Proxy of Cropland Production

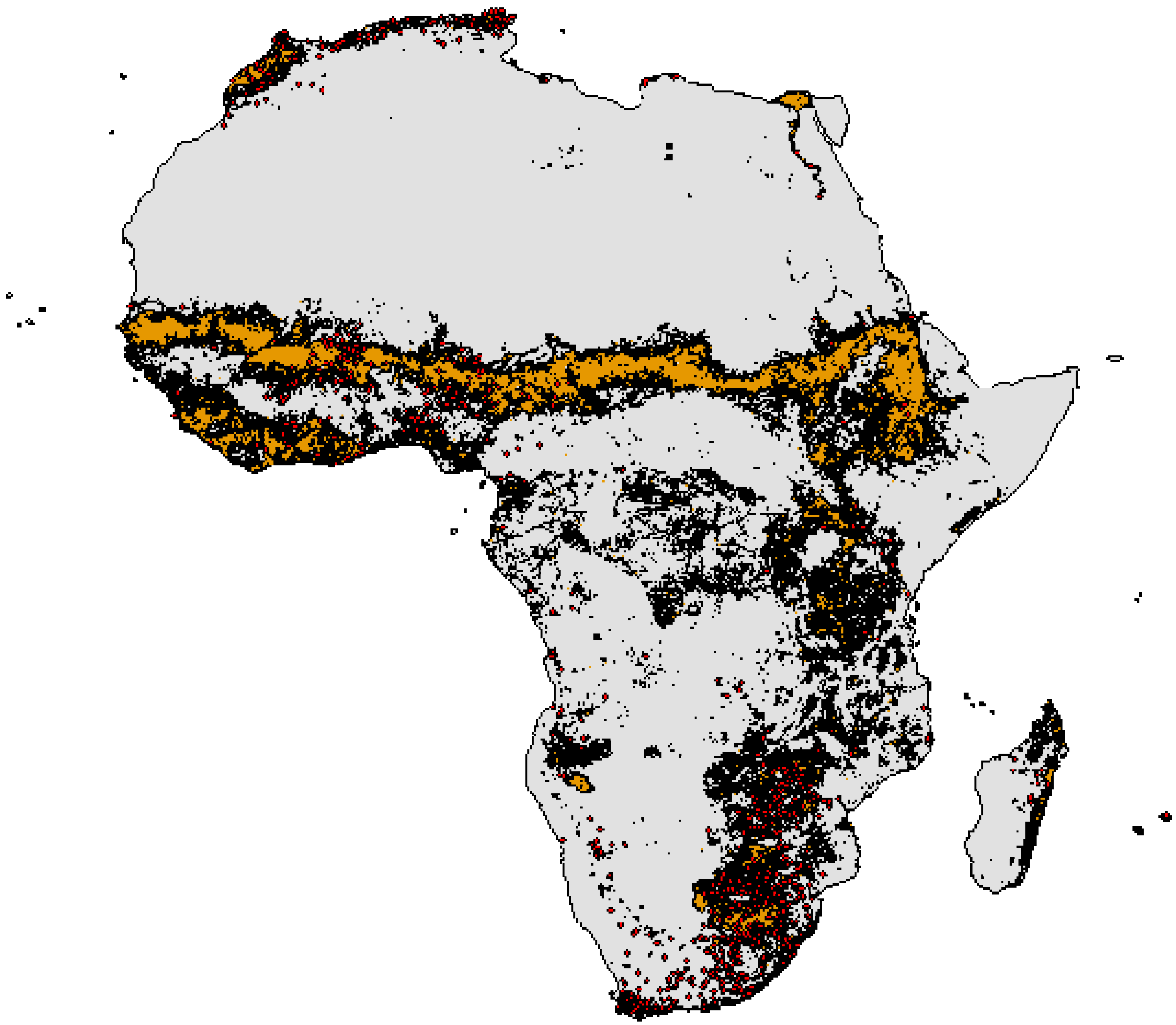
- Note: No agricultural data available for our regional unit of analysis

