number of common branches to the maximum possible number of 15 for the entire tree. n_i is the population share of group i and m is the number of groups (source: Esteban et al., 2012).

Mountainous terrain: Proportion area of a country that is mountainous (source: Fearon and Laitin, 2003).

Non-contiguous: Noncontiguous states refer to countries with territory holding of at least 10,000 people and are separated from the land area containing the capital city either by land or by 100 kilometers of water (source: Fearon and Laitin, 2003).

Variation in elevation: This measure indicates the standard deviation of elevation within a country (source: Michalopoulos, 2012).

Mean land quality (soil-based): This measure presents the average agricultural suitability of land across regions based on soil properties (source: Michalopoulos, 2012).

E. Variables used for exploring the channels of influence

Masculinity: An index capturing the extent to which a society favors achievement, heroism, assertiveness and material rewards for success (sources: Hofstede et al. (2010); The Hofstede Centre).

Income inequality: It is an estimate of the Gini index in equivalized (square root scale) household market income. The Luxembourg Income Study data are used as a standard. Market income is the pre-tax and pre-transfer income coming to households. The data are averaged over the period 1961-2014 (source: Solt, 2016).

Ethnic fractionalization: This is defined as the probability that two randomly selected individuals in a country will be from different ethnic groups (source: Fearon, 2003).

Income per capita (log): Average real Gross Domestic Product per capita over the period 1960-2014 (source: WDI, 2017).

Night light per capita: The data are computed using night light time series data provided by the National Centre for Environment Information (<https://ngdc.noaa.gov/eog/dmsp/downloadV4composites.html>). The data are averaged over each day of the year. They are available as a raster image of 30 arc second grids, spanning -180 to 180 degrees longitude and -65 to 75 degrees latitude. We use administrative boundaries for countries from GADM project to extract average night light for each country. The measure is then divided by the population size in each country.

F. Categorization of levels of input used to compile crop yield

In their natural state, many soils, particularly in the tropics, cannot be continuously cultivated without undergoing degradation. Such degradation is marked by a decrease in crop yield and a deterioration of soil structure, nutrient status, and other physical, chemical, and biological attributes. Under traditional low-input farming systems, this deterioration is kept in check by alternating some years of cultivation with periods of fallow. Regeneration of nutrients and maintenance of soil fertility under low input cultivation is achieved through natural bush or grass fallow. At somewhat higher inputs to soils, soil fertility is maintained through fallow that may include a grass, grass- legume ley, or a green-manure crop for a portion of time. The high-level input assumes the use of the best farming technology, soil nutrient inputs, and management know-how today.

With balanced fertilizer applications and proper pest and disease management (which is most possible at high level of inputs), only limited fallow will be required to maintain soil fertility and to keep pest and disease outbreaks in check. At low level of inputs – assuming virtually no application of chemicals and only limited organic fertilizer, and very limited or no application of biocides – there is a need for considerable fallow periods in the crop rotations to restore soil nutrient status and to break pest and disease cycles. The expected long-term yields estimated by the GAEZ procedures assume that proper crop/fallow cycle is followed.

As a rule of thumb for low level input/management conditions, fallow period requirements may vary between 30–90% of the cultivation fallow cycle. At high levels of inputs and management, fallow requirements are uniformly set at 10%. At intermediate level of inputs, the fallow requirements are set at one third of the levels required under low level of inputs. On average, long-term achievable yields are 10%, 20%, and 55% lower than maximum attainable yields, at high, intermediate, and low levels of inputs, respectively.

G. Actual crop yield

Data on actual crop yield are constructed using the agricultural yield data of Monfreda et al. (2008) and the caloric content data used by Galor and Özak 2016. Monfreda et al. (2008) provide estimates of agricultural yield (in tons per harvested hectare) for 175 crops on a 5×5 arc-minute grid over the period 1997-2003. Galor and Özak 2016 obtain caloric content for their 48 crops from the USDA National Nutrient Database for Standard Reference. Of the 175 crops available from Monfreda et al. (2008), 36 can be matched to the 48 crops used by Galor and Özak 2016. To generate the actual caloric yield of a crop for a grid, we multiply the crop yield value of the grid by its corresponding caloric content. The resulting crop-specific caloric yield for a grid is measured in thousands of kilocalories per hectare per year. The average value of 36 crops is used to obtain the actual crop yield estimate for each grid cell.

