27th Annual Conference

Online

May June 2021

ASSESSING THE IMPACT OF IRRIGATION ON KURDISH SEPARATISM IN SOUTHEASTERN TURKEY

OLLIE BALLINGER

SUSTAINABLE DEVELOPMENT GOALS AND EXTERNAL SHOCKS IN THE MENA REGION:

FROM RESILIENCE TO CHANGE IN THE WAKE OF COVID-19

Contact Us

erf@erf.org.eg

منتدى البحوث الاقتصادية

ECONOMIC RESEARCH FORUM

Assessing the Impact of Irrigation on Kurdish Separatism in Southeastern Turkey

Ollie Ballinger*

February 9, 2021

Abstract

This paper leverages a large-scale dam construction project in Southeastern Turkey to test the hypothesis that climactic shocks and their impacts on rural incomes play a causal role in civil conflict. I use original 5km and 10km gridded datasets on irrigation and Kurdish separatism from 1985-2019, exploiting exogenous topographical variation in the distribution of irrigation schemes. I find that conflict incidence and insurgent recruitment decline significantly in areas following the introduction of irrigation. A district-level analysis suggests the decoupling of agricultural income from rainfall as a likely mechanism. Clashes are more frequent following a poor harvest, and yields for all major crops except irrigated cotton are highly sensitive to rainfall. However, there is substantial treatment heterogeneity related to land inequality. Consistent results were derived from both cross-sectional Instrumental Variables approaches and spatial panel models, and were robust to the inclusion of a wide array of highly detailed political-economic control variables, alternative measures of irrigation and conflict, and fixed effects.

Keywords: Irrigation, Conflict, Agriculture, Turkey, Insurgent, PKK

*Oxford Department for International Development, 3 Mansfield Rd, Oxford OX1 3TB, UK. ollie.ballinger@st-annes.ox.ac.uk

I Introduction

The interconnections between rural incomes, climate shocks, and civil conflict have been the subject of considerable debate in recent years. Yet conclusive empirical evidence that links agricultural income shocks with increased civil conflict is scant. For example, though Miguel et. al. (2004) found that a drought related growth shock of 5% increased the likelihood of conflict by 50% in Africa, these findings were later disputed by Ciccone (2011). The conclusion in most of these papers is that more disaggregated data are necessary to precisely investigate the relationship between income, rainfall, and conflict. Blattman and Miguel (2010: 8) contend that "the most promising avenue for new empirical research is on the subnational scale, analyzing conflict causes, conduct, and consequences at the level of armed groups, communities, and individuals."

Turkey's Southeastern Anatolia region provides an optimal setting to test both the relationship and underlying mechanisms linking agricultural income and civil conflict. The region's nine provinces are characterized by an arid climate, a high degree of economic dependence on agriculture, and the highest levels of poverty in Turkey. This region is also the site of a Kurdish insurgency that has raged for the past 50 years. In the 1980s, the Turkish government broke ground on the Southeastern Anatolia Project (Güneydoğu Anadolu Projesi, henceforth GAP), a regional development program aiming to bring 1.8 million hectares of land under irrigation (GAP, 2016). The distribution of canal-fed irrigation schemes is largely determined by exogenous topographical constraints—they must be below the altitude of their distributary dams and must be on nearly completely level ground. Irrigation has both increased farmers' incomes by allowing them to grow higher value crops and has shielded them from ever-more frequent droughts. This, in turn, seems to strongly affect rural Kurds' views of the government; in the words of one farmer: "We did not trust the state before, but it brought electricity, water, phone, etc. to us and now we trust the state a lot" (Harris, 2009: 11).

In this paper, I leverage an original, highly disaggregated dataset to investigate the relationship between irrigation and Kurdish separatism in Southeastern Turkey between 1985 and 2019. Analysis is conducted at the level of 5km-by-5km and 10km-by-10km grid cells, and is accompanied by an interactive online tool visualizing raw geospatial data for key variables[1]. The primary explanatory variables include a remote-sensing based measure of irrigation, and several drought indices. Covariates include ballot-box level election data, topographical variables, a measure of Kurdish tribal control, and nightlights. The dependent variables consist of two different measures of conflict incidence and a measure of PKK recruitment derived from online obituaries. I seek to answer the following question: has irrigation reduced Kurdish separatism in Southeastern Turkey?

I first assess the cross-sectional impact of irrigation on conflict likelihood by exploiting exogenous topographical variation in the placement of irrigation schemes at the level of 5km-by-5km grid cells, during the resurgence of hostilities following the breakdown of a truce in 2015. Using a spatially autoregressive instrumental variables approach and ACLED conflict incidence data, I find that a fully irrigated 25 km^2 grid-cell is 58% less likely than the average cell to experience a conflict event involving Kurdish rebels during the 2016-2019 period. The effect is strengthened when the dependent variable is restricted to isolate military raids targeting villages that are perceived to be materially supporting the PKK. This effect is robust to the inclusion of a comprehensive array of control variables, aggressive geographic restrictions, and the inclusion of contiguous and inverse-distance spatial spillover effects.

To assess whether conflict decreases following the introduction of irrigation, I employ dynamic spatial panel models using UCDP conflict incidence data spanning over the period 1985-2018, at the level of 10km-by-10km grid-cells. To address potential selection bias in the placement of irrigation schemes, the benchmark specification excludes all grid-cells that never receive irrigation during the study period. Despite the fact that the panel models and instrumental variables models use different conflict datasets and are estimated at different spatial levels, the treatment effect of irrigation is similar: a 27 km^2 increase in a cell's

[1] https://ollielballinger.users.earthengine.app/view/gap

irrigated area leads to a 49% decrease in conflict likelihood for a given cell-year. Results remain consistent despite the use of three alternative measures of irrigation, and the use of PKK recruitment as the dependent variable rather than conflict incidence.

I present evidence on the mechanism underpinning the relationship between irrigation and conflict. A district-level analysis of the relationship between irrigation, agricultural production, and conflict is consistent with the opportunity cost of rebellion mechanism. Yields for four major crops—which together account for over 90% of cultivated land in the region—are shown to be highly sensitive to rainfall. Wheat, which accounts for nearly 50% of the sown area in Southeastern Anatolia, is particularly sensitive. District level panel models suggests that the precarity of agricultural income plays a role in Kurdish separatism: clashes are more frequent following a poor harvest of wheat, the dominant crop in the region. Irrigation induces a shift towards the cultivation of cotton, which is both more lucrative and the only crop in the sample for which yields were uncorrelated with rainfall. Thus, irrigation likely increases the opportunity cost of rebellion by generating two positive income effects: allowing farmers to grow higher value crops and insulating farmers from rainfall shocks.

As a further test of this mechanism, treatment heterogeneity related to land inequality is explored. The prevalence of tribal social structures characterized by "feudal" land tenure means that the degree to which farmers benefit economically from irrigation is likely to be uneven across the region. Interacting the irrigation variable with various indicators of tribal control suggests that the introduction of irrigation in tribal areas actually increases the likelihood of conflict by generating violent local competition over this new source of rents. This effect is strongest in areas with a high proportion of government-aligned tribes, many of whom function as state-sponsored paramilitaries through the "Village Guard" program. Local news reports confirm that historical competition between tribes—known as kan davalari or "blood feuds"—are increasingly being fought over scarce irrigation water and often involve paramilitaries. This aligns closely with recent literature on rent-seeking and lootability in civil wars (Berman et. al., 2017). However, the overall effect of irrigation on the likelihood of conflict remains negative and is strengthened relative to the benchmark when heterogenous effects in tribal areas are accounted for.

This paper contributes to the literature on the microeconomics of violent conflict through a detailed investigation of the political economy of Kurdish separatism in Southeastern Turkey. The main mechanism behind the relationship between low income, agricultural shocks, and conflict—the opportunity cost of rebellion—remains poorly understood and largely untested. Broadly, this mechanism holds that an individual's decision to join a rebellion is a function of "whether economic opportunities are so poor that the life of a rebel is attractive to 500 or 2,000 young men" (Fearon and Laitin, 2003: 88). I test this by examining heterogeneity in the relationship between rainfall and agricultural income introduced by a topographically determined irrigation project.

The paper proceeds as follows. Section II conducts an overview of the existing scholarship on relationship between agricultural income and civil conflict. Section III provides background on the Southeastern Anatolia Project, the dynamics of PKK recruitment, and their interconnections. Section IV describes the data, and sections V and VI contain the empirical analysis. The spatially autoregressive instrumental variables approach is conducted in section V, focusing on a cross-section of conflict events spanning 2016-2019. Section VI examines longitudinal trends through the use of dynamic spatial panel models during the 1985-2018 period. Section VII tests the "opportunity cost of rebellion" mechanism in two parts: first, by exploring the relationship between irrigation, agricultural production, and conflict; second, by examining treatment heterogeneity related to extreme land inequality in tribal areas. Section VIII concludes.

II Related Literature: Development, Drought, and Rebellion.

The most well-established mechanism through which economic development affects violent conflict is through the former's effect on the opportunity cost of rebellion (Collier and Hoeffler, 1998). As incomes rise relative to the economic returns to participating in an insurgency, the incentive to join a rebel group diminishes (Grossman, 1991). Dal Bó and Dal Bó (2004) suggest that in a two-sector model of the economy, negative shocks to the labor-intensive (rather than the capital-intensive) sector significantly increase relative returns to joining a rebellion. Droughts have been argued to have a uniquely strong effect in motivating civil conflict due to their negative effect on the availability of essentials such as food and water, and because they disproportionately affect low-income rural communities engaged in labor-intensive agricultural work (Hsiang et. al., 2011; Uexkull, 2014; Couttenier and Sobeyran, 2013; Maystadt and Ecker, 2014).

The provision of irrigation to farmers interacts with both of the mechanisms outlined above by simultaneously increasing rural incomes through crop substitution and by insulating farmers from climactic shocks. Indeed, in studies that use rainfall as an instrument for the effect of agricultural income on civil conflict, irrigation is often cited as a threat to identification, a potential policy solution, and an avenue for further research (Blattman and Miguel, 2010; Miguel et al. 2004; Bohlken and Sergenti, 2010; Harari and LaFerrara, 2018). Despite abundant empirical evidence on the relationship between agricultural income shocks and civil conflict, the role of irrigation as a potential mitigating factor has been largely neglected. One of the only exceptions is Sarsons' (2015) finding that in India, income in districts downstream from dams is much less sensitive to rainfall shocks, but that this has no effect on the incidence of Hindu-Muslim riots. This is largely irrelevant to the mechanisms discussed above, however, as participation in a riot offers no economic benefits. As such, mechanisms involving the opportunity cost of rebellion and agricultural income shocks remain largely untested.

Furthermore, many of the empirical findings linking drought and civil conflict have been either weak or contested. Rainfall is frequently used as an instrument for agricultural income, and the impacts of the former on conflict are consequently treated as causal (Miguel et. al. 2004; Harrari and LaFerrara, 2018). However, rainfall variables likely violate the exclusion restriction, not least through the well-established positive relationship between rainfall and elevation (Song et al., 2019). Figure 1 shows that in Southeastern Anatolia, 88% of the variation in a 5km cell's mean water balance is explained solely by elevation.

High levels of spatial aggregation and resulting bias from within-country heterogeneity in cropping patterns and the spatial distribution of conflict also hamper identification (Ciccone, 2011). As a result, empirical analyses are increasingly being conducted using grid-cells, remote sensing data, and geospatial techniques (Harari and LaFerrara, 2018; Verwimp et. al., 2019).

The present study addresses these theoretical and empirical gaps in the literature on the microeconomics of violent conflict. Empirical analysis is conducted at the level of 10 $\times$ 10 km and 5 $\times$ 5 km grid-cells, using two distinct measures of conflict incidence and a measure of PKK recruitment, an irrigation variable derived from remote sensing, and a rich array of georeferenced political, climactic, and economic covariates. By examining insurgent recruitment in the context of irrigation in Turkey's arid Kurdish region at such a high level of detail, fine-grained tests of the opportunity cost mechanisms of insurgent become possible. This paper makes empricial and theoretical contributions to the expanding literature on the microeconomics of violent conflict, the impact of infrastructural investments on development, and spatial econometrics.

III Background: Kurdish Insurgency and The Southeastern Anatolia Project.

The Southeastern Anatolia Project (Güneydoğu Anadolu Projesi, henceforth GAP), is a regional development program consisting of 22 dams and 19 hydroelectric power plants on the Tigris and Euphrates rivers, as well as 1.8 million hectares of irrigated land (GAP, 2016). The rate of extreme poverty in the nine provinces encompassed by the project is more than five times the national average, with 44% of the population living below the national poverty line of US$1.1/day in 2007 (Fikret, 2016; Saatci and Akpinar, 2007: 632). Nearly two thirds of all economic activity in the region is derived from agriculture, and income gains associated with the transition from rain-fed subsistence agriculture to irrigated cotton cultivation are estimated to range from three- to sevenfold (Bilgen, 2016; Tokdemir et. al., 2016: 2). Exports from Southeastern Anatolia more than quadrupled between 2005 and 2015 (GAP, 2018). There is evidence, however, that the developmental impact of the project has been highly uneven, with income gains tightly confined to irrigated areas, leaving non-irrigated areas virtually unchanged by GAP (Bakirci, 2001). Even within irrigated areas, inequality related to land tenure is significant (Fikret, 2016). Furthermore, flooding caused by the dams has displaced up to 355,000 people and destroyed cultural heritage sites such as Hasankeyf (Varsamidis, 2010).

The economic destitution of Turkey's Kurdish region is an explicit feature in the writings of the PKK's founder, Abdullah Öcalan (2007; 2015). The Marxist ideological character of nearly all 20th-century Kurdish rebel movements is often attributed to the fact that "the Kurdish identity question was expressed in terms of regional economic inequalities and suggested a socialist solution" (Yavuz, 2001: 10). In a study of PKK recruitment, Tezcür (2016) finds an inverse correlation between recruitment and district-level GDP, though he makes no claims to causality. As a "peasant movement", the PKK's main base of support is among the rural farming villages in Southeastern Anatolia and nearby mountainous regions

(Yarkin, 2015: 31). Ethnographic studies conducted in newly irrigated areas in Southeastern Anatolia found a "heightened sense of state legitimacy as a function of irrigation access"; in the words of one farmer, "our view of the state changed positively... we had hatred before, but now they started investing in the Southeast" (Harris, 2016: 9). Another farmer stated, "We did not trust the state before, but it brought electricity, water, phone, etc. to us and now we trust the state a lot" (Harris, 2009: 11). Conversely, one farmer—frustrated that his village had not received irrigation—asked, "Why should I not support Öcalan?" (Harris, 2006: 193).

There was an explicit expectation among Turkish policymakers that "GAP will help to decrease, if not eliminate, the appeal of the PKK" (Jongerden, 2010: 137; Olson, 1996: 96). A leaked U.S. intelligence cable paraphrases then-President Abdullah Gül as saying "If Kurds are gainfully employed, have better educational opportunities, and see increased levels of infrastructure development throughout their region, their affinity for the terrorist PKK will wane further. A top priority is ensuring completion of the massive Southeastern Anatolia Project (GAP) within five years." (Wikileaks, 2008b).

IV Data

I constructed a dataset spanning a comprehensive array of political, economic, and climactic variables for Southeastern Anatolia. All variables are georeferenced, enabling analysis at multiple spatial scales and the use of highly disaggregated geographic units. Variables are derived from remote sensing, web scraping, and existing datasets used widely in the literature.

The primary explanatory variable in this analysis is the expansion of irrigated agricultural land, which is gauged using remote sensing. Because of overlapping growth schedules, the crop cycle in Southeastern Anatolia only supports the planting of one crop per year in a given field (Ozdogan et. al, 2002). Cotton, which accounts for 96% of irrigated crops in the region, is grown in the mid-to-late summer and harvested in early October (Unlu, 2007). Thus, if green vegetation is observed in July or August, it is almost certainly irrigated agriculture, and as such "there is overwhelming consensus on the efficiency of vegetation indices such as the NDVI in identifying irrigated fields" in Southeastern Anatolia (Ozdogan 2006). 32-day composite NDVI images were sourced for July and August from NASA's LANDSAT satellites, from 1985 to 2019. A minimum NDVI cutoff filters out wild vegetation. Figure 2 compares an unprocessed satellite image of the district of Suruç to a processed image, highlighting the extent of irrigation. Three distinct measures of irrigation are derived from the NDVI data. The first measure denotes the percent of a grid-cell that is under irrigation in a given year. The second is a binary variable indicating the onset of irrigation, moving from 0 to 1 when a grid-cell is more than 20% irrigated. The third denotes the number of years since irrigation was first introduced. A comparison of these three measures for a sample district is shown in Figure 3.

