

Adapting to Monsoon variability in India: the case for Irrigation

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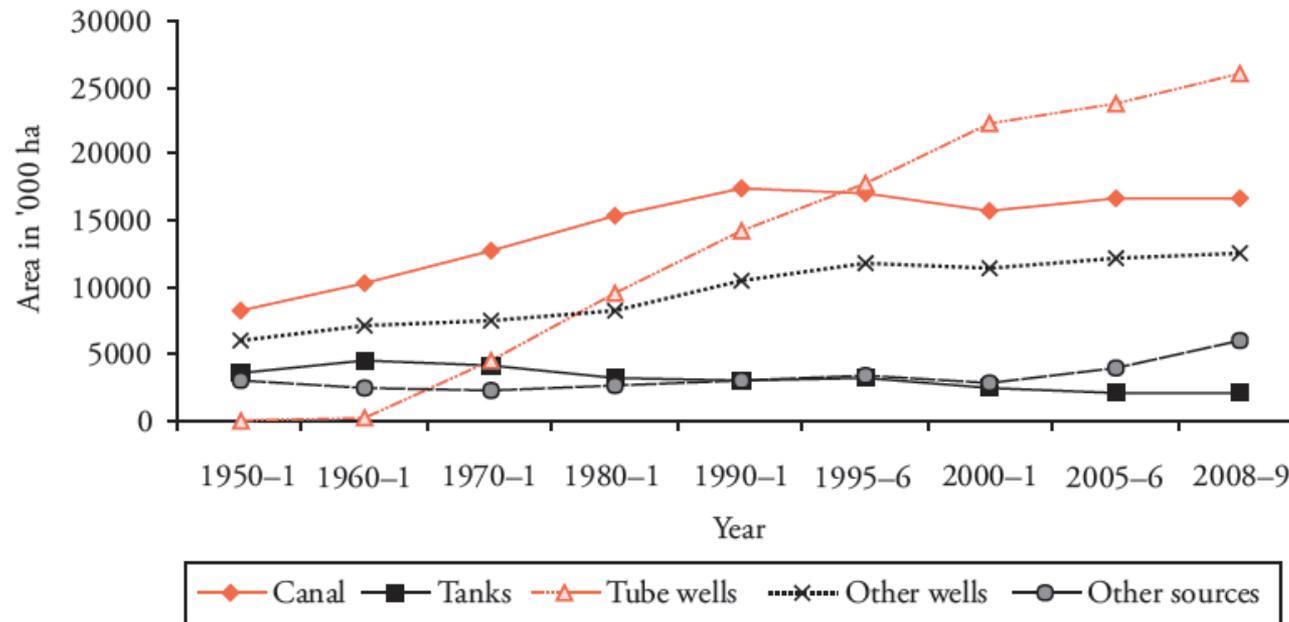
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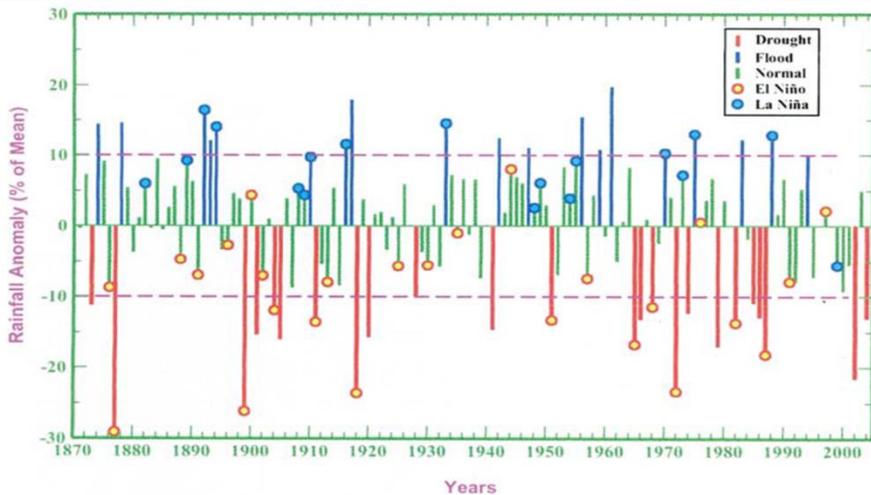
Background