- Challenge:
  1. Identifying cropland within our regions
  2. Finding a proxy for cropland production
- For (1) we use Global Land Cover 2000 data, which classifies land at 1 km resolution into 22 categories (3 of which refer to cropland)

  - Main roblem with using this to identify relevant croplands: Time invariant ("Dumb Farmer Bias")

Proxy of Cropland Production

Cropland



Proxy of Cropland Production

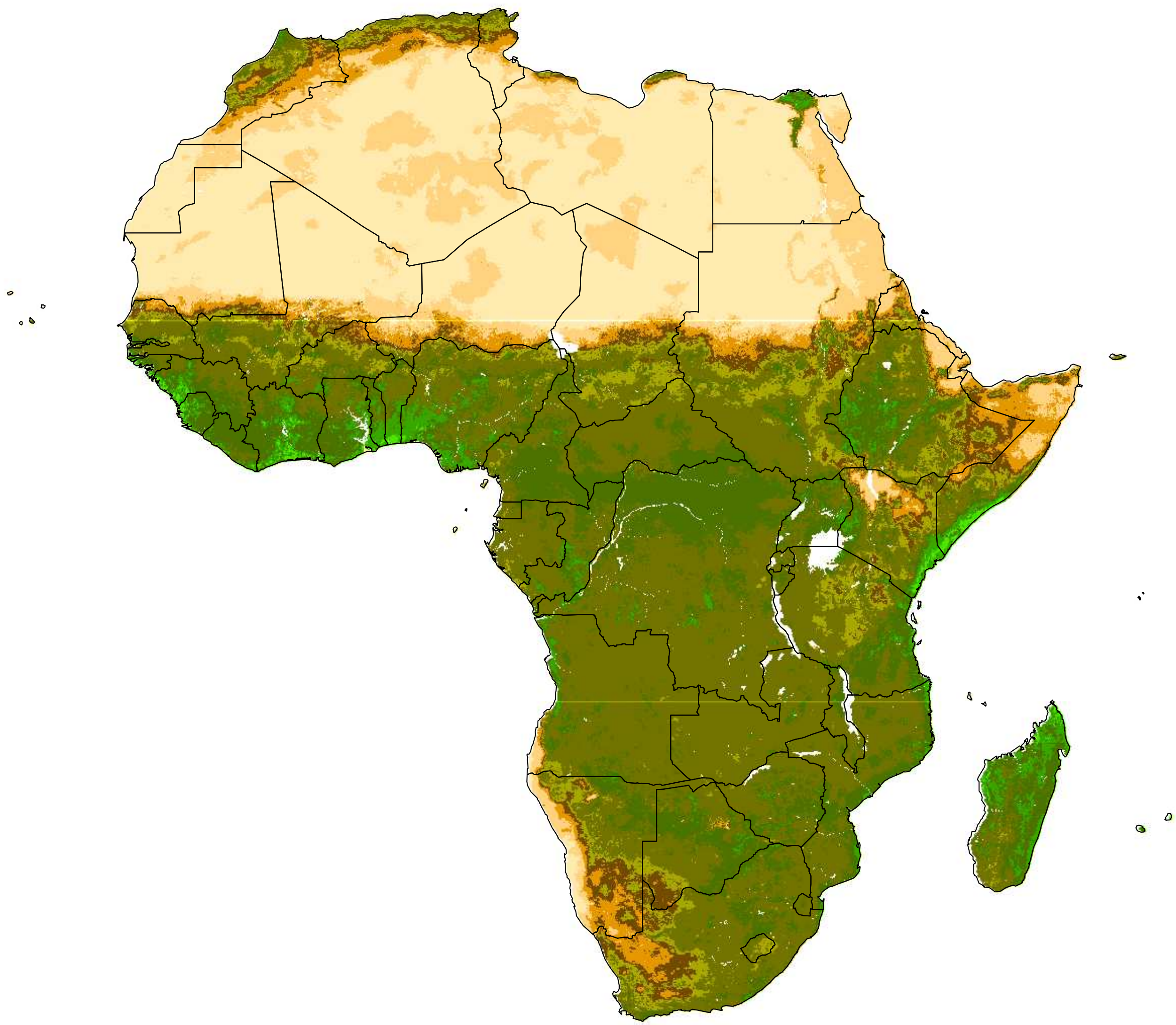
- For (2) [proxy for cropland productivity] we take advantage of the concept of *Net Primary Production*
- *Production*: “creation of new organic matter”
- *Primary Production*: “the synthesis and storage and storage of organic molecules during the growth and reproduction of photosynthetic organisms”
- *Net Primary Production (NPP)*: “the amount of primary production net of the plant respiration” – roughly this is the net amount of energy stored in plant biomass
- NPP is intrinsically related to crop yields
- NPP of cropland may change because of (a) shifts in types of crops, (b) management practices, and/or (c) climate