Conflict variables are derived from two main sources. Panel data on conflict were compiled from the Uppsala Conflict Data Program, one of the most widely used conflict datasets. The main conflict variable used herein is a binary measure of whether fighting occurred involving the PKK in a cell in a given year, spanning from 1989 to 2019. The frequency of clashes over time is shown in Figure 4. This includes PKK attacks on Turkish Armed Forces (TSK) and civilians, as well as TSK raids on PKK positions. For added robustness, conflict data were also compiled from the Armed Conflict Location and Event Data project (ACLED). ACLED data contain more detail than the UCDP data, but only go as far back as 2016 for Turkey. As such, the ACLED data were pooled across three years (2016-2019) to create a cross-sectional variable denoting the spatial distribution of conflict events in the recent flare-up of fighting between the PKK and the government. Figure 5 shows the geographic distribution of conflict events from both datasets at the 10 km grid-cell level, showing a high density of clashes in the Eastern portion of the study area.

In addition to looking at conflict incidence from two different sources, data on PKK recruitment are also used to provide an even more detailed investigation of conflict channels.

Data on PKK recruitment was obtained from Tezcür (2016). Each observation includes the year and location of an individual's recruitment to the PKK. The dataset was compiled from PKK obituaries listed in two online magazines (Serxwebûn and Berxwedan) published by the PKK since 1982. Each obituary contains biographical information on the recruit including name, gender, as well as locations and dates of birth, death, and recruitment. Many even include a recruit's previous occupation, their parents' occupation, and whether they had relatives who had joined previously. There are data on 8,266 recruits in total—though the present analysis uses a subsample of 2,678 who were born and recruited in the study area—between 1985 and 2012. The dataset as a whole comprises roughly 41% of known militants based on numbers reported by both the PKK and a Turkish Parliamentary commission (Tezcür, 2016). In contrast to the vast majority of empirical analyses on conflict and development that utilize conflict incidence as a proxy for recruitment, these data contain the actual dates and geographic coordinates of recruitment, allowing for an unusually detailed investigation of individual motivations for joining a rebellion.

A key feature of the political economy of rural Southeasten Anatolia is the prevalence of Kurdish tribes (aşiretler). A subgroup of these tribes—mainly those that practice Sunni Islam, speak Kurmancî, and have become involved in right-wing politics—were armed by the Turkish state to form paramilitary "village guards" (köy koruçuluğu) to fight the PKK (Guida, 2014). On the other hand, a significant number of tribes—mainly those that practiced Alevi Islam, spoke Zazaki, and had become involved in socialist politics during the 20th century— have historically been at the helm of the Kurdish struggle for autonomy (Yavuz, 2001). Furthermore, accounting for aşiret control is important because land tenure is often characterized as "feudal" in tribal areas, likely tempering the positive income effect of irrigation wrought by the Southeastern Anatolia Project (Öktem, 2014: 180).

The quantitative identification of tribal regions of Turkey relies on their practice of "combined voting" (birleşik oy), whereby "many villages vote en masse—usually without making a single deviance—for the party chosen by the chieftain" (Guida, 2014: 176). Scans of individual ballot box receipts are available on the Turkish Supreme Elections Board (YSK) website for all elections since 2009. Web scraping was used to access data from a total of 2.9 million ballot boxes spanning 20 elections at various levels (municipal, provincial, presidential, and parliamentary). The spatial distribution of ballot box-level election results for the whole of Turkey is shown in Figure 6, with a pane magnifying central Diyarbakir. Ballot boxes in which one party or candidate received over 95% of the vote were reclassified into separate dummy variables with 1 denoting bloc voting for a given party. The number of instances of bloc voting in each district or grid-cell was divided by the total number of ballot boxes therein, yielding a measure of the proportion of likely tribally administered villages in each area. 3,840 instances of birleşik oy were encountered (1564 for the HDP, 2276 for the AKP), constituting 5.36% of the total sample. This is consistent with survey findings by Akşit and Akçay (1997), who found that 4.3% of the 187 villages in their survey sample were under aşiret control.

In addition to the variables on tribal control, several additional variables were derived from ballot-box data. The respective vote shares of the AKP or HDP across all elections are measured to provide a sense of the overall political leanings of a given area. Finally, the log number of voters registered at each ballot box is used as a highly detailed proxy for population density.

Climactic variables were constructed using monthly rainfall and temperature values from the University of Idaho's TerraClimate dataset. These values are used to compute the Standardized Precipitation-Evapotranspiration Index (SPEI), which unlike conventionally- used drought indices, such as the Standardized Precipitation Index (SPI) or the Palmer Drought Severity Index (PDSI), integrates not only rainfall but temperature into its calculation. Harrari and La Ferrara (2018) note that while the conflict literature tends to consider the effects of either temperature or rainfall, SPEI allows for their joint effect to be estimated. The calculation of SPEI begins with the computation of the water balance, or the difference between rainfall and potential evapotranspiration. These values are standardized by cell such that the resulting value is expressed in terms of standard deviations from the cell's historical average. The main climactic variables used herein are an annual measure of SPEI, and the water balance.

To avoid neglecting the urban dimension of the conflict, nighttime lights data are used to capture cell-level information on urbanization and economic development. Nighttime lights data were collected from the Defense Meteorological Satellite Program (DMSP), and reflect the average radiance displayed by a cell in a given year. The difference in nighttime lights between 1992 and 2014 is used as a rough proxy for development at the cell level. As cities expand, highways are built, and villages receive electricity for the first time, their nighttime lights signature increases (Bruederle and Hodler, 2018). The maximum observed nightlights value in a given cell is also used to distinguish between urban, sub-urban, and rural areas.

Further time invariant cell-level covariates include elevation, slope, a binary indicator of whether a cell is on the southern border, and kilometers of roads. Finally, two longitudinal dummy variables control for different phases in the conflict; the first indicates whether or not a given year was in a period of ceasefire, and the other indicates the onset of the Syrian civil war. The former accounts for low levels of conflict resulting from armistice agreements, while the latter controls for possible cross-border spillovers from the Syrian civil war owing to the relationship between the PKK and Syrian Kurdish rebel groups such as the YPG. Summary statistics for all variables at the 5km and 10km level are reported in Table 1. The raw, unaggregated geospatial data for several key variables defined above are visualized in the interactive online tool.

V Cross-Sectional Instrumental Variables Approach

Exploiting exogenous topographic variation in the placement of irrigation schemes, this section examines the cross-sectional relationship between irrigation and conflict in Southeastern Anatolia. Employing a spatially autoregressive instrumental variables approach conducted at the level of 5km grid-cells, I show a persistent negative relationship between a cell's irrigated area and the likelihood of conflict incidence.

Following the breakdown of a 2013-2015 truce, hostilities between the PKK and the Turkish government have intensified almost to the level of the conflict's peak in 1994. This new wave of fighting provides an opportunity for a detailed investigation of the spatial relationship between irrigation and conflict. The confluence of high levels of both irrigation and conflict during the 2016-2019 period allows for an assessment of whether the resurgence of violence in Southeastern Anatolia systematically avoids irrigation schemes. Using three years' worth of conflict incidence data from the Armed Conflict Location and Event Dataset, I first estimate a cross-sectional instrumental variables model is estimated at the level of 5km by 5km grid-cells. Similar to Duflo and Pande (2007), who use river gradients as an instrument to assess the impact of dam construction on poverty in India, this approach exploits exogenous geographic variation in the placement of irrigation schemes.

Identification relies on two geographic constraints faced by gravity-fed irrigation schemes: they must be relatively low (below the altitude of distributary dams), and relatively flat to avoid runoff. Identifying irrigation schemes purely on the basis of elevation is complicated by the fact that dams in the region are built at different elevations. Similarly, the presence of flat high pastures prevents the precise identification of irrigation using only slope data. As such, the instrument used herein is defined as the log product of elevation and slope. The interaction of these terms highlights areas that are both relatively low and flat. Figure 7 compares the spatial distribution of the terrain instrument and the irrigation variable at the level of 5km grid-cells, showing a high degree of similarity. Equation (1) below specifies the general two stage instrumental variables strategy:

$$\begin{aligned} Irr_i =& \gamma_0 + \gamma_1 Z_i + \gamma_2 X_i + \epsilon \\ Y_i =& \beta_0 + \pi_1 \overline{Irr}_i + \beta_1 X_i + u \end{aligned} \tag{1}$$

Where Irr_i is an endogenous variable denoting the log area under irrigation in grid cell i, Z_i is the terrain instrument, X_i is a matrix of covariates, and Y_i is the dependent variable denoting conflict incidence.

The exclusion restriction assumes that topography only affects conflict by determining geographic eligibility for irrigation. This is likely violated in the full sample: many PKK training camps and bases are located in mountainous regions that are inaccessible to Turkish ground forces (Olson, 1997). As such, there is likely to be a positive relationship between topography and conflict incidence for reasons unrelated to irrigation. However, this is only true for extremely rugged areas, as the strategic benefit of placing bases in the mountains is only incurred if the terrain effectively precludes vehicular access meaning that the exclusion restriction plausibly holds for non-mountainous areas. Mountains are clearly identifiable in right tail of the elevation histogram of Southeastern Anatolia presented in Figure 8. The solid line represents an altitude cutoff at 1200 meters that excludes mountainous grid-cells. The dotted line shows a more aggressive altitude cutoff at 1000 meters that even begins to exclude agricultural land.

Equation (1) is estimated as a two-stage probit model in columns 1-3 of Table 2, and as a linear probability model via 2SLS in columns 4-6. Columns 1 and 4 use the full sample, columns 2 and 5 restrict the sample to observations below 1200 meters, and columns 3 and 6 further restrict the elevation cutoff to 1000 meters. The Kleibergen-Paap F statistic is 1697 for the full sample and 1743 for the maximum geographic restriction, suggesting that the instrument is not weak.

Table 2 indicates a consistent negative relationship between irrigation and conflict incidence in the 2016-2019 period. This effect persists across model specifications and geographic restrictions. The magnitude, direction, and significance of the coefficients is not substantively different between the probit model and the linear probability model.

However, due to the 5km resolution of the grid, spatial autocorrelation must be accounted for. The structure of spatial dependence is modeled using a spatial weighting matrix$W$ The benchmark W is a binary contiguity matrix which assigns a value of 1 to the eight cells directly bordering the cell of interest, and 0 to all others. The spatial lag of a variable X for cell c is denoted as $X_c \times W$ and is equal to the average value of X in the eight cells neighbouring c. For robustness, a spatial weighting matrix denoting the inverse distance from cell c is also used. Figure 9 shows the effect of spatially lagging the irrigation variable using contiguity and inverse-distance weighting matrices. Equation (2) augments the instrumental variables model by adding three spatially autoregressive terms:

$$\begin{aligned} Y_i =& \beta_0 + \pi_1 \overline{Irr}_i + \beta_1 X_i + \theta_1 W X_i + \lambda_1 W Y_i + u \\ u =& \rho W u + \epsilon \end{aligned} \tag{2}$$

WY_i is a spatial lag of the dependent variable, WX_i is a spatial lag of the independent variables, and u is a spatially autoregressive error term. The result is a Spatially Autoregressive Instrumental Variables (SAR-IV) model.

Columns 1-4 in Table 3 report the results of equation (2) where W is a binary contiguity spatial weights matrix, while columns 5-8 use an inverse distance matrix. All columns employ the most extreme geographic restriction (¡1000 meters). The dependent variable in columns 1 and 5 is general conflict incidence. Subsequent columns disaggregate conflict into its components: columns 2 and 6 use the incidence of PKK attacks as the dependent variable, columns 3 and 7 focus on military raids, and columns 4 and 8 use protest incidence. The same set of time invariant cell-level control variables used in the panel models is included but values are calculated at the 5km level. Two additional control variables are specified: historical water stress is measured as the cell-level mean of the rainfall variable, and temporal persistence of conflict is accounted for by taking the sum of pre-2000 clashes using the UCDP conflict data.

The results are instructive. Table 3 displays a consistent negative relationship between irrigation and conflict incidence regardless of whether spatial dependence is assumed to be confined to neighbouring cells, or to decrease linearly with distance. Though the overall effect of irrigation across all types of violent conflict is negative, there is heterogeneity in the strength and significance thereof.

Columns 1 and 4 indicate that irrigation strongly decreases the likelihood of experiencing a conflict event. Column 1 indicates that a fully irrigated 25 km^2 grid-cell is 58% less likely than the average cell to experience a conflict event involving Kurdish rebels during the 2016-2019 period. Disaggregating conflict shows that this effect is primarily driven by a negative relationship between irrigation and military raids. These "counter-terror operations" are typically carried out in villages that are believed to be materially supporting the PKK by harboring militants, serving as weapons caches, or producing improvised explosive devices. Columns 2 and 5 suggest that the relationship between irrigation and the likelihood of experiencing a PKK attack is much weaker.

The locations of military raids are a better proxy for popular support of the Kurdish insurgency than the locations of PKK attacks; the safehouses and weapons caches targeted by these raids are unlikely to placed in villages where guerillas do not feel they have the trust of the local population. The link between popular support for the PKK and the latter's choice of targets is less clear. On the one hand, opportunistic attacks against local security forces or police officers would likely be higher in areas with more militants. On the other hand, rebels probably do not carry out offensive attacks against the villages that support them—if anything, the opposite is likely to be true. Indeed, column 7 shows that military raids are less likely to occur in areas that consistently vote for the ruling AKP, while column 8 shows an insignificant but positive relationship between AKP vote share and the likelihood of experiencing a PKK attack. Thus, if irrigation erodes popular support for the PKK, this would be most visible through the former's effect on military raids. To illustrate this point, Table 4 contrasts the qualitative descriptions of sample PKK attacks and military raids drawn from the ACLED dataset.

The coefficients of the control variables further contextualize these results. There are strong indications that the resurgence of conflict in the lowlands of Southeastern Anatolia is largely taking place in inhabited areas rather than isolated hideouts and bases. Population, nighttime luminosity, and road cover are positively correlated with all types of conflict across all models. However, despite the strong positive relationship between overall luminosity and conflict, areas that experienced the greatest growth in nightlights are significantly less likely to experience conflict of any kind. Nightlights growth is strongest in rural villages that have received electricity for the first time (much of which is derived from hydropower), peri-urban areas on the outskirts of growing cities, and areas that have received substantial infrastructural investments such as roads and highways. This trend provides further contextual evidence that areas that have benefitted most from state-led development policies display lower levels of anti-government militancy. The fact that irrigation remains significant despite controlling for general economic development suggests that the latter's influence on conflict is not purely economic. It also further rules out omitted variable bias related to the potential endogeneity of infrastructural investments by accounting for uneven development across the region.

Conflict continues to display spatial and temporal dependence. The number of violent clashes experienced by a grid cell before the first ceasefire in 2000 is a consistently strong predictor of conflict in the current period. The spatially lagged dependent variable provides an insight into the nature of conflict spillovers in the region. Columns 1-3 indicate that the likelihood of experiencing conflict in a given cell is substantially increased if any of the neighbouring cells have experienced a conflict event. This is true for all types of conflict. When an inverse distance matrix is employed WY becomes insignificant, suggesting that conflict spillovers are highly local.

To summarize, exploiting exogenous geographic variation in the placement of irrigation schemes, this section finds that the resurgence of violence in Southeastern Anatolia between 2016 and 2019 is systematically lower in irrigated areas. This effect is robust to the inclusion of a wide array of control variables, aggressive geographic restrictions, and the inclusion of contiguous and inverse distance spatial spillover effects. Irrigation most strongly affects the likelihood of experiencing a military raid, which, in turn, acts as a proxy for popular support of the PKK; this is because raids are typically carried out against villages that are believed to be materially supporting the rebels.

VI Dynamic Spatial Panel Models

This section examines the longitudinal relationship between irrigation and Kurdish separatist conflict in Southeastern Turkey, using two sets of panel models. The first is estimated via OLS with standard errors corrected for spatial and serial correlation (Hsiang, 2010), and the second is a spatial Durbin model. The guiding question in this instance is whether separatism decreases in a given area decrease following the introduction of irrigation.