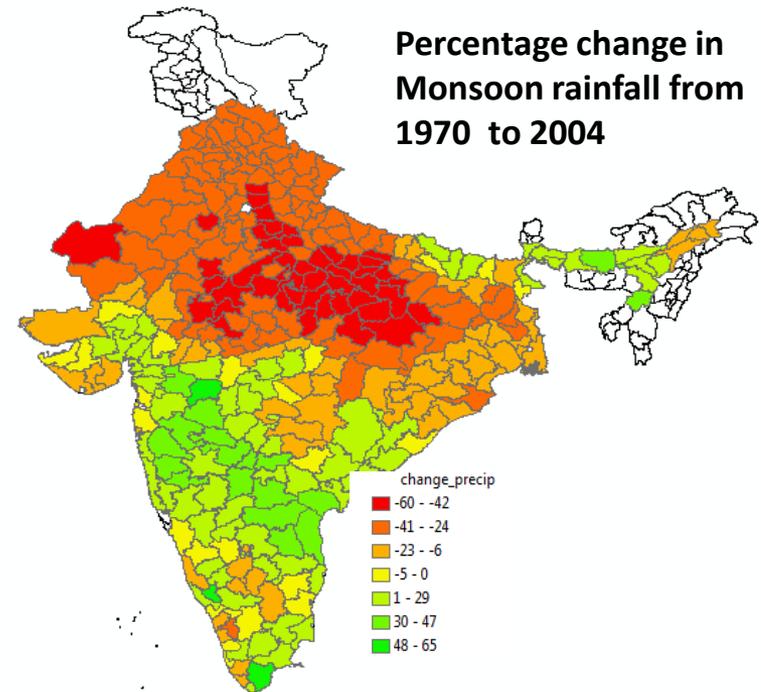
Empirical Model

Step 1: How have crop irrigated areas changed in response to monsoon variability in India?

Variation of all India summer monsoon rainfall anomalies 1874-2004
(Source: Wang, 2006 pg. 865)



Percentage change in Monsoon rainfall from 1970 to 2004



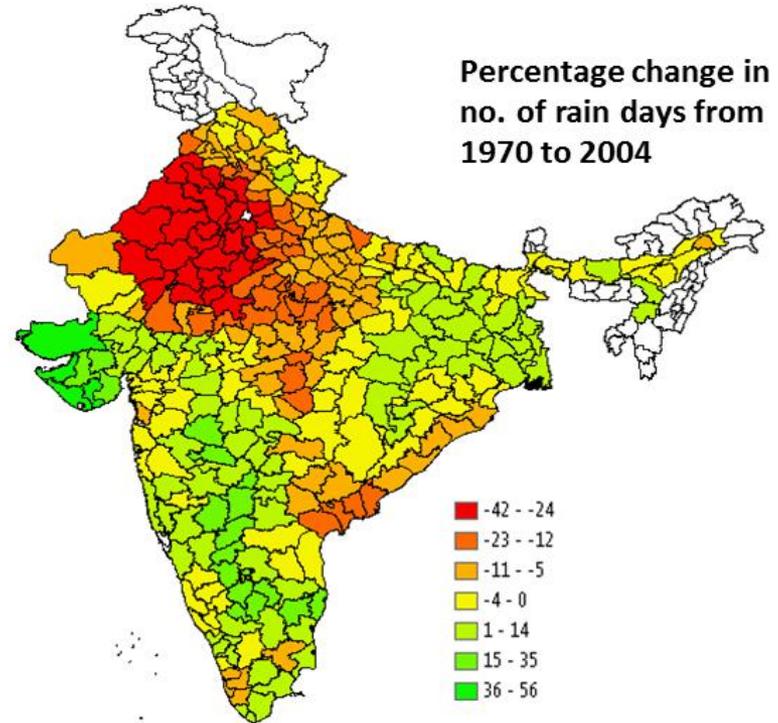
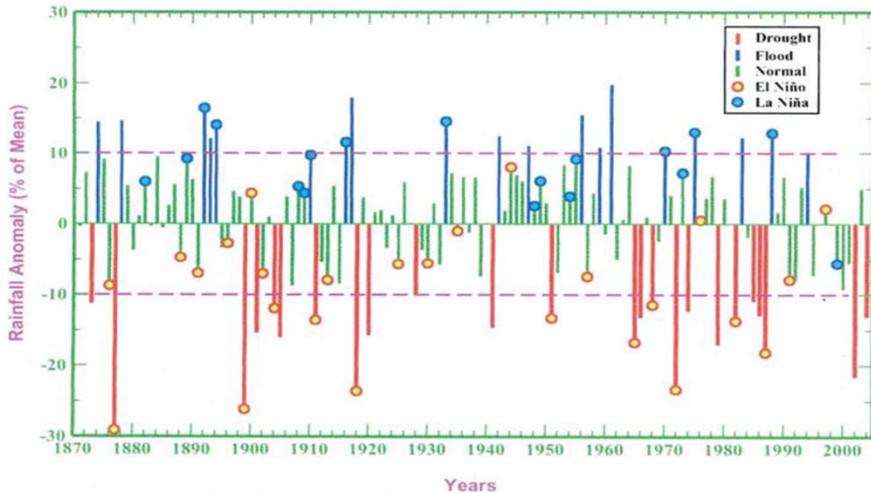
	Season	Crop water need (mm/total growing period)	Sensitivity to drought
Rice	Kharif, Rabi	450-700	high
Wheat	Rabi	450-650	low-medium
Sorghum	Kharif, Rabi	450-650	low