The gridded average actual caloric crop yield data with a resolution of a 5×5 arc minutes are then aggregated up to the national level and a larger grid-cell (2.5×2.5 decimal degrees) level in order to establish its association with potential crop yield. For the cross-country analysis, variation in actual crop yield for each country is calculated as the standard deviation of the actual crop yield across the 5×5 arc-minute grid cells within that country. Mean actual crop yield is calculated as the average crop yield across all grid cells within the country. For the grid-level analysis, we define the unit of analysis as grid cells with a size of 2.5×2.5 decimal degrees. Hence, their variation in actual crop yield and mean actual crop yield are calculated as the standard deviation and average of the actual crop yield values, respectively, across the 5×5 arc-minute grid cells within the larger grid cells.

II. DATA AND SUMMARY STATISTICS

Table A1: Country-level data on conflict incidence, mean and variation in potential crop yield

Country code	Country name	Conflict incidence	Mean of potential crop yield	Variation in potential crop yield
ALB	Albania	0	1893.3	467.0
ARE	United Arab Emirates	0	3.1	15.0
ARG	Argentina	3	1400.3	1127.0
ARM	Armenia	0	1580.7	648.2
AUS	Australia	0	566.5	729.8
AUT	Austria	0	1196.0	859.9
AZE	Azerbaijan	4	1811.3	524.3
BDI	Burundi	5	1593.4	317.1
BEL	Belgium	0	1586.8	191.1
BEN	Benin	0	1607.6	114.9
BFA	Burkina Faso	1	1256.9	397.1
BGD	Bangladesh	5	1538.5	154.0
BGR	Bulgaria	0	2260.8	515.3
BLR	Belarus	0	1710.9	308.8
BOL	Bolivia	1	1305.6	726.6
BRA	Brazil	0	1377.2	400.0
BTN	Bhutan	0	1151.5	964.5
BWA	Botswana	0	728.8	610.4
CAF	Central African Republic	3	1587.1	197.1
CAN	Canada	0	241.0	416.1
CHE	Switzerland	0	860.3	782.7
CHL	Chile	1	255.2	457.2
CHN	China	1	904.5	953.7
CIV	Cote d'Ivoire	2	1495.6	159.4
CMR	Cameroon	2	1355.2	252.5
COG	Congo, Rep.	3	1259.3	94.0
COL	Colombia	11	928.7	331.4
CRI	Costa Rica	0	1067.2	312.2
CUB	Cuba	1	1908.7	145.0
CYP	Cyprus	0	1333.9	158.0
CZE	Czech Republic	0	1521.0	395.3
DJI	Djibouti	2	8.7	53.1
DNK	Denmark	0	1373.1	112.3
DOM	Dominican Republic	1	1797.9	265.7
DZA	Algeria	5	106.0	353.8
ECU	Ecuador	0	933.7	432.1
EGY	Egypt, Arab Rep.	3	5.1	41.9
ERI	Eritrea	2	238.0	275.5
ESP	Spain	4	1563.9	425.6
EST	Estonia	0	1193.5	80.0
FIN	Finland	0	284.2	311.8
FRA	France	1	1811.9	475.8
GAB	Gabon	1	1118.6	85.4
GBR	United Kingdom	6	824.8	459.5
GEO	Georgia	3	1639.4	950.1
GHA	Ghana	2	1541.7	130.3
GIN	Guinea	1	1634.8	182.1
GMB	Gambia, The	1	1377.2	62.6
GNB	Guinea-Bissau	1	1630.1	28.6
GRC	Greece	0	1725.3	341.8
GTM	Guatemala	8	1526.9	278.2
GUY	Guyana	0	1401.6	70.0
HND	Honduras	0	1667.8	352.2
HRV	Croatia	2	2280.0	376.7
HUN	Hungary	0	2590.3	135.6
IDN	Indonesia	9	990.7	306.7
IND	India	11	1442.5	541.9