Analysis is conducted at the level of 10km by 10km grid cells. At higher resolutions, conflict events become too rare to be estimated consistently in the panel models. Conversely, decreasing the resolution of the cells hampers the precise delineation between irrigated and non-irrigated areas. The main dependent variable is a binary indicator of PKK-involved conflict incidence derived from the UCDP dataset. The primary explanatory variable is a binary measure indicating the onset of irrigation.

For a panel of N cells and t years, Irr denotes the irrigation variable, X a vector time-invariant controls, and L a vector of time-varying controls. Fixed effects for year and district are represented by γ and μ, respectively, and a linear time trend is denoted by τ:

$$Y_{c,i,t} = \beta_0 + \beta_1 Irr_{c,t} + \beta_2 X_c + \beta_3 L_t + \gamma_t + \mu_i \tau_c + \epsilon_{c,i,t} \tag{3}$$

A linear probability model is estimated via OLS, using panel-adjusted Conley (1999) standard errors developed by Hsiang (2010), thereby accounting for both spatial and serial correlation.

Duflo and Pande (2007: 3) outline several concerns related to the endogeneity of infrastructural investments, specifically related to dam construction and irrigation. Key among these is the fact that the provinces that are chosen for dam construction projects are often targeted for political and economic reasons including potential agricultural productivity or the political clout of local governments.

As such, all analysis is restricted to observations within the nine provinces that were selected for the Southeastern Anatolia Project. While the selection of these provinces was very likely endogenous, the first stage IV results from the previous section suggest that the distribution of gravity-fed irrigation schemes within this area was largely determined by topographical factors. The use of a 10km grid further allays these concerns; though it is plausible that even the districts within these nine provinces were also endogenously selected for treatment, the feasibility of such targeting (both administratively and practically) at the level of 10km grid cells is low. Nevertheless, the benchmark specification excludes all grid-cells that never receive irrigation.

Several complexities in the dynamics of conflict remain to be accounted for. Harari and La Ferrara (2019) note that the spatial dependence of conflict can be disaggregated into two main categories: autocorrelation in conflict determinants, and direct spillovers from fighting into neighbouring areas. Furthermore, they expect conflict to exhibit strong serial correlation.

To model spatial and temporal dependence, a dynamic, spatially autoregressive Durbin model (SDM) is estimated using maximum likelihood.

$$\begin{aligned} Y_{c,i,t} = & \beta_0 + \beta_1 Irr_{c,t} + \beta_2 X_c + \beta_3 L_t + Y_{c,i,t-1} \\ & + \rho W + \theta_1 Irr_{c,t} \times W + \theta_2 X_c \times w + \beta_3 L_t + \gamma_t + \mu_i \tau_c + \epsilon_{c,i,t} \end{aligned} \tag{4}$$

The temporal persistence of conflict is integrated into the model with the addition of a one-year lag of the dependent variable. The addition of spatially lagged independent variables accounts for autocorrelation in conflict determinants, while the spatial lag of the dependent variable captures variation in conflict incidence owing to direct contagion.

The selection of fixed effects is informed by the inclusion of a comprehensive array of time-invariant cell-level characteristics including elevation, slope, distance to the border, population, nighttime lights, historical party vote shares, tribal control, and road cover. Combined with the already narrow geographic focus of the study area, these variables either directly or indirectly control for many of the innate political, economic, ethnic, and geographic differences between cells. As such, the main threat posed by omitted variables relates to time-varying trends in the political and -economic history of the region. These include elections at all levels, which likely affected the intensity of the government's approach to both infrastructural investment and Kurdish separatism. Year fixed effects control for national-level shocks. Year and district-year fixed effects control for national- and local-level shocks, respectively. Another is forced displacement: many areas experienced long-term outmigration as a result of climate shocks, conflict, or poverty. District- and cell-level linear time trends control for these unobserved phenomena.

VI.a Results

Table 5 reports the results from equations 3 and 4. Columns 1 and 2 employ the full sample of observations, while columns 3 and 4 restrict the sample to only include areas that receive irrigation at some point during the study period. Columns 1 and 3 are estimated using a panel OLS model with standard errors corrected for serial and spatial autocorrelation (Hsiang, 2010). Results in columns 2 and 4 correspond to spatial Durbin Models estimated via Maximum Likelihood, using a binary contiguity spatial weighting matrix.

As the results show, there is a strong negative relationship between the onset of irrigation and the likelihood of experiencing conflict in a given cell-year across all models. Results derived from the full sample of observations suggest that the introduction of irrigation reduces conflict likelihood by between 1.2% and 1.9%. Though this effect may appear small, it corresponds to between 37% and 58% of the unconditional mean of the dependent variable.

However, results derived from the full sample are potentially driven by endogeneity in the selection of irrigation schemes. This is partially mitigated through the inclusion of a fixed effect for the "treatment" group which denotes that a cell received irrigation at some point during the study period, accounting for innate differences between areas that were selected for irrigation and areas that were not. For added robustness, columns 3 and 4 omit all cells that never receive irrigation. The negative effect of irrigation on conflict incidence not only survives the sample restriction, it is slightly strengthened.

Results are also robust to the inclusion of a detailed array of control variables, fixed effects, and model specifications. The dynamic spatial Durbin models include a one year lag of the dependent variable, which shows that conflict in the previous year significantly increases the likelihood of experiencing conflict in the following year. Restricting the sample to only include irrigated areas does not substantially affect the association between irrigation and conflict, the coefficients of several control variables are affected. Covariates associated with urban land cover are particularly affected; in the full sample, these is a strong positive association between conflict and both population and road cover. When the sample is restricted to irrigated cells, both of these relationships become insignificant. This likely results from the omission of most large cities in columns 3 and 4. Interestingly, the ceasefire variable follows the same pattern, suggesting that the 2001-2013 truce saw a decrease in urban clashes, but not in rural fighting. Finally, restricting the sample to irrigated areas has a strong effect on the association between conflict and tribal voting behaviour. In the full sample Durbin model (column 2) there is a significant negative relationship between the two, while in the restricted sample Durbin model (column 4), a strong positive relationship emerges. This result is explored in detail in section VII.

VII Robustness to Alternate Measures

Results from the panel models are robust to a number of alternative specifications of both the dependent and independent variables. This section explores various modifications of the benchmark model presented in column 4 of Table 5 above. This baseline specification is a spatial Durbin model restricted to irrigated areas, employing a binary contiguity weighting matrix, year fixed effects and a district-level linear time trend, a full set of covariates, and a one-year lag of the dependent variable. Table 6 reports the results of these alternative specifications.

Alternative measure of conflict.—The dependent variable in columns 1 and 2 is the UCDP conflict incidence measure. However, it is substituted in columns 3 and 4 for an obituary-derived measure of PKK recruitment developed by Tezcür (2016). This measure is also binary and denotes the year and location of an individual's recruitment to the PKK. As previously explored, clashes (and particularly military raids) primarily take place in villages that are perceived to be materially supporting the PKK. Measuring recruitment is a more direct way of assessing an area's support for the PKK, though there are potential biases posed by the fact that the measure is derived from PKK-reported obituaries.

Alternative measures of irrigation.—Instead of the binary irrigation onset variable, two additional measures of irrigation are employed. Columns 2 and 4 use irrigated area as the treatment variable, which represents the number of square kilometers of the grid cell under irrigation in a given year. Figure 3 shows that irrigated area varies both cross-sectionally, as some grid cells become more irrigated than others, and longitudinally as irrigation is phased in over time. Both of these sources of variation allow for an examination of whether treatment intensity affects conflict.

The effect of irrigated area on conflict incidence is reported in column 2. In 2019, the average irrigated grid cell contained 27 km^2 of irrigated cropland, representing roughly a quarter of its total area. Though the marginal effect of each additional square kilometer of irrigated cropland on the likelihood of conflict incidence is small, the cumulative effect is considerable. A 27 km^2 increase in irrigated area leads to a 0.91% decrease in the likelihood of conflict incidence. Given that the average likelihood of experiencing a conflict event in a given cell-year is 1.8%, this effect is equivalent to nearly 50% of the unconditional mean of the dependent variable. In other words, receiving the average quantity of irrigation over the whole study period decreases the likelihood of experiencing a conflict event by roughly half.

Column 4 reports the effect of irrigated area on PKK recruitment, which yields similar results. A 27 km^2 increase in irrigated area leads to a 0.62% decrease in the likelihood of PKK recruitment, equivalent to 39% of the latter's unconditional mean. A cell in the top quartile of irrigated area (receiving 38 km^2 of irrigation over the whole period) would experience a 56% decrease in the relative likelihood of experiencing a recruitment event, and a 69% decrease in the likelihood of conflict incidence. These results suggest that greater treatment intensity leads to greater reductions in the likelihood of experiencing conflict and recruitment events.

The treatment variable in columns 1 and 3 is a measure of the number of years that have elapsed since the introduction of irrigation. Unlike irrigated area, this variable does not vary cross-sectionally and isolates longitudinal treatment intensity. Though there is a significant effect on both conflict incidence and recruitment, the effect on the latter is smaller. This might reflect the different time periods covered by each model; the recruitment data spans from 1985-2012, while the UCDP data covers 1989-2018.

These alternative specifications also shed light on the relationship between conflict and some of the covariates. There a strong negative relationship between historical electoral support for the AKP and PKK recruitment, and a consistent positive relationship between HDP support and conflict incidence. Tribal voting behaviour is strongly correlated to both conflict incidence and PKK recruitment.

These results indicate a consistent negative relationship between irrigation and Kurdish separatism in Southeastern Turkey which is robust to the inclusion of a highly detailed array of control variables, fixed effects, time trends, and spatial and temporal dependence structures add further validity. This relationship persists whether irrigation is measured as a binary phenomenon with a before and after period, as the number of square kilometers under irrigation in a cell-year, or as the number of years since its onset. It also persists whether Kurdish separatism is measured as conflict incidence or PKK recruitment.

VIII Mechanisms

Both cross-sectional and panel models indicate a persistent negative relationship between irrigation and conflict incidence in Southeastern Anatolia. This section examines the possible mechanisms underlying this relationship. I first explore the relationship between irrigation, agricultural production, and conflict via district-level fixed-effect panel models. I find that irrigation decouples crop yields from rainfall, and that there is a positive relationship between conflict and the cultivation of rainfall-sensitive wheat. This suggests that irrigation Next, I examine heterogeneity in the treatment effect related to tribalism. I find that irrigation actually increases the likelihood of conflict incidence in tribal areas due to violent competition between tribes over scarce irrigation water. The negative effect of irrigation on conflict not only persists, but is strengthened when accounting for heterogenous effects in tribal areas.

VIII.a Agricultural Income

The dominant mechanism linking agricultural income and conflict in the literature is the opportunity cost of rebellion (Collier and Hoeffler, 1998). Low agricultural income levels and negative income shocks decrease the opportunity cost of joining an insurgency (Blattman and Miguel, 2010). Writing before the onset of large-scale irrigation, White (1998: 148) notes that "most of the economically active Kurds in the Kurdish region's agricultural sector are very poor—often destitute—sharecroppers. In virtually none of these cases do these Kurds have adequate savings to insulate them from further adversity during harder economic times". As such, the opportunity cost of joining the PKK is likely to be very low for rainfall-dependent farmers, and perhaps even negative in times of severe drought. Irrigation likely increases the opportunity cost of rebellion by generating two positive income effects: allowing farmers to grow higher value crops and insulating farmers from rainfall shocks. This section examines the relationship between irrigation, cropping patterns, and conflict in greater detail using district-level crop production data. Figure 10 shows the composition of the crop mix of Southeastern Anatolia between 2004 and 2019. Five crops—wheat, barley, cotton, lentils, and hazelnuts—account for over 95% of the cultivated land in the region. Wheat is by far the dominant crop, making up over half of the total sown area in most years. The introduction of irrigation is often followed by a drastic shift in the crop mix in favor of higher-value cotton. Figure 11 plots the relative proportions of crops grown in the district of Suruç over time. The primary crops were barley and wheat until the onset of irrigation in 2015, which led to a dramatic shift towards cotton production. In 2019, the price per kilogram of cotton (3.2) was nearly triple that of barley and wheat (1.2), despite relatively similar yields (TUIK, 2020). Thus, the transition to irrigated agriculture likely generates significant income gains through crop substitution.

Irrigation in Southeastern Anatolia also effectively insulates farmers from income shocks associated with rainfall deficits. In 2008, Southeastern Anatolia suffered a severe drought, with the average water balance 24% below the mean. The impact thereof on crop yields is visible in Figure 12. The yields for all crops other than cotton were between 54% and 61% lower than average. Yet despite having the highest water requirement out of the crops shown in Figure 10, cotton saw the smallest decline in yields.

To investigate this formally, I estimate district-level fixed effect panel models estimating the effect of rainfall and irrigation on crop yields in Southeastern Anatolia between 2004 and 2018. The results are reported in Table 7. There is a strong positive relationship between rainfall and yields for all crops except cotton, confirming the trend observable in Figure 10. Yields for barley, lentils, and hazelnuts are unaffected by the proportion of a district under irrigation. However, a 10% increase in district-level irrigation is associated with a

64kg/decare increase in wheat production and a 31kg/decare increase in cotton production. The fact that wheat is both highly sensitive to rainfall but also more productive in districts with irrigation suggests that the majority of wheat is rain-fed, but a small proportion thereof is irrigated. If the proportion of irrigated wheat were high, we would expect yields to be largely independent of rainfall, as is the case for cotton.

In Table 8 I examine the relationship between crop production statistics and conflict at the district level. The production statistics consist of a one-year lag of the yield and sown area of a given crop in a given district. There is a significant negative relationship between wheat yields and conflict incidence, suggesting that the risk of conflict is higher following a poor wheat harvest. There is also a significant positive relationship between the sown area of wheat and conflict incidence, suggesting that districts that are highly reliant on this rainfall-sensitive crop are also more conflict-prone. Both of these results are highly consistent with the mechanism that agricultural income shocks decrease the opportunity cost of rebellion. Though we might expect a negative relationship between yields and conflict for all rain-fed crops, the effect is only observable for wheat because it accounts for over 50% of the cultivated land in the region.

In the context of extreme poverty, low savings rates, and widespread subsistence agriculture, the opportunity cost of joining the PKK is likely to be very low particularly during times of economic hardship. The relationship between conflict and agricultural production suggests that economic precarity plays a role in Kurdish separatism: clashes are more frequent in districts reliant on rain-sensitive wheat, particularly following a poor wheat harvest. The introduction of irrigation is often accompanied by a shift in production to higher value crops such as cotton, and the decoupling of crop yields from rainfall. In conjunction, these dynamics suggest that the effect of irrigation on agricultural production and income is an important mediating factor in the relationship between irrigation and Kurdish separatism.

VIII.b Tribal Treatment Heterogeneity

The previous section has identified the incomes generated by irrigation as one of the likely mechanisms linking irrigation and conflict. However, the distribution of these incomes is unlikely to be homogenous across the study area, particularly given the prevalence of tribal social structures which have been described as "feudal" (Aksit and Akcay, 1997). This section explores heterogeneity in the treatment effect related to tribal social structures.

The Turkish (and before it, Ottoman) government has relied on tribal chieftains to rule Southeastern Anatolia; these local elites were allowed to maintain power and collect rents from their territory on the condition that they align themselves with the government (Guida, 2014: 178). The most significant recent iteration of this phenomenon was the formation of the "Village Guard" [koy koruculugu] system in 1985, through which the government selectively armed loyalist tribes as a paramilitary force to fight the PKK (ibid). At the height of the conflict there were 95,000 village guards, equivalent to nearly half the number of total active military personnel in the entire Turkish Armed Forces (Oktem, 2014; TSK, 2014). The spatial distribution of ballot boxes displaying tribal bloc voting is shown in Figure 13.

Thus, an alternative explanation for the reduction in Kurdish separatism following the introduction of irrigation could be the government's use of irrigation to co-opt tribal chieftains. A stronger treatment effect in tribal areas would support this mechanism. On the other hand, a diminished treatment effect in tribal areas would strengthen the opportunity cost of rebellion mechanism; because the distribution of land in tribal areas is highly unequal, income gains associated with irrigation are unlikely to directly benefit farmers.