Source: Brouwer and Heibloem (FAO, 1986)

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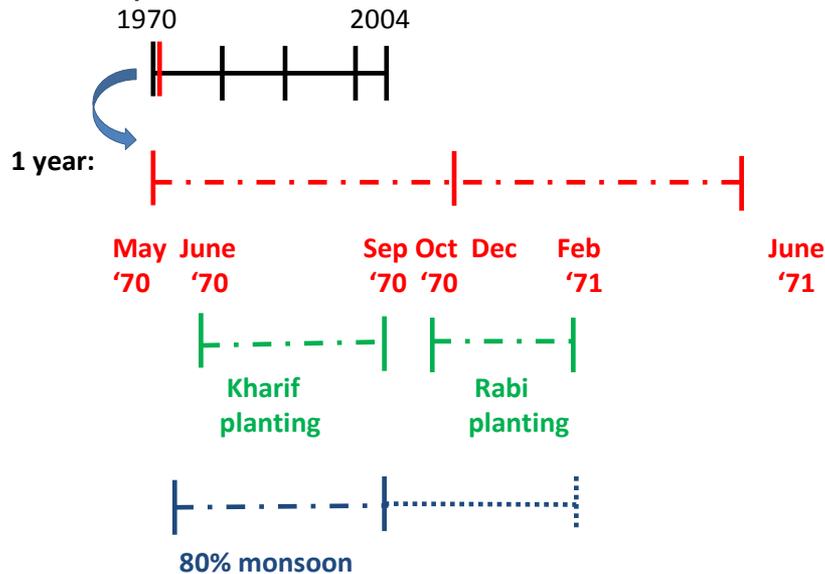
Empirical model

$$Y_{dt} = f(\sum Y_{d,t-i}, \sum W_{d,t-i}, SDD_{dt}, controls), i = 0,1,2,..$$

$$Y_{dt} = \alpha_{00} + \sum \alpha_i Y_{d,t-i} + \sum \beta_i W_{d,t-i} + \beta_2 SDD_{dt} + \gamma_t + \mu_d + \alpha_s t + \epsilon_{dt}$$

$W_{dt} = \{No. of rain days, total precipitation\}$

Historical period: 1970-2004



Major Rabi crop: **Wheat**, mostly grown in the Rabi season across states.