Proxy of Cropland Production

- NPP of cropland is difficult to measure ‘locally’ (usually done with crop yield data)
- But can be derived from remotely sensed (satellite) data
- More precisely, since there is a (a) relationship between the spectral reflectance of plant biomass and the absorption of solar radiation by plants and (b) a relationship between the absorption of solar radiation by plants and their NPP
- → can use satellite snapshots of spectral reflectance to calculate NPP!
- Here we use the NPP data produced from NASA’s GLO-PEM model, which provides values 10 day values for 8km*8km cells covering the world’s land area over 1981-2000
- Example:

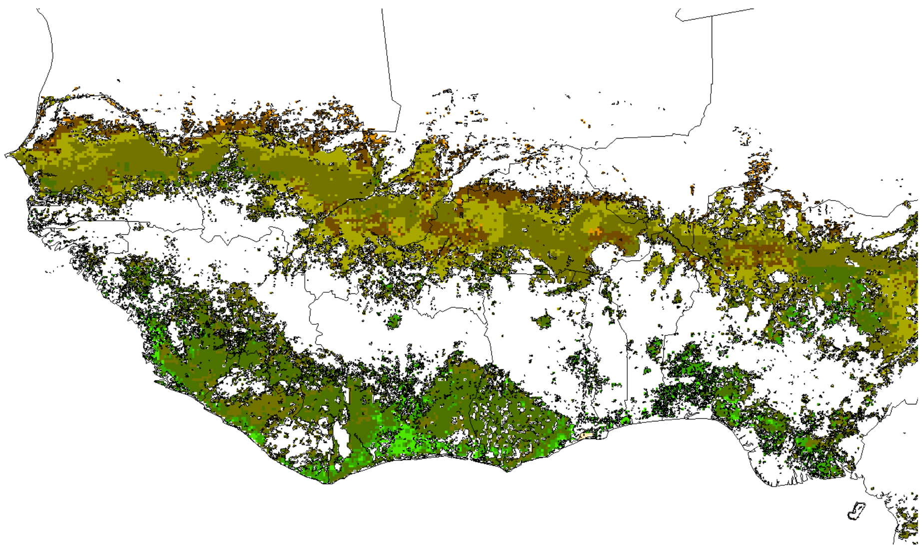
Proxy of Cropland Production

Africa 2000

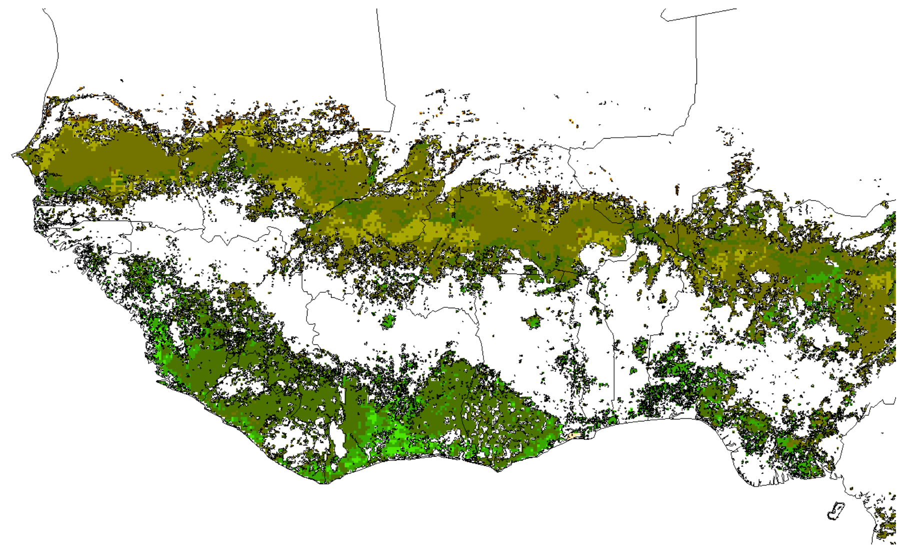


Proxy of Cropland Production

Western Africa 1988



Western Africa 2000



Proxy of Cropland Production

- We calculate average annual values of NPP for each year for the cropland area of each of our `regions’ (note : not all regions have cropland)

Econometric Estimation

- Want to estimate:

$$CropProd_{it} = \alpha + \beta_1 Dams_{it} + \beta_2 UDams_{it} + \beta_3 X_{it} + \varepsilon_{it}$$

- But, there is likely to be an endogeneity problem – i.e., dams are unlikely to be randomly allocated across regions

- Regional fixed effects can take care of the time invariant unobservables, but for the time varying ones we don't have much control variables (only population density)

- Duflo and Pande (2007) 'solve' this by (a) predicting dams at the higher state level by the share of dams in a state prior to their sample period and multiplying this by total dams in India, then (b) multiply this predicted variable by river gradient categories

- Note: (b) can be justified on engineering grounds, but (a) implicitly assumes that the *relative* state allocation of dams by river gradient is independent of their dependent variable(s) of interest

Econometric Estimation

- Thus, they make some ‘implicit’ assumption about the underlying policy of dam allocation decisions

Our approach:

- Here we take advantage of an explicit and arguably ‘exogenous’ policy behind dam allocation

“Fact” #1: rivers and river basins are transnational in Africa

“Fact”#2: most transnational water related events have been ‘positive’ → a lot of cooperation in water management in Africa