To explore treatment heterogeneity related to tribalism, the benchmark spatial Durbin Model (Table 5, column 4) is estimated with the addition of interactions between the irrigation variable and indicators of tribal voting behaviour. The results of these specifications are reported in Table 9. Column 1 adds an interaction between the treatment variable and the total proportion of ballot boxes displaying tribal bloc voting in a given grid-cell to the benchmark SDM. The coefficient on this interaction is both highly significant and positive, suggesting that conflict likelihood actually increases when irrigation is introduced into tribal areas. Columns 2 and 3 disaggregate the tribal indicator, isolating bloc voting for the AKP and HDP, thereby accounting for the political alignment of tribes. The interaction term is positive and significant when AKP aligned tribes are isolated, but not HDP aligned tribes. This trend persists in column 4 when both disaggregated interaction terms are included. In all cases, accounting for heterogenous treatment effects in tribal areas actually strengthens the main treatment effect relative to the benchmark. These counterintuitive results highlight an important facet of the political economy of violence in Southeastern Anatolia: tribal competition over scarce resources.

The effect of selective government support and co-optation of Kurdish tribes, especially during the civil war, was the militarization of "blood feuds" [kan davalari] between tribes. Ozcan (2006: 5) notes that "the tribal phenomenon helps to explain the sense of disunity among Kurds, the absence of accord, and the pitilessness of internal clashes". Akpolat (2009: 423) conducted fieldwork on one such feud which left 44 men, women, and children dead in (heavily irrigated) Mardin province, and found that the cause of these feuds is "the struggle over ownership of the primary means of production in this area: land, livestock, and water". This struggle over the means of production occurs in what has been described as an "anarchic" environment, where the citizenry—particularly the paramilitary Village Guards— is more heavily armed than the Jandarma and the local police (Criss, 1995). Because irrigation schemes sometimes cover hundreds of thousands of hectares, they often encompass the territories of several tribes. Thus, when irrigation water is rotated from villages in one tribe's territory to another, this too can become a potential site of conflict.

Local news reports have covered "blood feuds" over access to irrigation in Silvan, Sirnak, Sanliurfa, Kisehir and beyond (Hurriyet, 2007; Karar, 2019). Mahmut Tezcan (1981: 64), an anthropologist studying these feuds at Anakara University, provides a detailed account of an irrigation-induced blood feud in Kirsehir that decimated several generations from two clans:

"Cuhadar Gedik's father used to fight with Necip Aslan about water. 'you are going to irrigate now? No, I am going to irrigate now!' and so on. They fight, and Cuhadar's father shoots four of Necip's relatives and a bystander. Then one of their fathers shoots back and injures him. He shoots the brother of the man whose father attacked him. Then his father shoots back. Cuhadar's grandmother is hit in the crossfire and dies. [...] Cuhadar goes to some relatives who he saw shooting guns at a wedding in 1966 and borrows a gun. Then he goes to get coffee. Necip's brother is also there. They fight and pull guns on each other. Mehmet Aslan gets shot in the arm. he dies a while afterwards. Cuhadar is 14 years old. he goes to jail for 19 years. While he is in jail, Cuhadar's aunt is killed."

This type of local cleavage between tribes resulting from competition over irrigation water was exploited by the government and turned into a new front in the battle against the PKK. One article in a national newspaper reads:

"In the village of Otlubayir in Agri province, Muhtar [village head] Vehbi Aksoy and his relatives began a feud with Nihat Aslan, a Village Guard, over the issue of irrigation water. Village Guard Aslan fired on the Muhtar and his relatives with an automatic Kalashnikov rifle. Muhtar Aksoy and his nephews Serkan, Sinan, Hakan, and Vahit were killed, and three others were injured". (Hurriyet, 2010)

The Kalashnikov in question was given to Aslan by the government to aid in the fight against the PKK but it was used in a feud over irrigation water. The guerrillas also frequently get involved in these feuds, as they did in Şirnak, when a bus carrying 12 Village Guards to the construction site of an irrigation scheme was ambushed by the PKK, killing all passengers (CNN Turk, 2018).

A parliamentary inquiry into the Village Guard system found this to be a systematic phenomenon: "Several Village Guards have killed villagers with whom they have blood feuds based on the pretext that the latter are PKK supporters" (Belge, 2011: 107). Between 1985 and 1997, 17 village guards were prosecuted for participating in blood feuds (ibid). The militarization of these feuds was also perpetuated by the PKK itself—McDowall (2003: 421) notes that “Rather than assaulting the agha class as a whole, the PKK operated with fine calculation, exploiting blood feuds where these existed, helping to create them where they did not”.

Kalyvas (2003: 487) contends that “framing civil wars in binary terms is misleading” and that “local cleavages and intracommunity dynamics must be incorporated in theories of civil war”. The evidence above suggests that competition over access to irrigation can spark or intensify blood feuds that have abounded in the Southeast. The divisions between tribes that often lead to these feuds have been fostered by governments since the Ottoman era, with the most recent iteration of this policy involving the selective armament of pro-government tribes to fight the PKK through the Village Guard system. The result, as demonstrated, is that irrigation can actually intensify conflict where competition over resources overlaps with these historically reinforced divisions.

An increase in conflict resulting from the introduction of a new high-value resource aligns closely with the literature on rent-seeking and lootability in civil wars. Recently, Berman et. al. (2017) found that roughly a quarter of violence in Africa involved control over mining facilities, and that clashes increased when mineral prices were high. They motivate their study by analyzing a feud between two tribes in Darfur over control of a gold mine that left 800 dead. In the context of Southeastern Anatolia, the introduction of irrigation in tribal areas appears to increase violent local competition over this new source of rents. However, the overall effect of irrigation on conflict likelihood remains negative and is strengthened relative to the benchmark when heterogenous effects in tribal areas are accounted for. This result further strengthens the opportunity cost mechanism discussed in the previous section as tribal areas tend to exhibit extreme land inequality, negating the positive income effect of irrigation for farmers.

IX Conclusion

This paper provides a highly detailed test of the dominant mechanism linking agricultural income and civil conflict. This has direct bearing on the large and ever-growing body of literature examining the relationship between rainfall, income, and civil war. A fully irrigated 25 km^2 grid-cell was found to be 58% less likely than the average cell to experience a conflict event involving Kurdish rebels during the 2016-2019 period. Between 1985 and 2019, a 27 km^2 increase in irrigated area decreased the likelihood of experiencing a conflict event in a 100 km^2 grid-cell in a given year decreased by 49% relative to the mean. Agricultural income is likely the mediating factor: conflict incidence is higher in districts reliant on rain-sensitive wheat, particularly following a bad harvest. Irrigation triggers a shift from rain-sensitive crops to cotton, which is both more lucrative and resistant to rainfall shortages. Accounting for heterogeneity in the relationship between irrigation and conflict related to unequal land tenure in tribal areas strengthens the negative effect of irrigation on Kurdish separatism, providing further evidence for the opportunity cost mechanism. However, the onset of irrigation in tribal areas is associated with an increase in conflict due to militarized competition between tribes over irrigation-derived rents.

These findings have policy relevance both within and beyond Turkey. Strong serial dependence in conflict incidence, as well as the negative association between recruitment and irrigation, suggest that a military approach to the Kurdish insurgency is counterproductive. Instead, insulating farmers from climactic shocks and enhancing their livelihoods through irrigation appears to more effective in quelling separatism. The extent to which this is true in other contexts is subject to several caveats. The PKK was established as a "peasant movement", which recruited heavily in agricultural communities. There was direct ethnographic evidence that irrigation mediated Kurdish farmers' affinity for either the Turkish state or the PKK (Harris, 2006; 2009; 2016). There was also evidence that the Turkish state explicitly expected GAP to reduce the appeal of the PKK (Wikileaks, 2008a; 2008b). Thus, climactic vulnerability, irrigation, and insurgent recruitment were directly linked in the political economy of Southeastern Anatolia, in ways that may not be true in other cases.

Further research is needed to establish the validity of the conclusions drawn herein in other contexts at a comparable level of spatial and temporal disaggregation. A more detailed empirical inquest into the concrete mechanics of the "opportunity cost of rebellion" mechanism would also be beneficial. For example, given that Dal Bó and Dal Bó (2004) propose that negative income shocks would have opposite effects in capital-intensive versus labor-intensive sectors, more work is needed to account for the fact that agriculture tends to become significantly more capital-intensive over time.

References

Akşit, Bahattin, and A. Adnan Akçay. "Sociocultural aspects of irrigation practices in Southeastern Turkey." International Journal of Water Resources Development 13.4 (1997): 523-540.

Anceschi, Luca, Gennaro Gervasio, and Andrea Teti, eds. Informal power in the Greater Middle East: hidden geographies. Routledge, 2014.

Angrist, Joshua D., and Jörn-Steffen Pischke. Mostly harmless econometrics: An empiricist's companion. Princeton university press, 2008.

Barreca, Alan I., Jason M. Lindo, and Glen R. Waddell. "Heaping-induced bias in regression-discontinuity designs." Economic Inquiry 54.1 (2016): 268-293.

Bilgen, Arda. "A project of destruction, peace, or techno-science? Untangling the relationship between the Southeastern Anatolia Project (GAP) and the Kurdish question in Turkey." Middle Eastern Studies 54.1 (2018): 94-113.

Blomquist, W. and Schlager, E. "Political pitfalls of integrated watershed management." Society and Natural Resources 18.2 (2005): 101-117.

Bohlken, Anjali Thomas, and Ernest John Sergenti. "Economic growth and ethnic violence: An empirical investigation of Hindu—Muslim riots in India." Journal of Peace research 47.5 (2010): 589-600.

Calvo E, Escolar M. The local voter: a geographically weighted regression approach to ecological inference. American Journal of Political Science. 2003;47(1):189–204

Carkoglu, Ali, and Mine Eder. "Domestic concerns and the water conflict over the Euphrates-Tigris river basin." Middle Eastern Studies 37.1 (2001): 41-71.

Çarkoğlu, Alı. "Macro Economic Determinants of Electoral Support for Incumbents in Turkey, 1950–1995." New Perspectives on Turkey 17 (1997): 75-96.

Cattaneo, Matias D., Nicolás Idrobo, and Rocıo Titiunik. "A practical introduction to Regression Discontinuity Designs: Volume I." (2018).

Chahim, Dean. "Damming Peace and Developing Dissent." History (2010).

Ciccone, Antonio. "Economic shocks and civil conflict: A comment." American Economic Journal: Applied Economics 3.4 (2011): 215-27.

Collier, Paul, and Anke Hoeffler. "On economic causes of civil war." Oxford economic papers 50.4 (1998): 563-573.

Couttenier, Mathieu, and Raphael Soubeyran. "Drought and civil war in sub-saharan africa." The Economic Journal 124.575 (2013): 201-244.

Criss, Nur Bilge. "The nature of PKK terrorism in Turkey." Studies in Conflict Terrorism 18.1 (1995): 17-37.

Dal Bó, Ernesto, and Pedro Dal Bó. "Workers, warriors, and criminals: social conflict in general equilibrium." Journal of the European Economic Association 9.4 (2011): 646-677.

Dormann, Carsten F., et al. "Methods to account for spatial autocorrelation in the analysis of species distributional data: a review." Ecography30.5 (2007): 609- 628.

NASA, 2016. "drought in Eastern Mediterranean worst in past 900 years." https://climate.nasa.gov/news/2 in-eastern-mediterranean-worst- of-past-900-years/

Elbadawi, E., and N. Sambanis (2000) "Why Are There So Many Civil Wars in Africa? Understanding and Preventing Violent Conflict." Journal of African Economies 9, 3,

244-269.
Fearon, James D., and David D. Laitin. "Ethnicity, insurgency, and civil war." American political science review 97.1 (2003): 75-90.
Gruen, George E. "Turkish waters: Source of regional conflict or catalyst for peace?." Environmental Challenges. Springer, Dordrecht, 2000. 565-579.
Güner, Serdar. "The Turkish-Syrian war of attrition: The water dispute." Studies in conflict terrorism20.1 (1997): 105-116.
Güneydogu Anadolu Projesi (GAP) Bölge Kalkinma Idaresi Baskanligi. "GAP Nedir?" 2018
Harari, Mariaflavia, and Eliana La Ferrara. "Conflict, climate, and cells: a disaggregated analysis." Review of Economics and Statistics 100.4 (2018): 594-608.
Harris, Leila M. "State as socionatural effect: Variable and emergent geographies of the state in southeastern Turkey." Comparative Studies of South Asia, Africa and the Middle East 32.1 (2012): 25-39.
Harris, Leila M. "States at the limit: Tracing contemporary state-society relations in the borderlands of southeastern Turkey." European Journal of Turkish Studies. Social Sciences on Contemporary Turkey 10 (2009).
Harris, Leila M. "Theorizing gender, ethnic difference, and inequality in relation to water access and politics in southeastern Turkey." The Politics of Fresh Water: Access, Conflict and Identity (2016): 141.
Harris, Leila M. "Water and conflict geographies of the Southeastern Anatolia Project." Society Natural Resources 15.8 (2002): 743-759.
Harris. Leila M. "Water Rich, Resource Poor: Intersections of Gender, Poverty, and Vulnerability in Newly Irrigated Areas of Southeastern Turkey." World Development 36.12 (2008): 2643-2662.
Hatem, Robert, and Mark Dohrmann. "Turkey's Fix for the" Kurdish Problem"." Middle East Quarterly 20.4 (2013): 49-58.
Hipel, Keith W., D. Marc Kilgour, and Rami A. Kinsara. "Strategic investigations of water conflicts in the middle east." Group Decision and Negotiation 23.3 (2014): 355-376.
Hommes, Lena, Rutgerd Boelens, and Harro Maat. "Contested hydrosocial territories and disputed water governance: Struggles and competing claims over the Ilisu Dam development in southeasternTurkey." Geoforum 71 (2016): 9-20.
Hsiang, Solomon M., Kyle C. Meng, and Mark A. Cane. "Civil conflicts are associated with the global climate." Nature 476.7361 (2011): 438.
Imbens, Guido, and Karthik Kalyanaraman. "Optimal bandwidth choice for the regression discontinuity estimator." The Review of economic studies 79.3 (2012): 933-959.
Jongerden, Joost. "Dams and politics in Turkey: utilizing water, developing conflict." Middle East Policy 17.1 (2010): 137-143.
Kadirbeyoğlu, Zeynep, and Gökhan Özertan. Users' perceptions of water user associations: Evidence from three cases in Turkey. Vol. 1. Working Paper 2011.
Kadirbeyoglu, Zeynep. "The Impact of Power and Civic Engagement in the Decentralized Management of Natural Resources: The Case of Turkey." Public Administration and Development37.4 (2017): 277-291.
Kayhan Pusane, Özlem. "Turkey's Military Victory over the PKK and Its Failure to end the PKK Insurgency." Middle Eastern Studies 51.5 (2015): 727-741.

Kibaroglu, A., and J. Schmandt. ”Sustainability of engineered rivers in arid land: Euphrates-Tigris and Rio Grande/Bravo.” Policy Research Project. Austin: LBJ School of Public Affairs, University of Texas (2016).

Maystadt, Jean-François, and Olivier Ecker. ”Extreme weather and civil war: does drought fuel conflict in Somalia through livestock price shocks?.” American Journal of Agricultural Economics 96.4 (2014): 1157-1182.

McKee, T.B., N. J. Doesken, and J. Kliest, 1993: The relationship of drought frequency and duration to time scales. In Proceedings of the 8th Conference of Applied Climatology, 17-22 January,Anaheim, CA. American Meterological Society, Boston, MA. 179-18

Miguel, Edward, Shanker Satyanath, and Ernest Sergenti. ”Economic shocks and civil conflict: An instrumental variables approach.” Journal of political Economy 112.4 (2004): 725-753.

Mousseau, Demet Yalcin. ”An inquiry into the linkage among nationalizing policies, democratization, and ethno-nationalist conflict: the Kurdish case in Turkey.” Nationalities Papers 40.1 (2012): 45-62.

National Aeronautic and Space Administration (NASA). ”Atatruk Dam in Turkey from Landsat”, 2018.

Nestor, Carl E. ”Dimensions of Turkey’s Kurdish Question and the Potential Impact of the Southeast Anatolian Project (GAP): Part I.” The International Journal of Kurdish Studies 8.1/2 (1995):33

Öcalan, Abdullah. Democratic confederalism. Lulu Press, Inc, 2015.

Öcalan, Abdullah. Prison writings: The PKK and the Kurdish Question in the 21st century. Transmedia Publishing, 2007.

Oktav, Özden Zeynep. ”Water dispute and Kurdish separatism in Turkish-Syrian relations.” The Turkish Yearbook 34 (2003): 91-117.