16 states. 311 districts

Dependent variable: Irrigation ratio	Wheat			
	(1)	(2)	(3)	(4)
Lag of irrigation ratio		0.362**	0.363**	0.334*
		(0.123)	(0.123)	(0.130)
2 year lag of irrigation ratio		0.310***	0.310***	0.308***
		(0.059)	(0.059)	(0.087)
3 year lag of irrigation ratio				0.045
				(0.080)
no. of rain days	-0.149	-0.061	-0.054	-0.074
	(0.092)	(0.066)	(0.064)	(0.071)
Lag of no. of rain days			-0.063	-0.075
			(0.047)	(0.057)
Monsoon rain	-0.044	-0.053*	-0.054*	-0.061*
	(0.034)	(0.024)	(0.024)	(0.027)
Lag of monsoon rain			0.047**	0.044*
			(0.018)	(0.019)
Rabi degree days	-0.201***	-0.130*	-0.126+	-0.140*
	(0.047)	(0.063)	(0.066)	(0.061)
Kharif degree days	-0.246	-0.358*	-0.363*	-0.692
	(0.272)	(0.174)	(0.175)	(0.588)
Constant	-22.367***	-3.378	-3.517	0.412
	(1.775)	(2.762)	(2.837)	(5.405)
N	7500	6932	6932	6659
R-sq (within)	0.272	0.517	0.517	0.508

* p<0.05 ** p<0.01 ***p<0.001. All variables are in logarithmic form. Coefficients are elasticities. Standard errors clustered at district level.

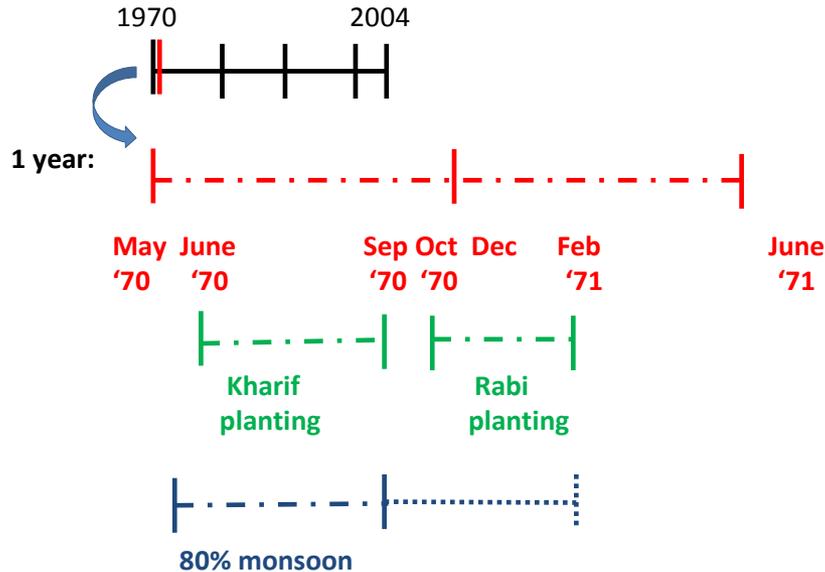
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$W_{dt} = \{No. of rain days, total precipitation\}$

Historical period: 1970-2004



Major Kharif crop: **Kharif Sorghum** grown only in the Kharif season

16 states. 311 districts

Dependent variable: irrigation ratio	Kharif sorghum			
	(1)	(3)	(6)	(7)
Lag of irrigation ratio		0.310***	0.312***	0.313***
		(0.025)	(0.025)	(0.026)
2 year lag of irrigation ratio		0.113***	0.112***	0.086***
		(0.022)	(0.022)	(0.023)
3 year lag of irrigation ratio				0.051*
				(0.025)
no. of rain days	-0.931+	-1.599**	-1.619**	-1.747***
	(0.546)	(0.500)	(0.494)	(0.511)
Lag of no. of rain days			0.436	0.276
			(0.420)	(0.417)
Monsoon rain	-0.948***	-0.808***	-0.802***	-0.863***
	(0.169)	(0.155)	(0.155)	(0.157)
Lag of monsoon rain			-0.013	-0.066
			(0.144)	(0.144)
Kharif degree days	1.525**	0.157	0.158	-0.622
	(0.467)	(0.820)	(0.824)	(2.654)
Constant	-20.627*	-5.505	-7.051	3.726
	(9.097)	(7.775)	(7.993)	(21.106)
N	5736	5353	5353	5162
R-sq (within)	0.149	0.271	0.271	0.273

* p<0.05 ** p<0.01 ***p<0.001. All variables are in logarithmic form. Coefficients are elasticities. Standard errors clustered at district level.