IRL	Ireland	0	706.4	169.6
IRN	Iran, Islamic Rep.	9	543.7	500.3
ISR	Israel	11	966.0	590.4
ITA	Italy	0	1834.0	671.6
JAM	Jamaica	0	1614.9	139.6
JOR	Jordan	0	137.7	297.6
JPN	Japan	0	1933.8	530.0
KAZ	Kazakhstan	0	608.1	382.1
KEN	Kenya	1	1188.1	621.0
KGZ	Kyrgyz Republic	0	480.3	587.9
KHM	Cambodia	7	1366.8	84.4
KOR	Korea, Rep.	0	2501.3	98.9
KWT	Kuwait	0	3.9	27.1
LAO	Lao PDR	5	1591.6	154.8
LBN	Lebanon	5	1223.1	338.5
LBY	Libya	1	55.3	189.8
LKA	Sri Lanka	7	1454.5	207.8
LSO	Lesotho	1	1497.2	700.8
LTU	Lithuania	0	1377.1	55.1
LVA	Latvia	0	1288.0	51.1
MAR	Morocco	4	741.3	710.3
MDA	Moldova	1	2535.4	160.2
MDG	Madagascar	1	1838.6	507.1
MEX	Mexico	2	1164.0	674.6
MKD	Macedonia, FYR	1	1986.0	526.2
MLI	Mali	3	394.2	598.9
MNG	Mongolia	0	85.5	162.0
MOZ	Mozambique	5	1955.2	338.7
MRT	Mauritania	2	41.9	115.1
MWI	Malawi	0	2131.4	278.1
MYS	Malaysia	6	884.6	141.9
NAM	Namibia	0	540.7	617.5
NER	Niger	3	146.8	253.4
NGA	Nigeria	5	1367.6	361.3
NIC	Nicaragua	4	1407.5	279.6
NLD	Netherlands	0	1397.1	128.8
NOR	Norway	0	113.7	281.0
NPL	Nepal	4	1600.4	988.9
NZL	New Zealand	0	937.9	490.7
OMN	Oman	3	3.4	19.2
PAK	Pakistan	7	393.7	718.1
PAN	Panama	1	948.8	214.3
PER	Peru	7	699.5	576.1
PHL	Philippines	10	1185.7	240.3
PNG	Papua New Guinea	2	921.0	298.2
POL	Poland	0	1886.6	280.8
PRT	Portugal	0	1729.5	148.4
PRY	Paraguay	1	1989.0	321.5
RUS	Russian Federation	5	362.9	586.8
RWA	Rwanda	5	1238.8	340.5
SAU	Saudi Arabia	1	0.5	9.2
SDN	Sudan	11	675.3	703.2
SEN	Senegal	4	1018.4	473.6
SLE	Sierra Leone	3	1318.1	123.3
SLV	El Salvador	5	1752.5	119.5
SVK	Slovak Republic	0	1848.2	602.5
SVN	Slovenia	0	1869.1	557.5
SWE	Sweden	0	416.0	518.6
SWZ	Swaziland	0	2038.8	292.9
SYR	Syrian Arab Republic	4	684.3	545.1
TCO	Chad	10	512.5	631.4
TGO	Togo	1	1642.6	55.6
THA	Thailand	6	1517.3	179.6
TJK	Tajikistan	4	545.2	666.9
TKM	Turkmenistan	0	423.7	277.9
TTO	Trinidad and Tobago	1	1442.3	61.3
TUN	Tunisia	1	448.5	590.1
TUR	Turkey	7	1585.8	437.8
TZA	Tanzania	0	1964.5	278.9

UKR	Ukraine	1	2138.6	260.6
URY	Uruguay	1	2742.8	106.9
USA	United States	3	1363.8	1127.3
UZB	Uzbekistan	2	439.5	478.0
VEN	Venezuela, RB	3	1314.8	376.6
VNM	Vietnam	0	1361.7	201.7
ZAF	South Africa	5	987.7	855.9
ZMB	Zambia	0	2207.7	241.5
ZWE	Zimbabwe	3	1743.0	509.8