Öktem, Kerem. Angry nation: Turkey since 1989. Zed Books Ltd., 2012.

Olson, Robert. ”The impact of the Southeast Anatolian Project (GAP) on Kurdish nationalism in Turkey.” The International Journal of Kurdish Studies 9.1/2 (1996): 95.

Olson, Robert. ”Turkey-Syria Relations since the Gulf War: Kurds and Water.” Middle East Policy5.2 (1997): 168-193.

Özcelik, Sezai. ”Theories, practices, and research in conflict resolution and low- Intensity conflicts: The Kurdish conflict in Turkey.” Journal of Conflict Studies 26.2 (2006).

Özdogan, Mutlu, et al. ”Changes in summer irrigated crop area and water use in Southeastern Turkey from 1993 to 2002: Implications for current and future water resources.” Water resources management 20.3 (2006): 467-488.

Özerdem, Alpaslan, and Tim Jacoby. ”Conflict induced internal displacement.” Human Rights in Turkey (2007): 159-69.

Özhan, Taha, and Hatem Ete. ”A new agenda for the Kurdish question.” Insight Turkey (2009): 97-114.

Pool, Alexandra M., and Velma I. Grover. ”GAPs in the dialogue of governance: Conflicting ideologies of development in Turkey.” Water: Global common and global problems (2006): 373-97.

Republic of Turkey Ministry of Development, 2018. “Southeastern Anatolia Project Regional Development Administration”.

Saini, Hargurdeep S., and Mark E. Westgate. "Reproductive development in grain crops during drought." Advances in agronomy. Vol. 68. Academic Press, 1999. 59-96.

Saatci, Esra, and Ersin Akpinar. "Assessing poverty and related factors in Turkey." Croatian medical journal 48.5 (2007): 628-635.

Sarsons, Heather. "Rainfall and conflict: A cautionary tale." Journal of development Economics 115 (2015): 62-72.

Scheumann, Waltina. "Conflicts on the Euphrates: An analysis of water and non-water issues." Water in the Middle East. Springer, Berlin, Heidelberg, 1998. 113-135.

Svoboda, M., M. Hayes, and D. Wood. "Standardized precipitation index user guide." World Meteorological Organization Geneva, Switzerland (2012).

Tezcür, Güneş Murat. "Ordinary people, extraordinary risks: Participation in an ethnic rebellion." American Political Science Review110.2 (2016): 247-264.

Türk Cumhuriyeti Yüksek Seçim Kurulu (Turkish High Electoral Commission), 2018. "Election Data Archive"

Uexkull, Nina. "Sustained drought, vulnerability and civil conflict in Sub-Saharan Africa." Political Geography 43 (2014): 16-26.

Varsamidis, Aristotelis. An assessment of the Water Development Project (Gap) of Turkey: meeting its objectives and EU criteria for Turkey's accession. NAVAL POSTGRADUATE SCHOOL MONTEREY CA, 2010.

Verwimp, Philip, Patricia Justino, and Tilman Brück. "The microeconomics of violent conflict." (2019): 102297.

Warner, J. F. "Contested hydrohegemony: hydraulic control and security in Turkey." Water Alternatives 1.2 (2008): 271-288.

Warner, Jeroen. "Mending the GAP—Hydro-Hegemonic Stability in the Euphrates- Tigris Basin." Water, Development and Cooperation—Comparative Perspective: Euphrates-Tigris and Southern Africa (2005): 184.

Warner, Jeroen. "The struggle over Turkey's Ilısu Dam: domestic and international security linkages." International Environmental Agreements: Politics, Law and Economics 12.3 (2012): 231-250.

White, Paul J. "Economic marginalization of Turkey's Kurds: the failed promise of modernization and reform." Journal of Muslim Minority Affairs 18.1 (1998): 139-158.

Wikileaks, "NON-MILITARY SOLUTIONS TO THE PKK PROBLEM" U.S. Embassy Ankara, (2008a).

Wikileaks, "TURKEY: VIEW FROM THE HEARTLAND III: KURDS IN SOUTHEAST SAY EU REFORMS NOT IMPLEMENTED." U.S. Embassy Ankara, (2003).

Wikileaks, "TURKEY'S OUTREACH TO THE KURDS OF THE SOUTHEAST: GRAPPLING WITH THE ROOT CAUSES OF THE PKK PROBLEM" U.S. Embassy Ankara, (2008b).

Yarkin, Güllistan. "The ideological transformation of the PKK regarding the political economy of the Kurdish region in Turkey." Kurdish Studies 3.1 (2015): 26-46.

Yavuz, M. Hakan. "Five stages of the construction of Kurdish nationalism in Turkey." Nationalism and Ethnic Politics 7.3 (2001): 1-24.

Tables

Table 1: Summary Statistics

	5km Grid Cells			10km Grid Cells		
Variable	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Irrigated Area	85400	0.911	3.086	27230	3.048	10.481
Post Irrigation	85400	0.154	0.361	27230	0.159	0.365
Clashes (UCDP)	73200	0.009	0.096	23340	0.033	0.179
Clashes (ACLED)	85400	0.084	0.278	27230	0.225	0.418
Population	85400	5.326	0.966	27230	5.508	0.855
AKP voteshare	85400	0.595	0.191	27230	0.588	0.164
HDP voteshare	85400	0.136	0.12	27230	0.144	0.111
Tribal	85400	0.108	0.098	27230	0.108	0.08
Nightlights Change	85400	4.658	5.072	27230	4.159	3.721
Nightlights	85400	7.88	7.301	27230	7.329	5.87
Roads	85400	9.727	1.212	27230	11.015	1.114
SPEI	82960	-0.046	0.69	26452	-0.045	0.688
Slope	85400	7.822	6.149	27230	8.536	6.595
Elevation	85400	803.996	305.47	27230	851.096	359.956
Ceasefire	85400	0.229	0.42	27230	0.229	0.42
Syrian War	85400	0.257	0.437	27230	0.257	0.437
Area	85400	24.583	2.224	27230	94.013	17.527
Border	85400	0.028	0.165	27230	0.075	0.263

This table provides summary statistics for all variables at both the 10km and 5km grid cell level.

Table 2: Irrigation and Conflict Incidence, Cross-Sectional IV Estimates

	(1) Probit	(2) Probit	(3) Probit	(4) 2SLS	(5) 2SLS	(6) 2SLS
Log Irrigated Area	-0.335***	-0.293***	-0.268***	-0.0511***	-0.0410***	-0.0373***
	(0.0410)	(0.0447)	(0.0500)	(0.00720)	(0.00696)	(0.00769)
Population	0.136***	0.153***	0.209***	0.0256***	0.0257***	0.0322***
	(0.0477)	(0.0526)	(0.0578)	(0.00775)	(0.00777)	(0.00799)
AKP voteshare	-1.271***	-1.526***	-1.092***	-0.185***	-0.207***	-0.132***
	(0.306)	(0.331)	(0.384)	(0.0477)	(0.0506)	(0.0484)
HDP voteshare	0.490	0.278	0.902	0.0516	0.00934	0.0960
	(0.465)	(0.498)	(0.562)	(0.0697)	(0.0721)	(0.0699)
Tribal	-0.0266	0.175	-0.231	0.122**	0.137**	0.0898
	(0.576)	(0.634)	(0.735)	(0.0580)	(0.0603)	(0.0618)
Nightlights Change	-0.0617***	-0.0632***	-0.0573**	-0.0174***	-0.0183***	-0.0179***
	(0.0233)	(0.0243)	(0.0231)	(0.00437)	(0.00431)	(0.00424)
Nightlights	0.0697***	0.0665***	0.0592***	0.0203***	0.0202***	0.0195***
	(0.0176)	(0.0185)	(0.0174)	(0.00321)	(0.00318)	(0.00311)
Roads	0.157***	0.217***	0.202***	0.0132***	0.0196***	0.0189***
	(0.0463)	(0.0669)	(0.0694)	(0.00320)	(0.00542)	(0.00581)
SPEI	2.698	-1.222	-5.205	0.396	-0.0959	-0.481
	(4.834)	(5.402)	(6.239)	(0.653)	(0.720)	(0.802)
Area	0.0465**	0.0328	0.0313	0.00481**	0.00489*	0.00508
	(0.0227)	(0.0257)	(0.0277)	(0.00195)	(0.00275)	(0.00321)
Previous Clashes	0.00375**	0.00337*	0.00234	0.00155*	0.00131	0.000911
	(0.00184)	(0.00179)	(0.00163)	(0.000839)	(0.000818)	(0.000783)
Border	0.707**	0.709**	0.694**	0.0690	0.0782	0.0805
	(0.280)	(0.294)	(0.311)	(0.0441)	(0.0502)	(0.0537)
Observations	2,440	2,223	1,965	2,440	2,223	1,965
Geographic Restriction	None	<1200	<1000	None	<1200	<1000

$***p < 0.01, **p < 0.05, *p < 0.1$

This table reports IV estimates of the effect of irrigation on PKK recruitment at the level of 5km by 5km grid cells, with robust standard errors displayed in parentheses. Equation (1) is estimated as a two-stage probit model in columns 1-3 of Table 2, and as a linear probability model via 2SLS in columns 4-6. Columns 1 and 4 use the full sample, columns 2 and 5 restrict the sample to observations below 1200 meters, and columns 3 and 6 further restrict the elevation cutoff to 1000 meters. The Kleibergen-Paap F statistic is 1697 for the full sample and 1743 for the maximum geographic restriction.

Table 3: Irrigation and Conflict Incidence by Type, Spatially Autoregressive IV Estimates

	W= Binary Contiguity Matrix				W= Inverse Distance Matrix			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	All Conflict	PKK Attacks	Military Raids	Protests	All Conflict	PKK Attacks	Military Raids	Protests
Log Irrigated Area	-0.0134**	-0.00646*	-0.0132***	-0.00349	-0.0192**	-0.0180***	-0.0199***	-0.00563
	(0.00549)	(0.00362)	(0.00452)	(0.00352)	(0.00774)	(0.00601)	(0.00612)	(0.00391)
Y x W	0.497***	0.372**	0.466**	0.145	1.605	-3.066	0.976	3.480***
	(0.162)	(0.157)	(0.195)	(0.177)	(1.178)	(2.085)	(1.162)	(1.316)
Population	0.0453***	0.0306***	0.0349***	0.0216***	0.0400***	0.0298***	0.0312***	0.0207***
	(0.00898)	(0.00681)	(0.00791)	(0.00590)	(0.00818)	(0.00629)	(0.00709)	(0.00556)
AKP voteshare	-0.0514	0.0350	-0.0823	0.0336	-0.0872	0.0195	-0.113**	0.0120
	(0.0588)	(0.0371)	(0.0526)	(0.0248)	(0.0542)	(0.0353)	(0.0471)	(0.0237)
HDP voteshare	0.121	0.121*	0.0908	0.0840*	0.0717	0.0539	0.0367	0.0255
	(0.116)	(0.0660)	(0.110)	(0.0510)	(0.110)	(0.0636)	(0.0993)	(0.0483)
Tribal	0.0186	-0.0525	0.0724	-0.0303	0.0328	-0.0571	0.0869	-0.0489
	(0.0691)	(0.0418)	(0.0568)	(0.0401)	(0.0729)	(0.0451)	(0.0606)	(0.0425)
Nightlights Change	-0.0247***	-0.0256***	-0.0263***	-0.0268***	-0.0198***	-0.0221***	-0.0224***	-0.0240***
	(0.00382)	(0.00363)	(0.00364)	(0.00290)	(0.00380)	(0.00346)	(0.00360)	(0.00304)
Nightlights	0.0307***	0.0289***	0.0279***	0.0300***	0.0241***	0.0240***	0.0234***	0.0250***
	(0.00297)	(0.00290)	(0.00299)	(0.00260)	(0.00268)	(0.00249)	(0.00268)	(0.00238)
Roads	0.0224***	0.0152***	0.0134***	0.0134***	0.0218***	0.0128***	0.0127**	0.00894***
	(0.00613)	(0.00458)	(0.00495)	(0.00388)	(0.00644)	(0.00463)	(0.00503)	(0.00336)
SPEI	6.753***	5.313***	5.849***	2.135	6.605***	6.853***	4.463***	2.344**
	(2.195)	(1.678)	(1.827)	(1.344)	(2.186)	(1.913)	(1.418)	(1.191)
Area	0.00851**	0.00529*	0.00527*	0.00347	0.00573*	0.00311	0.00334	0.000598
	(0.00356)	(0.00274)	(0.00317)	(0.00251)	(0.00330)	(0.00257)	(0.00298)	(0.00236)
Previous Clashes	0.000663	0.00101	0.000851	0.000906	0.000808	0.00103	0.000970	0.00105
	(0.000561)	(0.000752)	(0.000671)	(0.000697)	(0.000602)	(0.000777)	(0.000699)	(0.000766)
Border	0.0284	0.00257	0.0220	-0.000650	0.0527	0.0261	0.0213	0.0125
	(0.0577)	(0.0424)	(0.0473)	(0.0379)	(0.0552)	(0.0399)	(0.0433)	(0.0345)
Observations	1,965	1,965	1,965	1,965	1,965	1,965	1,965	1,965
Geographic Restriction	<1000m	<1000m	<1000m	<1000m	<1000m	<1000m	<1000m	<1000m

$***p < 0.01, **p < 0.05, *p < 0.1$

This table reports spatially autoregressive IV estimates of the effect of irrigation on PKK recruitment at the level of 5km by 5km grid cells, with robust standard errors displayed in parentheses. Columns 1-4 report the results of equation (2) where$W$is a binary contiguity spatial weighting matrix. Columns 5-8 use an inverse distance matrix. All columns employ the most extreme geographic restriction (1000 meters). The dependent variable is general conflict incidence in columns 1 and 5, PKK attacks in columns 2 and 6, military raids in columns 3 and 7, and protest incidence in columns 4 and 8. The same set of time invariant cell-level control variables used in the panel models is included but values are calculated at the 5km level.