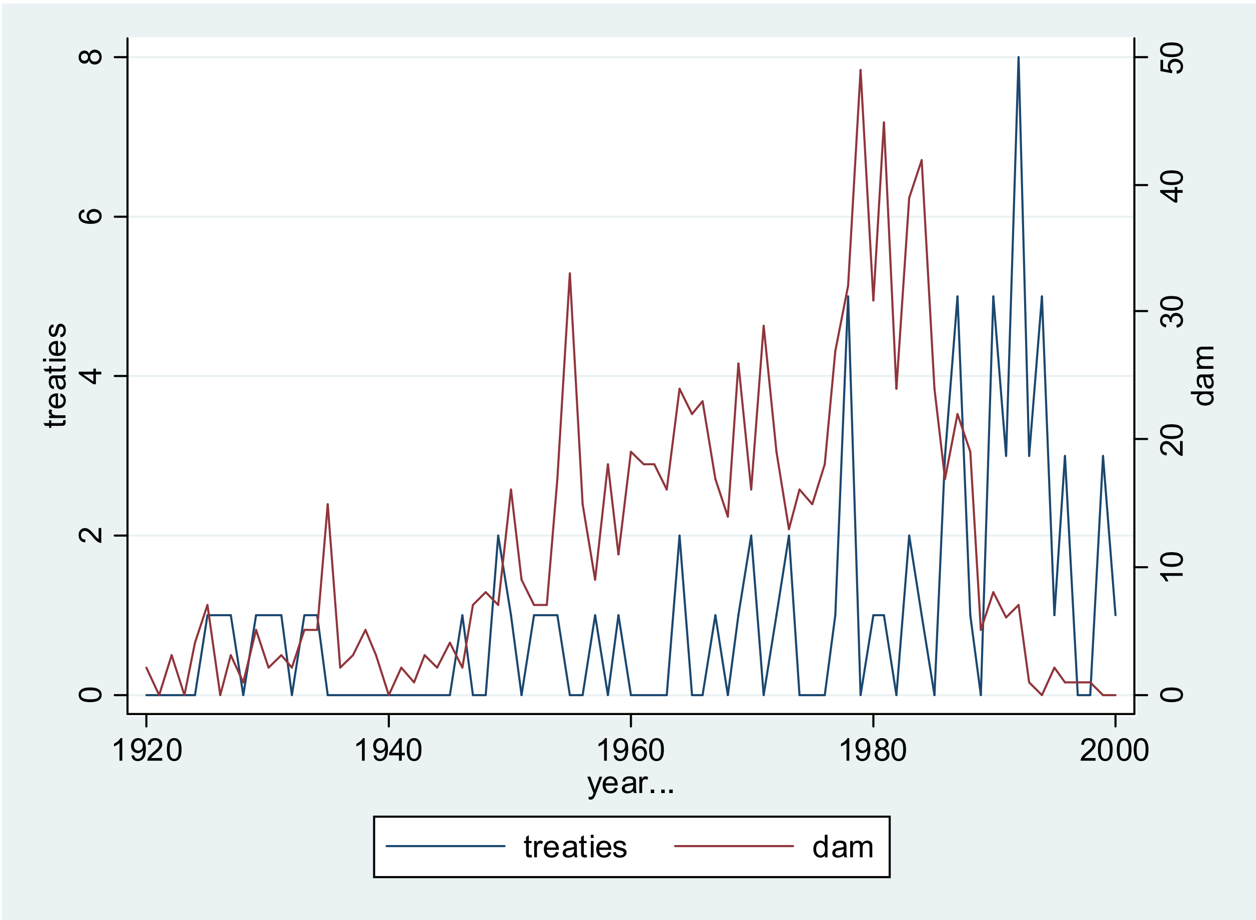
“Fact” #3: a significant part of dam allocation has been in response to transboundary agreements

  - This started in colonial times And continued after political independence
  - Reasons include that both upstream and downstream communities can benefit and tranboundary ‘agreements’ attracted more funding from the World Bank