Table A2: Summary statistics and correlations

Summary Statistics	No. of observations		Mean	Standard deviation	Minimum	Maximum
(1) Conflict incidence	135		2.3	2.9	0	11
(2) Variation in potential crop yield, log	135		5.6	0.9	2.3	7.0
(3) Mean potential crop yield, log	135		6.7	1.4	-0.7	7.9
(4) Terrain ruggedness	135		0.2	0.2	0.0	1.0
(5) Absolute latitude	135		0.3	0.2	0.0	0.7
(6) Elevation	135		0.6	0.5	0.0	2.7
(7) Distance to waterways	135		0.3	0.5	0.0	2.4
(8) Precipitation	135		86.6	59.3	2.9	260.0
(9) Landlockedness	135		0.3	0.4	0.0	1.0
(10) Temperature	135		17.9	8.5	-7.9	28.6
(11) % of pop in tropical zones	135		0.3	0.4	0.0	1.0

Correlation Matrix	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) Conflict incidence	1										
(2) Variation in potential crop yield, log	0.17 (0.04)	1									
(3) Mean potential crop yield, log	0.02 (0.78)	0.44 (0.00)	1								
(4) Terrain ruggedness	0.02 (0.81)	0.39 (0.00)	0.11 (0.20)	1							
(5) Absolute latitude	-0.32 (0.00)	0.18 (0.04)	-0.02 (0.82)	0.11 (0.22)	1						
(6) Elevation	0.07 (0.43)	0.49 (0.00)	0.03 (0.75)	0.68 (0.00)	-0.02 (0.79)	1					
(7) Distance to waterways	0.09 (0.29)	0.23 (0.01)	-0.16 (0.06)	-0.04 (0.64)	0.06 (0.51)	0.37 (0.00)	1				
(8) Precipitation	0.16 (0.07)	-0.08 (0.37)	0.43 (0.00)	0.06 (0.49)	-0.50 (0.00)	-0.14 (0.10)	-0.34 (0.00)	1			
(9) Landlockedness	-0.13 (0.15)	0.27 (0.00)	0.12 (0.18)	0.25 (0.00)	0.09 (0.28)	0.46 (0.00)	0.46 (0.00)	-0.22 (0.01)	1		
(10) Temperature	0.31 (0.00)	-0.33 (0.00)	-0.11 (0.22)	-0.26 (0.00)	-0.89 (0.00)	-0.25 (0.00)	-0.23 (0.01)	0.35 (0.00)	-0.19 (0.03)	1	
(11) % of pop in tropical zones	0.23 (0.00)	-0.28 (0.00)	0.28 (0.00)	-0.20 (0.02)	-0.74 (0.00)	-0.21 (0.01)	-0.16 (0.06)	0.76 (0.00)	-0.25 (0.00)	0.62 (0.00)	1

Notes: Conflict incidence is the number of five year sub-periods, between 1960 and 2014, that has at least one ongoing conflict of any intensity. Variation in crop yield and mean crop yield are the standard deviation and mean, respectively, of potential crop yield (measured in millions of kilo calories per hectare per year) across different regions in each country. Significance level are reported in the brackets. The unit of measurement for the above variables are: (1) count; (2) and (3) thousands of kilo calorie per hectare per year; (4) index; (5) degrees/90; (6) and (7) kilometers in thousands; (8) centimeter; (9) binary; (10) degree Celsius; and (11) percentage.