Connection to the Water Balance Model

Step 1: Looking back: How have irrigated areas changed in response to monsoon variability in India?

Step 2: Looking forward: How will future changes in precipitation affect water supply?

-Use projections of precipitation changes to estimate irrigation responses into the future using estimates from Step 1

Connection to the IAM

Step 1: Looking back: How have irrigated areas changed in response to monsoon variability in India?

Step 2: Looking forward: **How will future changes in precipitation affect water supply?**

-Use projections of precipitation changes to estimate irrigation responses into the future using estimates from Step 1

Step 3 : What are the future economic impacts?

-Use empirical estimates from Step 1 to inform demand for water in IAM agricultural sector in response to changes in precipitation

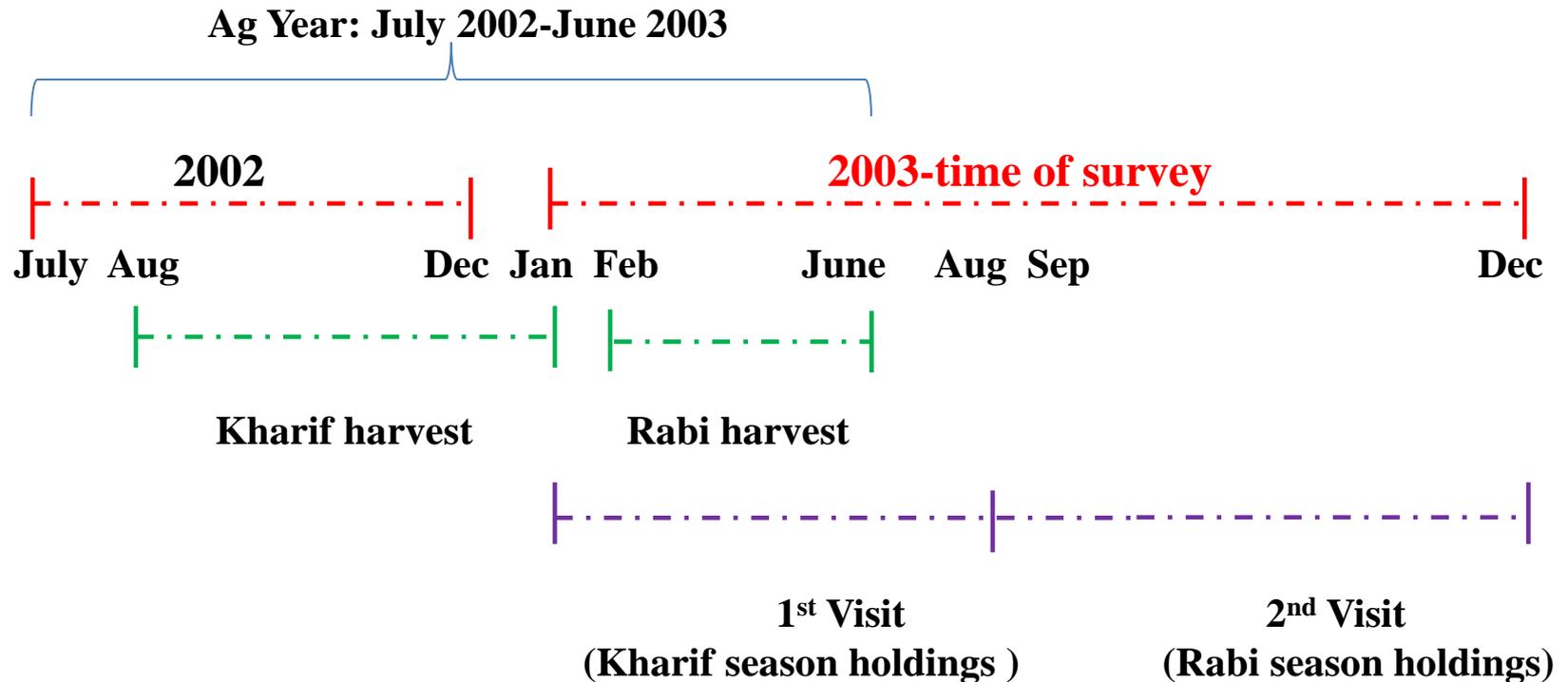
-Use WBM to inform supply side of water resources (fixed factor) in IAM

- Capture changes in crop production and crop trade balance via virtual water trade

Thank you!