Econometric Estimation

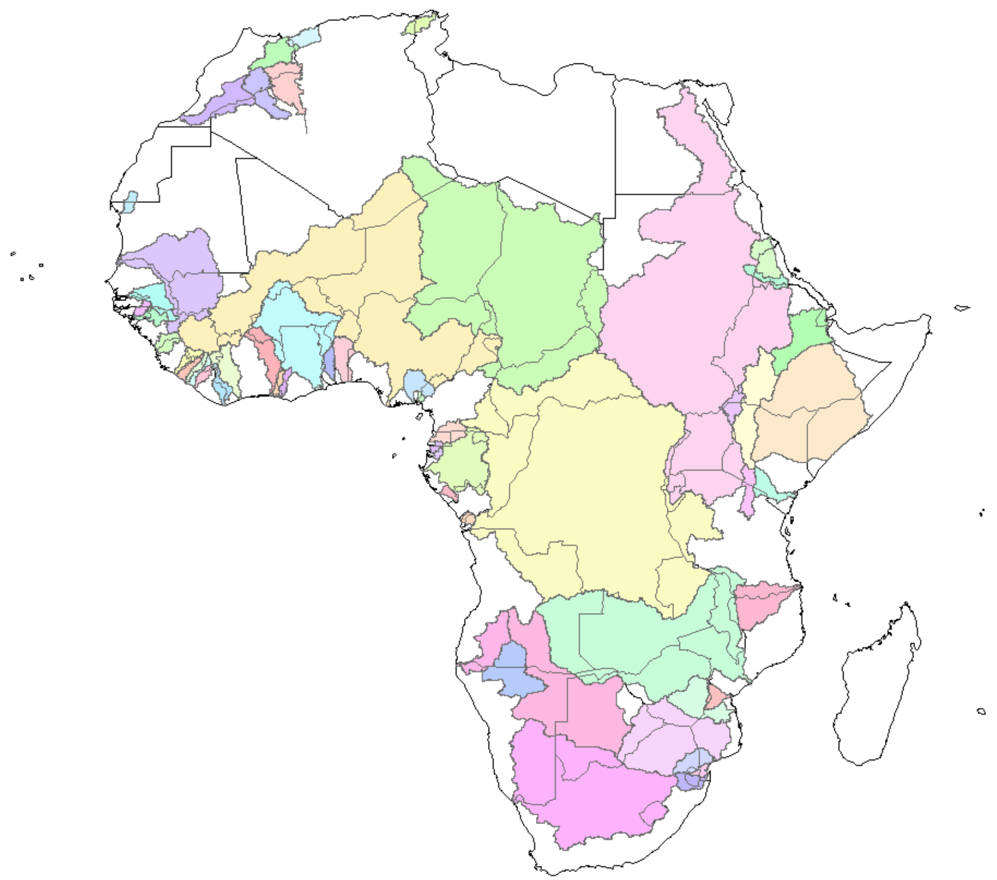
One can use International Treaties Database & International Basins Institutions Database to construct 'dam related' agreements to capture this:

Treaties and Dams Constructed



Econometric Estimation

- Arguably treaties are important time varying determinants of dam construction
- Note: each treaty is signed by two or more nations and refers to one of 59 (1-3 digit Pfaffstetter code) basins:



Econometric Estimation

- Our Instrumental Variable Strategy:
  a. We construct the cumulative 5 year moving average of 'agreements' affecting each of our local level 6 digit regions over our sample period
  b. Multiply these by river gradient categories of each level 6 region
  c. Use these to predict the number of dams constructed in each level 6 region
  d. Use predicted dams as instruments

- Justification for use of treaties: they (1) precede dam construction and (2) are at a much higher level than the treaties

Econometric Results

First Stage Regression