III. ADDITIONAL RESULTS

Table A3: The cross-country association between actual and potential crop yield

Dependent Variable	(1a)	(1b)	(1c)	(2a)	(2b)	(2c)
	Variation in actual crop yield, log			Mean actual crop yield, log		
Variation in potential crop yield, log	0.37*** (4.55)	0.42*** (4.36)	0.40*** (3.51)			
Mean potential crop yield, log				0.76*** (7.61)	0.63*** (6.59)	0.68*** (6.61)
Rugged terrain		-0.29** (-2.01)	-0.24 (-1.50)		-0.10 (-1.04)	-0.13 (-1.52)
Absolute latitude		-0.06 (-0.17)	-0.03 (-0.07)		0.39 (1.49)	-0.08 (-0.35)
Elevation		0.21 (1.11)	0.22 (1.16)		0.24* (1.91)	0.23* (1.98)
Distance to waterways		-0.00 (-0.03)	0.07 (0.57)		-0.09 (-1.25)	-0.05 (-0.62)
Precipitation		0.30 (1.60)	0.25 (1.36)		0.34*** (3.35)	0.18* (1.87)
Landlockedness		-0.26*** (-2.83)	-0.27*** (-2.80)		-0.09* (-1.69)	-0.10* (-1.85)
Temperature		-0.16 (-0.60)	-0.02 (-0.08)		0.20 (0.94)	0.14 (0.78)
% pop in tropical zones		-0.04 (-0.25)	-0.05 (-0.29)		0.06 (0.73)	-0.03 (-0.28)
Observations	0.13	0.24	0.25	0.58	0.65	0.70
Adjusted R-squared	135	135	135	135	135	135
Continent dummies	No	No	Yes	No	No	Yes

Notes: This table presents evidence on the association between potential and actual crop yield using an OLS estimator. The continent dummies are Africa, Asia, Europe, North America, South America, with Oceania as the excluded group. An intercept is included in all the regressions but not reported for brevity. Robust t-statistics are given in parentheses. *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table A4: The grid-level association between actual and potential crop yield

Dependent variable	(1a)	(1b)	(1c)	(4d)	(2a)	(2b)	(2c)	(2d)
	Variation in actual crop yield, log				Mean actual crop yield, log			
Variation in potential crop yield, log	0.68*** (33.17)	0.57*** (25.36)	0.54*** (25.54)	0.41*** (15.84)				
Mean potential crop yield, log					0.79*** (50.81)	0.73*** (45.06)	0.70*** (44.24)	0.58*** (26.68)
Rugged terrain		-0.15*** (-6.29)	-0.17*** (-7.21)	-0.12*** (-4.79)		-0.10*** (-5.05)	-0.14*** (-6.96)	-0.09*** (-4.16)
Absolute latitude		0.21*** (3.08)	-0.08 (-1.06)	-0.35*** (-3.27)		0.14** (2.41)	-0.12* (-1.94)	-0.32*** (-3.87)
Elevation		0.36*** (10.65)	0.27*** (8.38)	0.17*** (4.89)		0.37*** (13.59)	0.31*** (11.41)	0.15*** (5.22)
Distance to sea		0.03 (1.54)	0.00 (0.18)	0.07*** (3.28)		-0.00 (-0.01)	-0.03* (-1.84)	0.03* (1.66)
Precipitation		0.16*** (6.08)	0.06** (2.34)	-0.03 (-0.87)		0.09*** (4.17)	0.03 (1.22)	-0.12*** (-4.72)
Landlockedness		-0.01 (-0.88)	-0.02 (-1.24)	0.01 (0.50)		-0.05*** (-3.61)	-0.05*** (-3.96)	-0.01 (-0.99)
Temperature		0.39*** (6.82)	0.27*** (4.95)	0.41*** (4.84)		0.26*** (5.49)	0.15*** (3.52)	0.19*** (3.00)
% pop in tropical zones		-0.02 (-0.85)	-0.05** (-2.49)	-0.25** (-2.04)		-0.02 (-1.15)	-0.04** (-2.40)	-0.01 (-0.09)
Continent FE	No	No	Yes	Yes	No	No	Yes	Yes
Country FE	No	No	No	Yes	No	No	No	Yes
Observations	1827	1827	1827	1827	1827	1827	1827	1827
Adjusted R-squared	0.46	0.56	0.63	0.72	0.62	0.71	0.76	0.83

Notes: This table presents evidence on the association between potential and actual crop yield using an OLS estimator. The continent dummies are Africa, Asia, Europe, North America, South America, with Oceania as the excluded group. An intercept is included in all the regressions but not reported for brevity. Robust t-statistics are given in parentheses. *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table A5: Robustness to omitted covariates for cross-country regressions