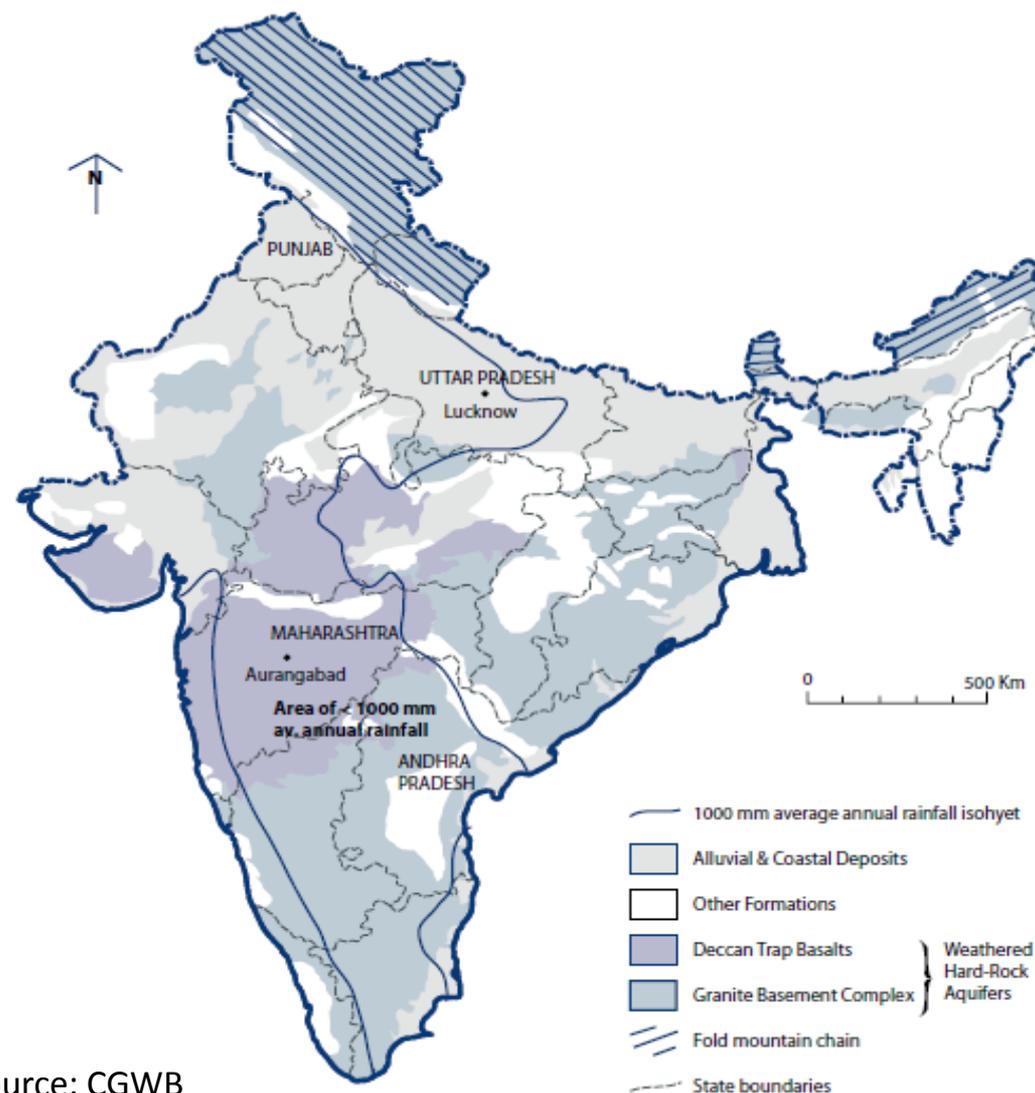
Further extensions

1. Use NSS 59th Round (plot level data) to analyze irrigation decisions



Further extensions

2. Use hydro-geological maps, and type of irrigation to further disaggregate irrigation change



Source: CGWB