	(1)	(2)	(3)
T(5)	0.132**	0.041**	
	(0.047)	(0.014)	
T(5)*LOW		1.213*	
		(0.564)	
T(5)*MEDIUM		1.359**	
		(0.512)	
T(5)*HIGH		0.567*	
		(0.235)	
T(10)			0.022***
			(0.006)
T(10)*LOW			0.731**
			(0.337)
T(10)*MEDIUM			0.751**
			(0.316)
T(10)*HIGH			0.413***
			(0.137)
DAMS:	ALL	ALL	ALL
FE	Yes	Yes	Yes
# Obs.	142620	142620	142620
# Areas	7131	7131	7131
F-Test	8.05**	6.37**	30.97**
R^2	0.014	0.017	0.017

Econometric Results

Second Stage Regression

	(1)	(2)	(3)	(4)	(1)	(2)
DAM	0.006**	0.004	-0.027	-0.040	-0.095	-0.074
	(0.001)	(0.005)	(0.183)	(0.183)	(0.393)	(0.328)
UDAM	0.033**	0.019**	0.243**	0.236**	0.514**	0.425**
	(0.002)	(0.006)	(0.040)	(0.041)	(0.085)	(0.082)
log($POPDENS_{t-1}$)				-0.010	-0.010	-0.010
				(0.007)	(0.007)	(0.007)
DAMS:	Actual	Actual	Pred. T(5)	Pred. T(5)	Pred. IRRIG.	Pred. OTHER
FE:	No	Yes	Yes	Yes	Cropland	Cropland
# Obs.	72380	72380	72380	72380	Yes	Yes
# Areas	3619	3619	3619	3619	72380	72380
F-Test	186.21**	5.69**	22.75**	15.73**	3619	3619
R^2	0.02	0.16	0.16	0.16	17.38**	11.15**
					0.16	0.16