Dependent Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	Conflict incidence (<i>confinc</i>)														
Variation in crop yield, log	0.42 ⁺ (4.34)	0.47 ⁺ (4.61)	0.39 ⁺ (3.81)	0.46 ⁺ (4.45)	0.37 ⁺ (3.89)	0.46 ⁺ (4.55)	0.39 ⁺ (4.19)	0.45 ⁺ (4.27)	0.33 [#] (2.31)	0.35 [#] (2.24)	0.47 ⁺ (4.77)	0.46 ⁺ (4.42)	0.40 ⁺ (3.91)	0.41 ⁺ (3.87)	0.46 ⁺ (3.96)
Mean crop yield	-0.06 (-0.62)	-0.07 (-0.71)	-0.08 (-0.88)	-0.06 (-0.63)	-0.08 (-0.96)	-0.10 (-0.96)	-0.13 (-1.10)	-0.08 (-0.76)	-0.15 (-1.07)	-0.15 (-1.09)	-0.09 (-0.87)	-0.07 (-0.64)	-0.16 (-1.54)	-0.08 (-0.83)	-0.11 (-0.75)
Origtime	-0.07 (-0.42)														
Migratory distance from East Africa		-0.41 (-1.04)													
State history up to 1500 AD			0.08 (0.58)												
Years since agricultural transition				0.09 (0.59)											
Biogeography					0.07 (0.46)										
Population density in 1500 AD (log)						0.09 (0.76)									
Executive constraints							0.33 (1.45)								
Autocracy							-0.10 (-0.51)								
Democracy							-0.22 (-1.08)								
GDP per capita, log							-0.28 [#] (-2.43)								
Colonial history (<i>F</i> -statistic)							1.94 [p=0.11]								
Legal origin (<i>F</i> -statistic)							2.04 [p=0.09]								
% Oil export in total export								0.03 (0.35)							
Minerals								-0.12 ⁺ (-1.93)							
Production of diamonds								-0.05 (-0.55)							
Timber								-0.06 (-1.38)							
Natural gas								-0.06 (-1.14)							
Duration of colonial experience									0.19 (1.55)						
Settler mortality, log										-0.30 [#] (-2.09)					
Ethnic fractionalization (Fearon, 2003)											0.10 (1.05)				
Religion fractionalization (Alesina et. al., 2003)												-0.06 (-0.67)			
Fractionalization (Estaben, 2012)													0.14 (1.26)		
Polarization (Estaben, 2012)													0.24 [#] (2.27)		
Greenberg Gini index (Estaben, 2012)													-0.27 ⁺ (-3.56)		
Mountainous terrain														0.22 (1.33)	
Non-contiguous														0.22 [#] (2.24)	
Variation in elevation															-0.00 (-0.02)
Mean land quality (soil-based)															0.04 (0.35)
Land area (1000 km ²)															0.09 (0.66)
Observations	128	130	123	126	121	128	135	123	75	70	135	133	118	135	130
Adj. R-squared	0.31	0.31	0.30	0.30	0.31	0.31	0.34	0.31	0.36	0.24	0.30	0.29	0.39	0.33	0.29
Baseline control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Continent FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents standardized beta coefficients of the reduced-form effect of variation in crop yield on conflict incidence using OLS. Absolute latitude, elevation, distance to sea, average precipitation, average temperature, ruggedness, landlockedness, and % population in tropical zones are included as additional controls in all regressions. The continent dummies are Africa, Asia, Europe, North America, South America, with Oceania as the excluded group. An intercept is included in all the regressions but not reported for brevity. Robust t-statistics are given in parentheses. *, # and + indicate significance at the 10%, 5% and 1% levels, respectively. The results can be benchmarked against the baseline estimates reported in Table 1. This table is identical to Table 7, except that the full set of estimates is reported here.