Table 4: Qualitative Examples of Military Raids and PKK Attacks

	Military Raid	PKK Attack
Description	Weapons Seizure: In Lice town the Turkish military seized more than 10 tons of explosives during an anti-PKK operation. As reported on the 27th of June.	PKK killed a village chief outside the village of Bahcebasi on the night of the 26th May. The militants also burnt the car belonging to the victim.
Side A	Military Forces of Turkey (2002-2016)	PKK: Kurdistan Workers Party
Side B	PKK: Kurdistan Workers Party	Civilians (Turkey)
ACLED ID	3398	3196
Description	On August 11 one PKK militant was killed in Yumurcak village of Kiziltepe district Mardin when clashes occurred during a police operation on his home.	A car bomb exploded at around 7.30pm on May 25th at a gendarmerie miliary checkpoint in Anitli village in Midyat district of Mardin. The explosion killed one soldier and two village guards as well as the two PKK militants who detonated the bomb from inside the car.
Side A	Police Forces of Turkey (2016-)	PKK: Kurdistan Workers Party
Side B	PKK: Kurdistan Workers Party	Military Forces of Turkey (2002-2016), Gendarmerie
ACLED ID	5145	3180
	Property destruction: Between February 28 and March 2, Gendarmerie Forces destroyed 19 shelters belonging to PKK during the operations in the rural areas of Kursunlu village, Dicle district, Diyarbakir	PKK militants raided Baglica village in Artuklu district of Mardin on the 20th May and killed a village guard. Following the attack, military vehicles and ambulances rushed to the scene and eight soldiers were injured when PKK detonated explosives at the convoy. No medical personnel were reported to have been injured.
Side A	Military Forces of Turkey (2002-2016), Gendarmerie	PKK: Kurdistan Workers Party
Side B	PKK: Kurdistan Workers Party	Village Guards
ACLED ID	5515	3138

Table 5: Irrigation and Conflict Incidence, Spatial Panel Models

	(1)	(2)	(3)	(4)
	OLS HAC I	Durbin I	OLS HAC II	Durbin II
Post Irrigation	-0.0193***	-0.0124***	-0.0189***	-0.0224***
	(0.00675)	(0.00445)	(0.00666)	(0.00428)
Treatment Group	-0.00144	0.00150		
	(0.00955)	(0.00487)		
Y_{t-1}		0.407***		0.249***
		(0.0199)		(0.0461)
Population	0.0376***	0.0133***	0.00359	0.000133
	(0.00814)	(0.00274)	(0.0105)	(0.00330)
AKP voteshare	0.0148	-0.0278**	-0.0299	-0.00312
	(0.0425)	(0.0137)	(0.0435)	(0.0155)
HDP voteshare	0.289***	0.0167	-0.0558	0.0746*
	(0.0553)	(0.0255)	(0.0689)	(0.0395)
Tribal	-0.0456	-0.0398**	0.0860	0.0973***
	(0.0547)	(0.0198)	(0.0595)	(0.0337)
Nightlights Change	0.00125	0.00178	0.00412	0.00166
	(0.00546)	(0.00136)	(0.0127)	(0.00600)
Nightlights	0.00332	0.00157*	0.0115	0.00696*
	(0.00338)	(0.000827)	(0.00799)	(0.00399)
Roads	0.0144***	0.0102***	-0.00694	-0.00495
	(0.00454)	(0.00143)	(0.00636)	(0.00320)
SPEI	0.00699	-0.00664	0.00419	0.0208*
	(0.00648)	(0.0156)	(0.00999)	(0.0117)
Slope	0.00535***	-0.00151**	0.00328	0.00154
	(0.00123)	(0.000593)	(0.00402)	(0.00169)
Elevation	1.32e-05	3.05e-05***	0.000100**	4.33e-05
	(2.52e-05)	(1.16e-05)	(4.50e-05)	(3.95e-05)
Cell Area	0.000486*	-5.59e-05	-0.000216	-0.000110
	(0.000254)	(7.46e-05)	(0.000355)	(9.10e-05)
Ceasefire	-0.212***	-0.0740***	0.00154	-0.0128
	(0.0308)	(0.0197)	(0.0154)	(0.0120)
Syrian War	0.270***	0.0472	0.00482	0.0244
	(0.0418)	(0.0306)	(0.0123)	(0.0177)
Border	0.00409	-0.0172**	-0.0231	-0.0167***
	(0.0192)	(0.00686)	(0.0206)	(0.00618)
Observations	23,340	22,562	6,510	6,293
Year FE	X	X	X	X
Cell Specific Time Trend	X		X	
District Specific Time Trend		X		X
Only Treated Cells			X	X

$***p < 0.01, **p < 0.05, *p < 0.1$

This table reports estimates of the effect of irrigation on PKK recruitment from spatial panel models at the level of 10km by 10km grid cells, with robust standard errors displayed in parentheses. Columns 1 and 2 employ the full sample of observations, while columns 3 and 4 restrict the sample to only include areas that receive irrigation at some point during the study period. Columns 1 and 3 are estimated using a panel OLS model with standard errors corrected for serial and spatial autocorrelation (Hsiang, 2010). Columns 2 and 4 are spatial Durbin Models estimated via Maximum Likelihood, using a binary contiguity spatial weighting matrix. All specifications include year fixed effects. Columns 1 and 3 include a cell fixed effect interacted with a linear time trend. Columns 2 and 4 include a district fixed effect interacted with a linear time trend.

Table 6: Spatial Panel Models with Alternate Measures of Irrigation and Conflict

	(1) Clashes	(2) Clashes	(3) Recruitment	(4) Recruitment
Irrigated Area		-0.000339**		-0.000232**
		(0.000172)		(0.000116)
Years Since Irrigation	-0.00222***		-0.000644***	
	(0.000388)		(0.000236)	
Y_{t-1}	0.247***	0.253***	0.125***	0.126***
	(0.0460)	(0.0459)	(0.0374)	(0.0373)
Population	0.000210	-0.000524	0.00607	0.00595
	(0.00332)	(0.00336)	(0.00395)	(0.00396)
AKP voteshare	-0.00497	0.000336	-0.0457**	-0.0477***
	(0.0156)	(0.0167)	(0.0180)	(0.0180)
HDP voteshare	0.0760*	0.0843**	0.00225	0.00545
	(0.0393)	(0.0398)	(0.0529)	(0.0527)
Tribal	0.104***	0.0979***	0.0658**	0.0679**
	(0.0333)	(0.0332)	(0.0314)	(0.0314)
Nightlights Change	0.00100	0.00191	-0.00623	-0.00578
	(0.00601)	(0.00600)	(0.00477)	(0.00469)
Nightlights	0.00736*	0.00681*	0.00604*	0.00576*
	(0.00399)	(0.00397)	(0.00320)	(0.00314)
Roads	-0.00316	-0.00548	-0.000634	-0.000784
	(0.00316)	(0.00338)	(0.00327)	(0.00331)
SPEI	0.0191	0.0238**	0.0168	0.0172
	(0.0117)	(0.0115)	(0.0132)	(0.0131)
Slope	0.00196	0.000638	-0.000350	-0.000718
	(0.00171)	(0.00169)	(0.00207)	(0.00210)
Elevation	4.36e-05	3.99e-05	2.71e-05	2.34e-05
	(4.01e-05)	(4.04e-05)	(4.15e-05)	(4.17e-05)
Cell Area	-9.18e-05	-5.74e-05	9.21e-05	0.000118
	(9.15e-05)	(9.76e-05)	(0.000123)	(0.000124)
Ceasefire	-0.0149	-0.0120	0.0164	0.0113
	(0.0117)	(0.0120)	(0.0107)	(0.00974)
Syrian War	0.0329*	0.0198	0.00992	0.00675
	(0.0177)	(0.0177)	(0.0152)	(0.0146)
Border	-0.0156**	-0.0155**	-0.0118	-0.0112
	(0.00611)	(0.00630)	(0.00817)	(0.00820)
Observations	6,293	6,293	5,859	5,859

$***p < 0.01, **p < 0.05, *p < 0.1$

Results in this table represent modifications of the specification found in column 4 of Table 5. The dependent variable in columns 1 and 2 is the UCDP-derived conflict incidence measure. The dependent variable in columns 3 and 4 is an obituary-derived measure of PKK recruitment developed by Tezcür (2016). Columns 2 and 4 use irrigated area as the treatment variable, which represents the number of square kilometers of the grid cell under irrigation in a given year. Robust standard errors are reported in parentheses.

Table 7: Irrigation and Crop Yields at the District Level

	(1) Cotton Yield	(4) Wheat Yield	(2) Barley Yield	(3) Lentil Yield	(5) Hazelnut Yield
Irrigated Area	0.331***	0.651***	0.305**	0.0775	0.0231
	(0.0665)	(0.0972)	(0.143)	(0.123)	(0.160)
Water Balance	0.000878	0.0637***	0.0730***	0.0236**	0.0299***
	(0.00598)	(0.0180)	(0.0259)	(0.0115)	(0.0108)
Observations	926	974	974	955	946
Year FE	X	X	X	X	X
District FE	X	X	X	X	X

$***p < 0.01, **p < 0.05, *p < 0.1$

This table reports the results of district-level fixed effect panel models estimating the effect of rainfall and irrigation on crop yields in Southeastern Anatolia between 2004 and 2018. All specifications include district and year fixed effects.

Table 8: Conflict Incidence and Lagged Crop Production

	(1) Clashes
Ceasefire	-0.284***
	(0.0474)
Syrian War	0.122***
	(0.0288)
Cotton Yield$_{t-1}$	0.236
	(0.245)
Barley Yield$_{t-1}$	0.0171
	(0.180)
Hazelnut Yield$_{t-1}$	0.449
	(0.399)
Wheat Yield$_{t-1}$	-0.496**
	(0.235)
Lentil Yield$_{t-1}$	0.170
	(0.289)
Cotton Sown Area$_{t-1}$	-0.000145
	(0.000142)
Barley Sown Area$_{t-1}$	-6.82e-05
	(9.39e-05)
Hazelnut Sown Area$_{t-1}$	-0.000112
	(0.000472)
Wheat Sown Area$_{t-1}$	3.56e-05
	(2.87e-05)
Lentil Sown Area$_{t-1}$	-0.000341**
	(0.000163)
Observations	10,745
R-squared	0.122
Year FE	X
District FE	X

$***p < 0.01, **p < 0.05, *p < 0.1$

This table reports the results of a district-level fixed effect panel model estimating the relationship between crop yields and conflict incidence in Southeastern Anatolia between 2004 and 2018. All specifications include district and year fixed effects.

Table 9: Tribal Treatment Heterogeneity

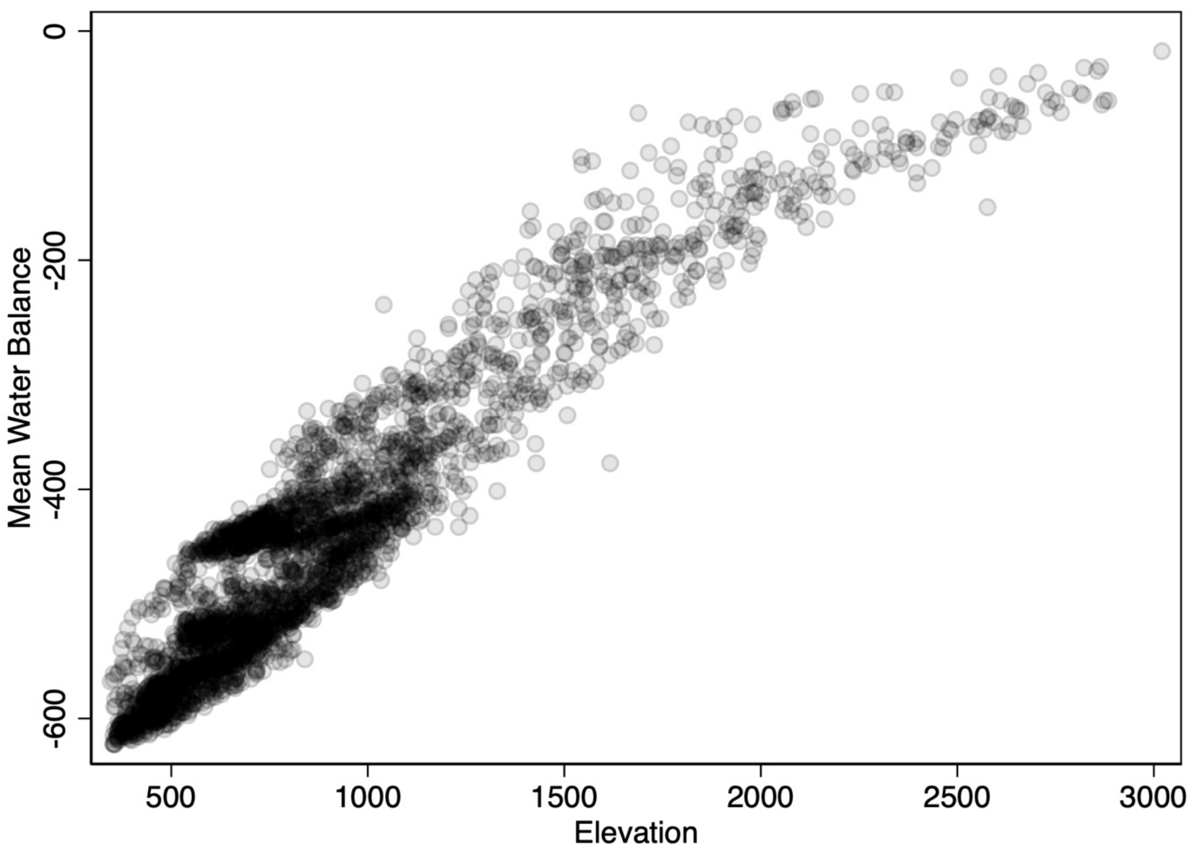
	(1) All Tribes	(2) AKP Tribes	(3) HDP Tribes	(4) AKP and HDP Tribes
Post Irrigation	-0.0498***	-0.0253***	-0.0441***	-0.0508***
	(0.00920)	(0.00533)	(0.00792)	(0.00977)
Post x Tribal	0.217***			
	(0.0500)			
Post x HDP Tribal		0.101		0.161*
		(0.0847)		(0.0896)
Post x AKP Tribal			0.0978***	0.106***
			(0.0222)	(0.0241)
Y x W	0.245***	0.249***	0.245***	0.245***
	(0.0462)	(0.0461)	(0.0461)	(0.0462)
Population	0.00167	0.000321	0.00129	0.00170
	(0.00336)	(0.00325)	(0.00336)	(0.00333)
AKP voteshare	-0.0158	0.00111	-0.0188	-0.0135
	(0.0162)	(0.0156)	(0.0164)	(0.0161)
HDP voteshare	0.0699*	0.0660	0.0803**	0.0671
	(0.0400)	(0.0431)	(0.0400)	(0.0433)
Tribal	-0.0157	0.0888**	0.00386	-0.0178
	(0.0455)	(0.0346)	(0.0425)	(0.0463)
Nightlights Change	0.000868	0.00188	0.000776	0.00104
	(0.00598)	(0.00600)	(0.00599)	(0.00598)
Nightlights	0.00739*	0.00685*	0.00744*	0.00731*
	(0.00398)	(0.00398)	(0.00398)	(0.00397)
Roads	-0.00548*	-0.00503	-0.00530*	-0.00546*
	(0.00313)	(0.00322)	(0.00317)	(0.00315)
SPEI	0.0204*	0.0205*	0.0207*	0.0201*
	(0.0117)	(0.0117)	(0.0117)	(0.0118)
Slope	0.00124	0.00157	0.00127	0.00129
	(0.00169)	(0.00170)	(0.00169)	(0.00171)
Elevation	6.52e-05	4.36e-05	6.23e-05	6.46e-05
	(4.10e-05)	(3.98e-05)	(4.07e-05)	(4.11e-05)
Ceasefire	-0.0117	-0.0124	-0.0120	-0.0114
	(0.0119)	(0.0120)	(0.0119)	(0.0119)
Syrian War	0.0262	0.0245	0.0258	0.0261
	(0.0177)	(0.0177)	(0.0178)	(0.0177)
Cell Area	-4.99e-05	-0.000123	-4.28e-05	-5.78e-05
	(9.19e-05)	(9.47e-05)	(9.48e-05)	(9.53e-05)
Border	-0.0141**	-0.0169***	-0.0141**	-0.0143**
	(0.00621)	(0.00622)	(0.00623)	(0.00627)
Observations	6,293	6,293	6,293	6,293
Year FE	X	X	X	X
District Time Trend	X	X	X	X

$***p < 0.01, **p < 0.05, *p < 0.1$

Results in this table represent modifications of the specification found in column 4 of Table 5. The dependent variable in all cases in the UCDP-derived conflict incidence measure. Column 1 adds an interaction between the treatment variable and the total proportion of ballot boxes displaying tribal bloc voting in a given grid-cell. Columns 2 and 3 interact the treatment variable with a disaggregated tribal indicator, isolating bloc voting for the AKP and HDP respectively. Column 4 includes both interaction terms.