- Robustness Checks: Neighboring Non-Upstream Dams, Non-Agricultural Areas, further Upstream Dams, 10 ma treaty etc.

Econometric Results

Can Dams Help Alleviate the Negative Effects of Droughts?

- To identify droughts we use IPCC data on monthly rainfall observations across Africa at the 0.5*0.5 degree grid cells over 1901-2000
- In order to identify droughts we use the Standardised Precipitation Index (SPI) - involves fitting rainfall series to a gamma distribution via maximum likelihood
- We then average these over our regions and define a drought as starting when the index first takes a value of less than -1 and ending when it is positive again (McKee et al, 1993) → severe drought
- Over our sample period there is on average a drought 60.8% of the time

Econometric Results

Second Stage Regression – Drought Effect

	(1)	(2)	(3)	(4)
DAM	0.006	0.191	-0.056	0.186
	(0.167)	(0.198)	(0.175)	(0.194)
UDAM	0.218**	0.212**	0.248**	0.205*
	(0.034)	(0.066)	(0.044)	(0.084)
DROUGHT	-0.033**	-0.003		-0.005
	(0.008)	(0.015)		(0.013)
DROUGHT*DAM		-0.228**		-0.214**
		(0.071)		(0.068)
DROUGHT*UDAM		0.013		-0.021
		(0.041)		(0.064)
UDAM(NDR)			0.117**	-0.003
			(0.037)	(0.058)
DROUGHT*UDAM(NDR)				0.123*
				(0.056)
log($POPDENS_{t-1}$)	-0.011	-0.011	-0.010	-0.011
	(0.007)	(0.007)	(0.007)	(0.007)
FE:	Yes	Yes	Yes	Yes
# Obs.	72380	72380	72380	72380
# Areas	3619	3619	3619	3619
F-Test	15.95**	30.27**	23.26**	37.47**
R^2	0.16	0.16	0.16	0.24

Economic Significance

Some “back of the envelope” calculations:

What would have cropland production been if there were no dams in Africa?

- (a) Regressed log of cropland production on log of NPP at the country level → significant positive coefficient of 0.22 (b) used this coefficient and our coefficients on dams variables from regression above to predict annual log cropland production if there were no dams

→ Annual (log) production was **2.88%** higher due to dams

But if one incorporates droughts:

→ Annual (log) production was **0.96%** lower because of dams

Considering only irrigation dams production was around 6.1% higher under both drought and no-drought scenario

Economic Significance

What potential benefits are there from further dam construction?

- Calculated the potential number of dams by examining

    a. Classifying hydrological regions as low/medium/high river gradient

    b. Then using mean number of dams by gradient type (or actual number of dams)

    c. Using estimated coefficients with potential dams to predict potential increase

→ Annual (log) production could increase by **20.0% (17.6% under drought scenario)**

Irrigation Dams only: **49% (38%)**

Concluding Remarks

- We examine for the distributional impact of dams on cropland productivity in Africa
- To this end we 'scientifically' define the relevant upstream/downstream areas and use geographically based proxies derived from mostly from satellite images
- Main Result 1: Dams have (net) negative effect in their vicinity during droughts
- Main Result 2: Upstream dams have (net) positive effect, particularly so during droughts
- Main Result 3: Further dam construction could bring large potential gains

But:

- A growing emphasis in policy circles is now on smaller dams
- Cropland productivity is just one of many distributional aspects…