Table A6: Robustness to omitted covariates for pooled cross-country regressions

Dependent variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	Conflict incidence (<i>confic</i>)														
Variation in crop yield, log	1.56 ⁺ (3.46)	1.89 ⁺ (4.04)	1.53 ⁺ (3.87)	1.89 ⁺ (3.99)	1.38 ⁺ (3.24)	1.81 ⁺ (3.97)	1.68 ⁺ (3.48)	1.34 ⁺ (3.12)	1.22 [#] (2.32)	1.09 [#] (2.22)	1.71 ⁺ (3.96)	1.68 ⁺ (3.79)	1.29 ⁺ (2.70)	1.48 ⁺ (3.45)	1.99 ⁺ (4.05)
Mean crop yield	-0.57 (-1.31)	-0.81 ⁺ (-1.83)	-0.64 ⁺ (-1.78)	-0.83 ⁺ (-1.86)	-0.59 (-1.54)	-0.83 ⁺ (-1.83)	-0.88 ⁺ (-1.87)	-0.40 (-0.91)	-0.91 ⁺ (-1.92)	-0.73 ⁺ (-1.74)	-0.74 ⁺ (-1.81)	-0.68 (-1.60)	-0.75 ⁺ (-1.74)	-0.65 (-1.57)	-1.25 [#] (-2.25)
Origtime	-0.10 (-0.18)														
Migratory distance from East Africa		-2.04 [#] (-2.25)													
State history up to 1500 AD			0.13 (0.39)												
Years since agricultural transition				0.94 [#] (2.21)											
Biogeography					0.67 (1.44)										
Population density in 1500 AD (log)						0.24 (0.69)									
Executive constraints							0.61 (0.80)								
Autocracy							-1.29 [#] (-2.30)								
Democracy							-1.71 [#] (-2.08)								
GDP per capita, log							-0.34 (-0.85)								
Colonial history (F-statistic)							5.00 [p=0.29]								
Legal origin (F-statistic)							875.29 [p=0.00]								
% Oil export in total export								0.25 (0.95)							
Minerals								-0.59 (-0.80)							
Production of diamonds								-0.23 (-0.92)							
Timber								-2.41 [#] (-2.01)							
Natural gas								-0.26 (-0.56)							
Duration of colonial experience									0.58 (1.52)						
Settler mortality, log										-0.59 (-1.43)					
Ethnic fractionalization (Fearon, 2003)											0.36 (1.24)				
Religion fractionalization (Alesina et. al., 2003)												-0.04 (-0.16)			
Fractionalization (Estaben, 2012)													0.47 (1.45)		
Polarization (Estaben, 2012)													0.79 ⁺ (3.12)		
Greenberg Gini index (Estaben, 2012)													-1.37 [#] (-2.49)		
Mountainous terrain														0.30 (0.79)	
Non-contiguous														0.95 ⁺ (3.06)	
Variation in elevation															-0.15 (-0.38)
Mean land quality (soil-based)															0.56 (1.54)
Land area (1000 km ²)															0.15 (0.53)
Conflict incidence, lagged	2.41 ⁺ (12.64)	2.44 ⁺ (12.96)	2.48 ⁺ (12.96)	2.48 ⁺ (12.95)	2.50 ⁺ (12.82)	2.46 ⁺ (12.94)	2.33 ⁺ (12.38)	2.45 ⁺ (12.78)	2.24 ⁺ (9.96)	2.21 ⁺ (10.24)	2.48 ⁺ (13.33)	2.51 ⁺ (13.36)	2.44 ⁺ (12.24)	2.41 ⁺ (12.87)	2.46 ⁺ (12.97)
Continent FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Baseline control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1068	1086	1045	1067	1033	1074	1076	1053	684	654	1116	1104	1023	1116	1086
Pseudo R-squared	0.35	0.35	0.35	0.36	0.37	0.35	0.36	0.36	0.33	0.29	0.35	0.35	0.38	0.35	0.35

Notes: This table presents standardized beta coefficients of the reduced-form effect of variation in crop yield on conflict incidence using a Poisson estimator. Absolute latitude, elevation, distance to sea, average precipitation, average temperature, ruggedness, landlockedness, and % population in tropical zones are included as additional controls in all regressions. The continent dummies are Africa, Asia, Europe, North America, South America, with Oceania as the excluded group. An intercept is included in all the regressions but not reported for brevity. Robust z-statistics are given in parentheses. *, # and + indicate significance at the 10%, 5% and 1% levels, respectively. The results can be benchmarked against the baseline estimates reported in Table 2. This table is identical to Table 8, except that the full set of estimates is reported here.