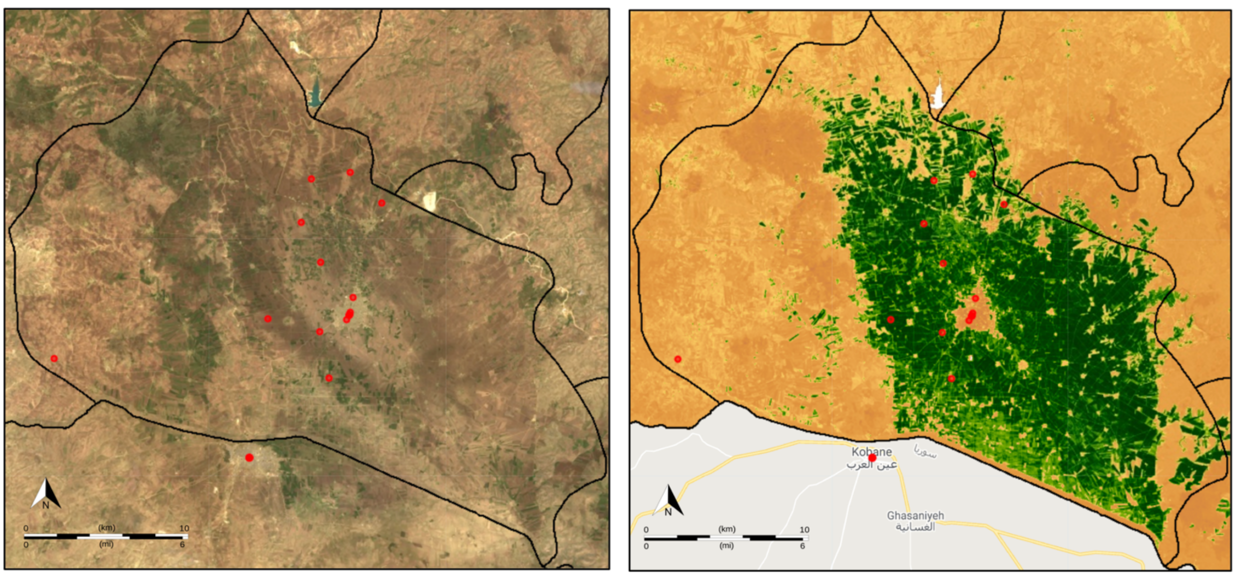
Figures

Figure 1: Relationship Between Water Balance and Elevation



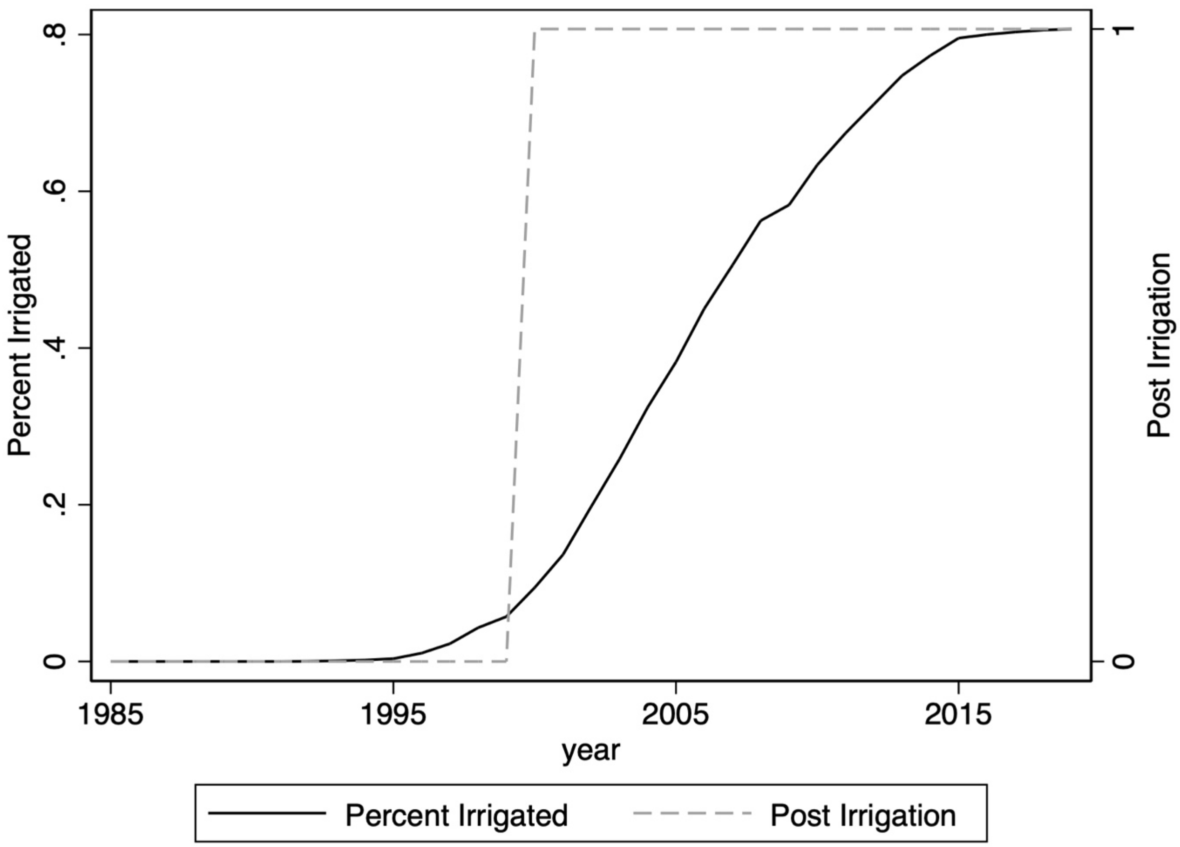
This figure displays the relationship between a 10km grid cell's mean water balance (precipitation minus evapotranspiration) and elevation in Southeastern Anatolia.

Figure 2: Isolating Irrigation using Summertime NDVI



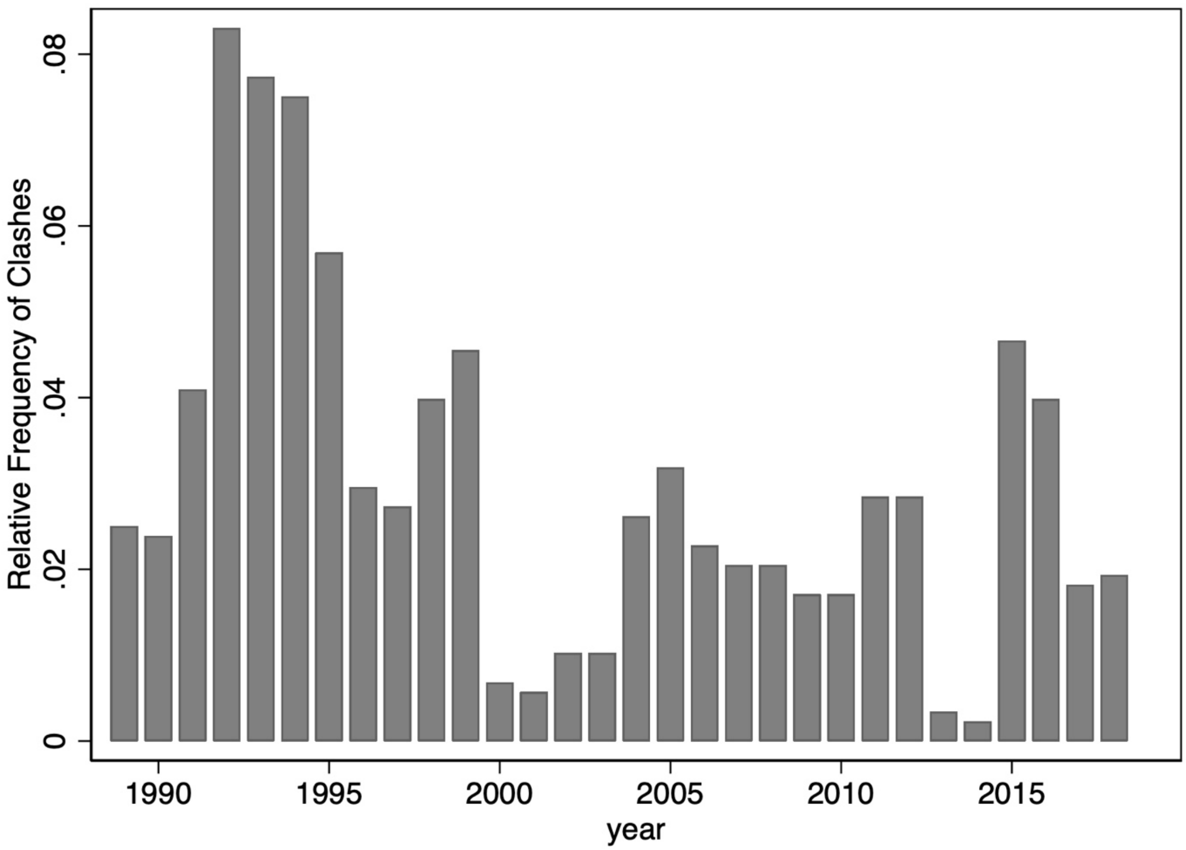
The panel on the left displays an optical satellite image of the district of Suruç, with red dots indicating the geolocated birthplaces of PKK recruits from Tezcür (2016). The panel on the right displays the Normalized Difference Vegetation Index (NDVI), calculated using Landsat 8 imagery taken during August 2020. This process clearly highlights the Suruç irrigation scheme.

Figure 3: Irrigated Area and Irrigation Onset variables



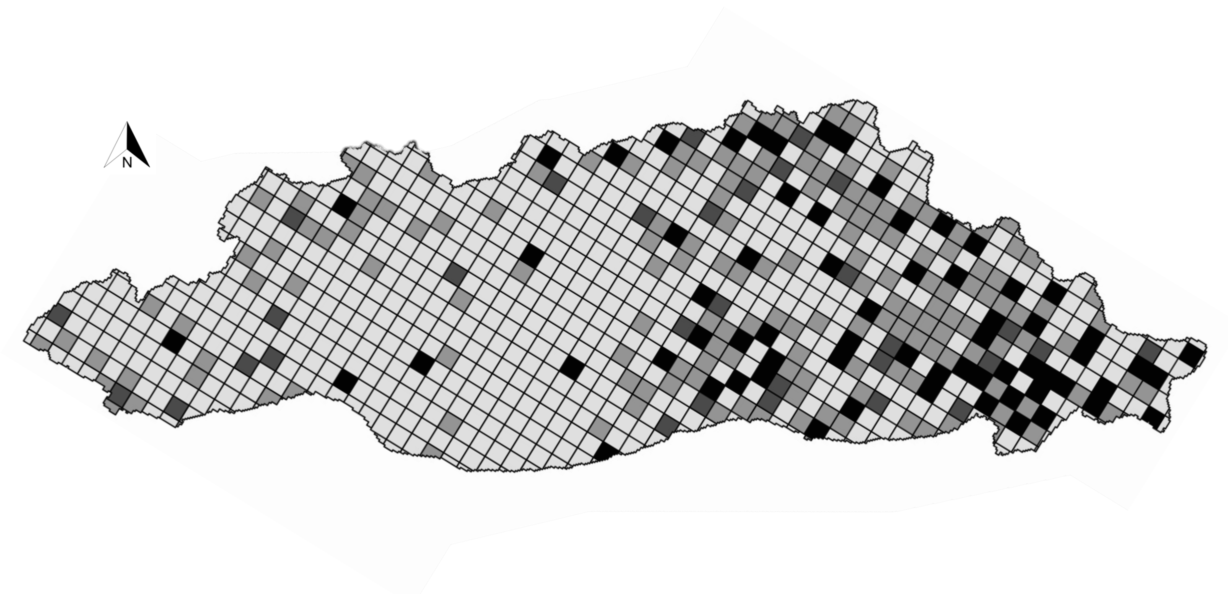
The solid line shows the percent of a 10km grid cell located in Kiziltepe that is under irrigation in a given year, derived from the remote sensing procedure carried out in Figure 2. The dashed line shows a binary variable indicating irrigation onset for the same cell.

Figure 4: Frequency of Violent Clashes Over Time



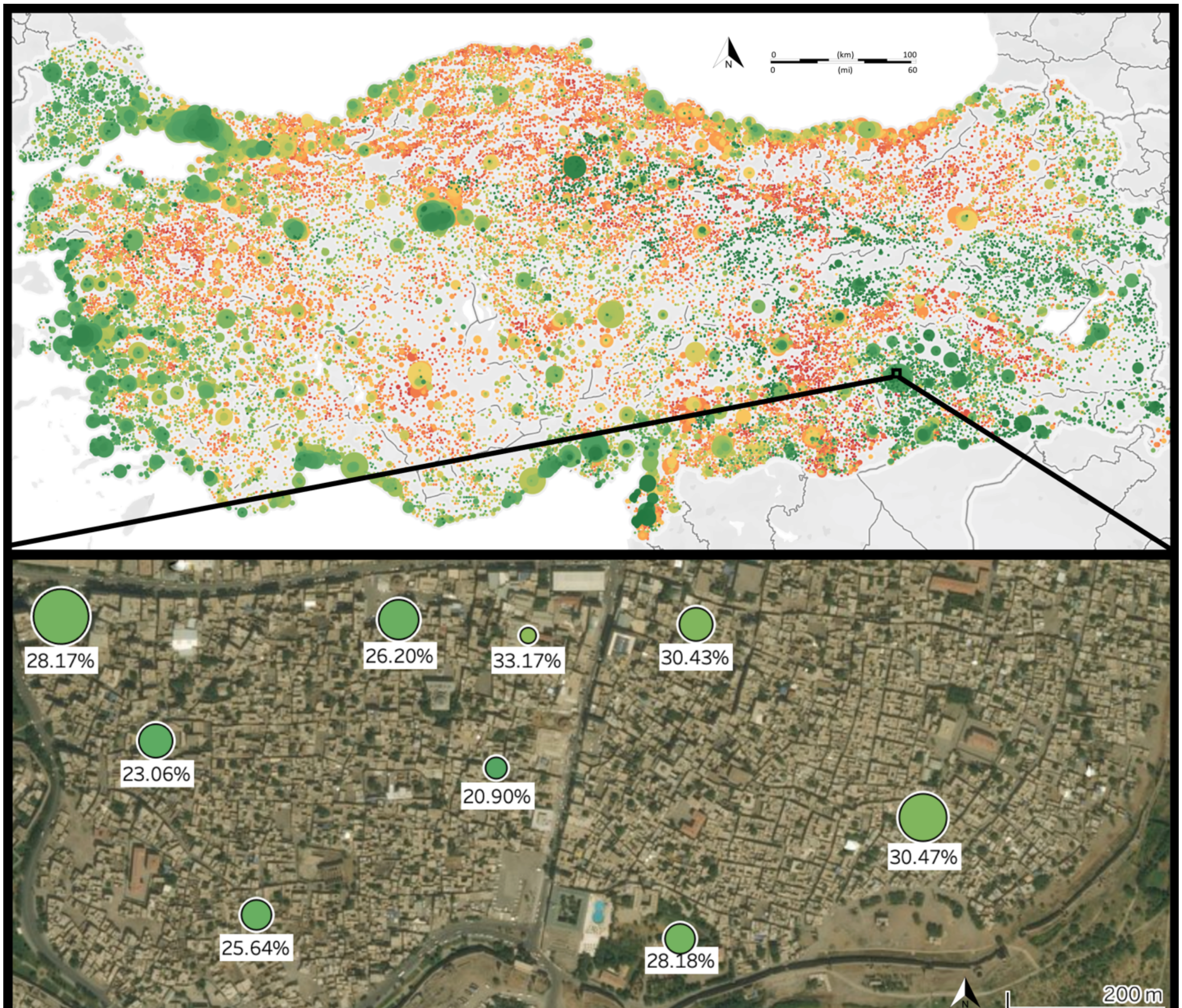
This figure shows the relative frequency of clashes between the PKK and the Turkish Government recorded in the Uppsala Conflict Data Program (UCDP) dataset. The large volume of clashes prior to the year 2000 indicates the conflict's active phase, which was followed by a ceasefire lasting until 2015.

Figure 5: Geographic Distribution of Violent Clashes



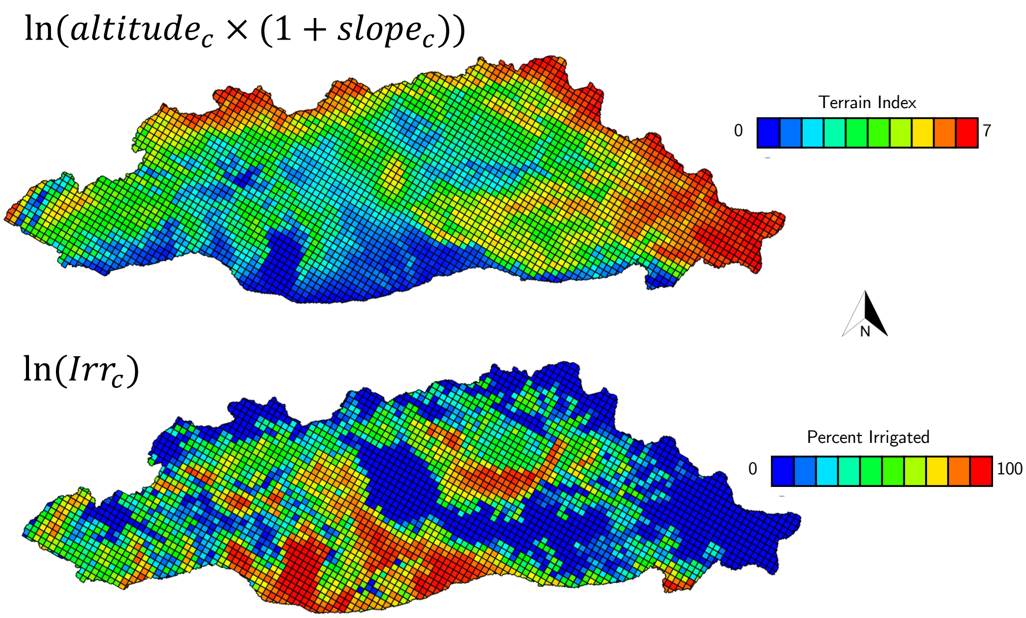
The figure above displays the spatial distribution of violent clashes between the PKK and the Turkish Government in Southeastern Anatolia using geolocated conflict data from the UCDP and Armed Conflict Location & Event Data (ACLED). Darker cells contain more total clashes across the entire study period.