Table A7: Robustness to omitted covariates for grid-level regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Dependent variable	<i>Frequency of conflict incidence</i>														
Variation in crop yield, log	0.30 ⁺ (3.44)	0.29 ⁺ (3.68)	0.29 ⁺ (3.40)	0.31 ⁺ (3.84)	0.31 ⁺ (3.63)	0.28 ⁺ (3.25)	0.21 ⁺ (1.92)	0.26 ⁺ (2.81)	0.21 [#] (2.54)	0.25 ⁺ (2.93)	0.28 ⁺ (3.17)	0.22 [#] (2.46)	0.30 ⁺ (3.57)	0.22 [#] (2.55)	0.22 [#] (2.57)
Mean crop yield	0.00 (0.01)	-0.10 (-1.18)	-0.05 (-0.50)	-0.10 (-1.07)	0.01 (0.06)	-0.08 (-0.84)	-0.04 (-0.30)	0.01 (0.11)	-0.12 (-1.29)	-0.15 (-1.43)	-0.03 (-0.31)	0.13 (1.26)	-0.13 (-1.37)	-0.02 (-0.23)	0.00 (0.03)
Origitime	-0.22 ⁺ (-5.02)														
Migratory distance from East Africa		-1.05 ⁺ (-11.94)													
State history up to 1500 AD			0.12 ⁺ (3.45)												
Years since agricultural transition				0.39 ⁺ (9.29)											
Biogeography					0.47 ⁺ (10.39)										
Population density in 1500 AD (log)						0.19 ⁺ (4.22)									
Executive constraints							-0.43 ⁺ (-5.05)								
Autocracy							-0.35 ⁺ (-4.48)								
Democracy							0.15 (1.59)								
GDP per capita, log							-0.26 ⁺ (-4.98)								
Colonial history (F-statistic)							52.56								
Legal origin (F-statistic)							[p=0.00] 2988.59								
% Oil export in total export								0.07 [#] (1.97)							
Minerals								-0.41 ⁺ (-3.54)							
Production of diamonds								-0.22 ⁺ (-6.53)							
Timber								-0.04 (-1.32)							
Natural gas								-0.20 ⁺ (-2.87)							
Duration of colonial experience									0.01 (0.28)						
Settler mortality, log										-0.18 ⁺ (-5.73)					
Ethnic fractionalization (Fearon, 2003)											0.00 (0.11)				
Religion fractionalization (Alesina et. al., 2003)												-0.24 ⁺ (-7.95)			
Fractionalization (Estaben, 2012)													0.05 (1.60)		
Polarization (Estaben, 2012)													0.14 ⁺ (6.48)		
Greenberg Gini index (Estaben, 2012)													-0.20 ⁺ (-4.36)		
Mountainous terrain														0.18 ⁺ (7.64)	
Non-contiguous														0.15 ⁺ (4.49)	
Variation in elevation															0.06 (1.57)
Mean land quality (soil-based)															-0.01 (-0.16)
Land area (1000 km ²)															-0.47 ⁺ (-3.60)
Continent FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Baseline control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1814	1827	1792	1820	1806	1826	1755	1690	897	1007	1818	1824	1689	1818	1827
Pseudo R-squared	0.36	0.40	0.36	0.37	0.39	0.35	0.39	0.39	0.28	0.31	0.34	0.37	0.36	0.37	0.36

Notes: This table presents standardized beta coefficients of the reduced-form effect of variation in crop yield on conflict incidence using a Poisson estimator. Absolute latitude, elevation, distance to sea, average precipitation, average temperature, ruggedness, landlockedness, and % population in tropical zones are included as additional controls in all regressions. The continent dummies are Africa, Asia, Europe, North America, South America, with Oceania as the excluded group. An intercept is included in all the regressions but not reported for brevity. Robust z-statistics are given in parentheses. *, # and + indicate significance at the 10%, 5% and 1% levels, respectively. The results can be benchmarked against the baseline estimates reported in Table 3. This table is identical to Table 9, except that the full set of estimates is reported here.