Figure 6: Ballot Box-Level Election Results



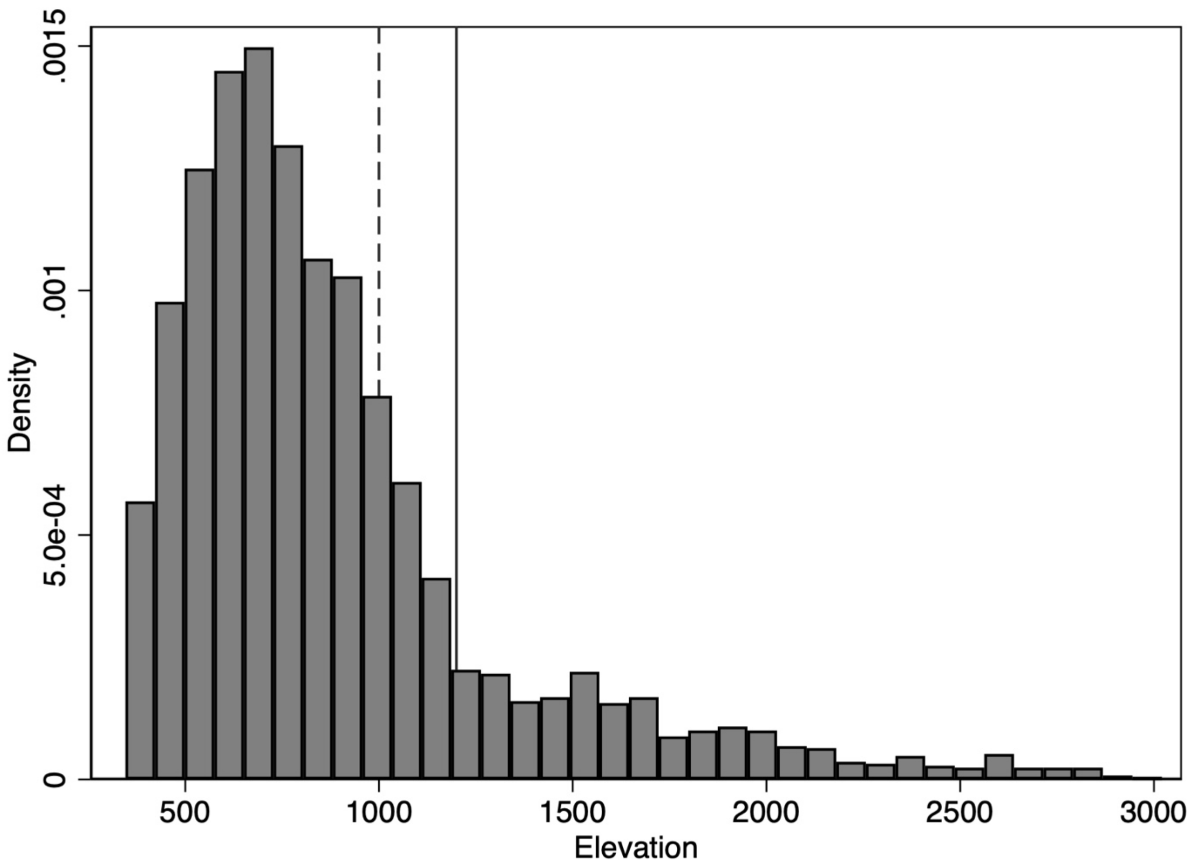
The results from 2.9 million ballot box-level election results between 2009 and 2019 are displayed above. Red indicates a high proportion of votes for the Justice and Development Party (AKP). Point size reflects the number of registered voters at a ballot box. The top panel shows results for all of Turkey, while the bottom panel shows results for several neighborhoods in Diyarbakir.

Figure 7: Topography and Irrigation



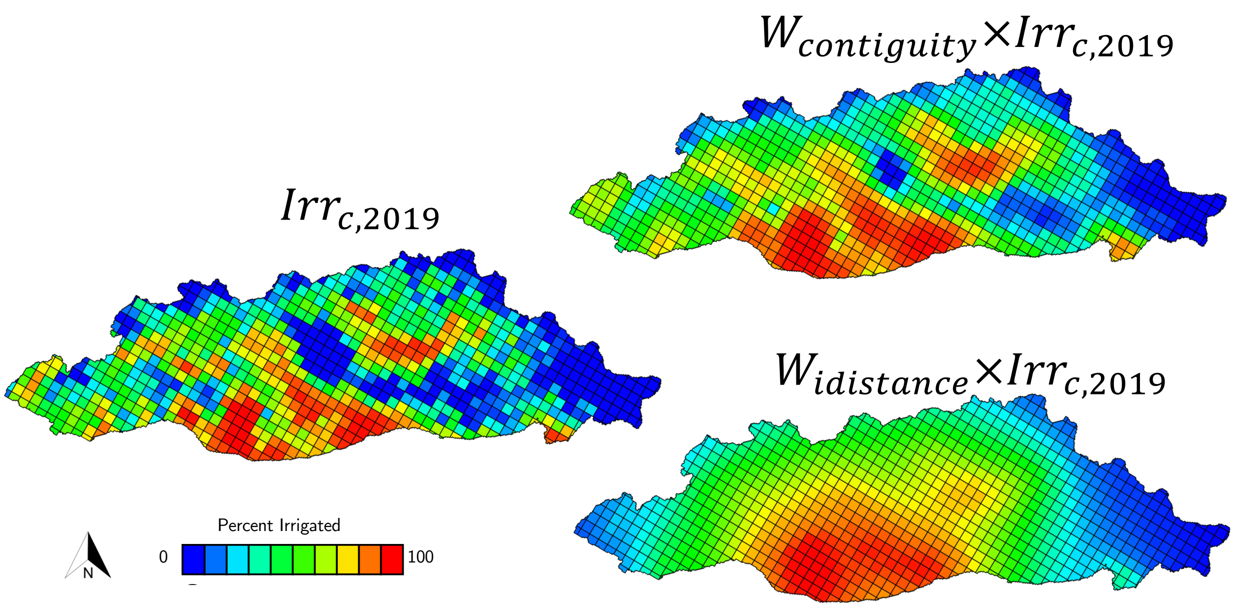
The top panel shows topographical variation in the study area using 5km grid cells. Low values in this Terrain Index denote areas that are relatively low and flat, while high values indicate areas that are high and steep. The bottom panel shows the distribution of irrigated cropland, which closely matches the distribution of low, flat terrain.

Figure 8: Elevation Histogram of Southeastern Anatolia



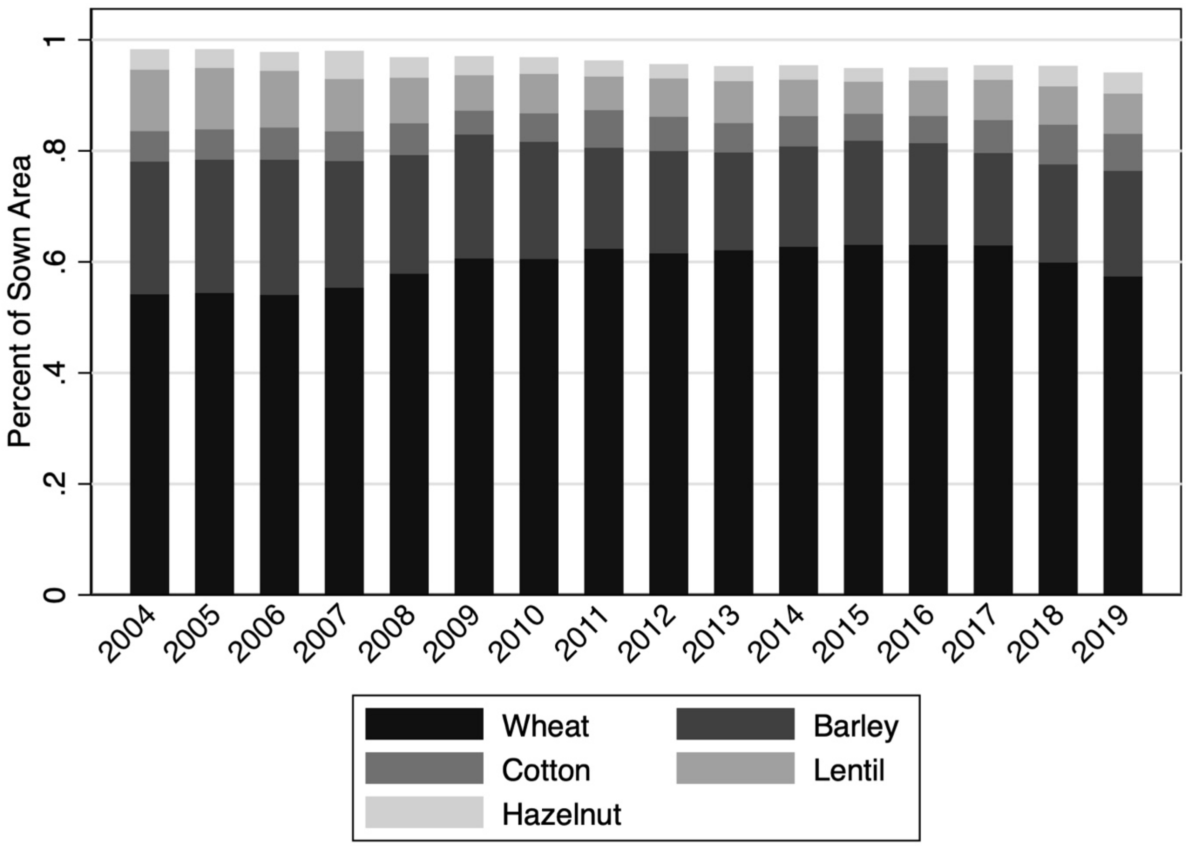
The histogram above shows the elevation profile of the study area. Mountainous areas are clearly identifiable as a long right tail in the distribution. The solid line denotes an altitude cutoff used to eliminate mountainous areas from the sample, and the dashed line shows a more aggressive geographic restriction used for robustness.

Figure 9: Effect of Spatial Weights on the Irrigation Variable



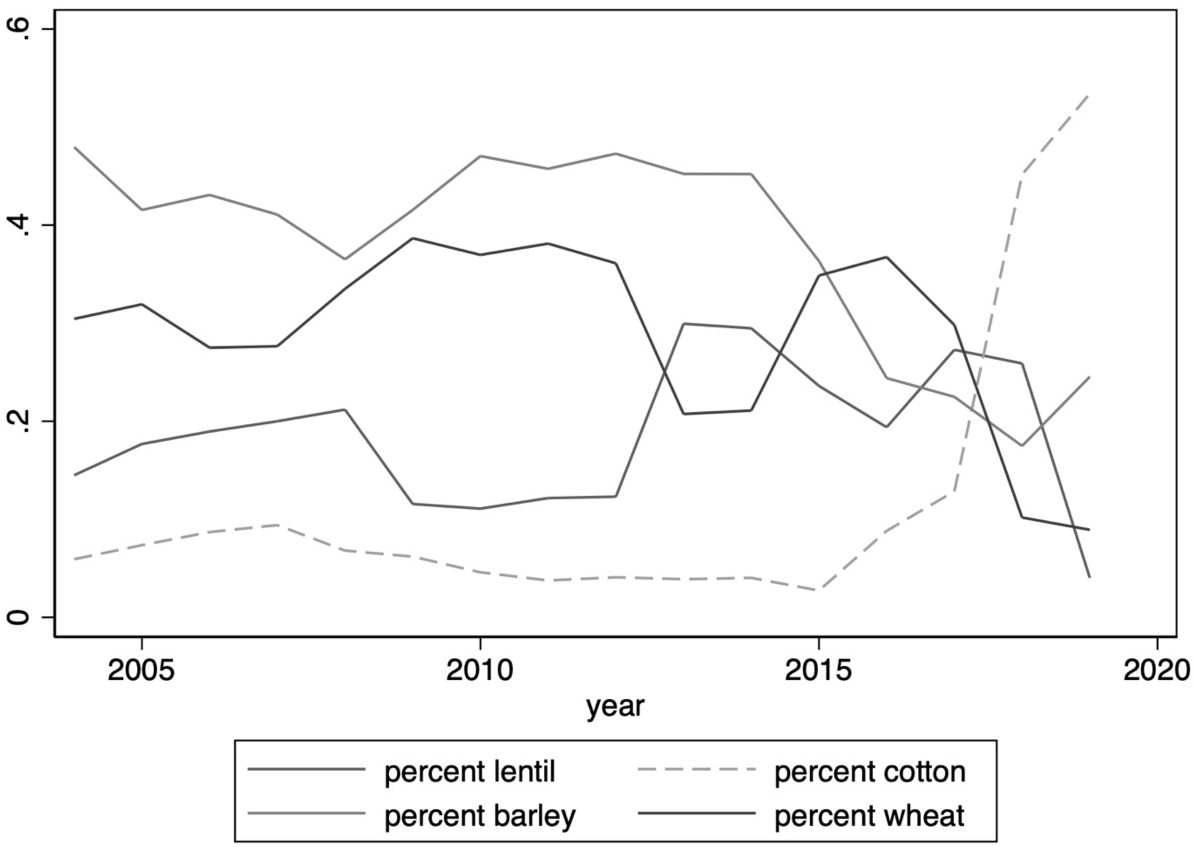
The map on the left shows the spatial distribution of the irrigation variable in 2019. The map on the top-right demonstrates the effect of an interaction between the irrigation variable and a binary contiguity spatial weighting matrix. The map on the bottom-right demonstrates the effect of using an inverse distance weighting matrix.

Figure 10: Southeastern Anatolia Crop Production Statistics



The chart above shows the relative shares of five major crops in terms of sown area. Wheat is by far the dominant crop, making up roughly 60% of sown area.

Figure 11: The Effect of Irrigation on the Crop Mix in Suruç

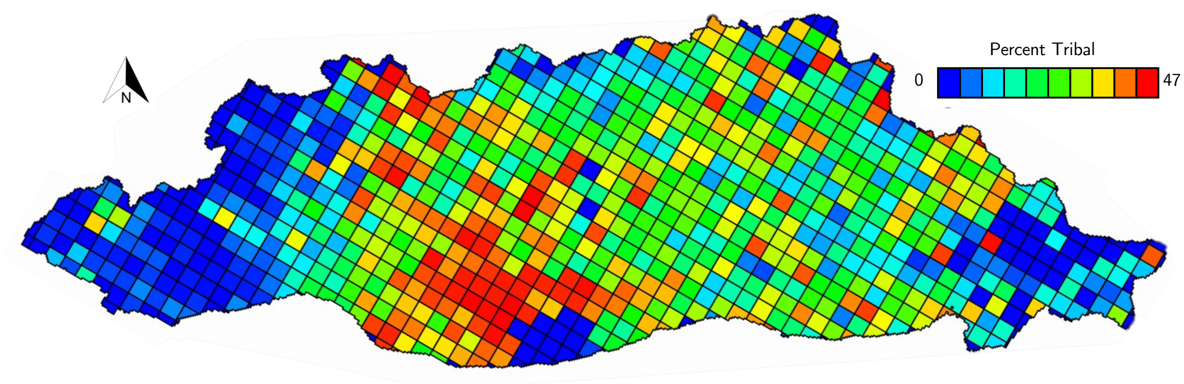


Prior to the introduction of irrigation in 2016, the dominant crop in Suruç was barley. Lentils and wheat were also grown interchangeably. Following the introduction of irrigation, the production for all three of these crops declines sharply, while production of cotton surges.

Figure 12: Crop Yield Sensitivity to Rainfall Shocks

The yields for five major crops over time are shown above. In 2008, Southeastern Anatolia experienced a severe drought. Yields for all non-irrigated crops decline sharply. Cotton, which is almost exclusively irrigated, suffered a much smaller decline in yields.

Figure 13: The Spatial Distribution of Tribes in Southeastern Anatolia



The choropleth map above indicates the proportion of ballot boxes in a 10km cell displaying tribal bloc-voting behaviour.