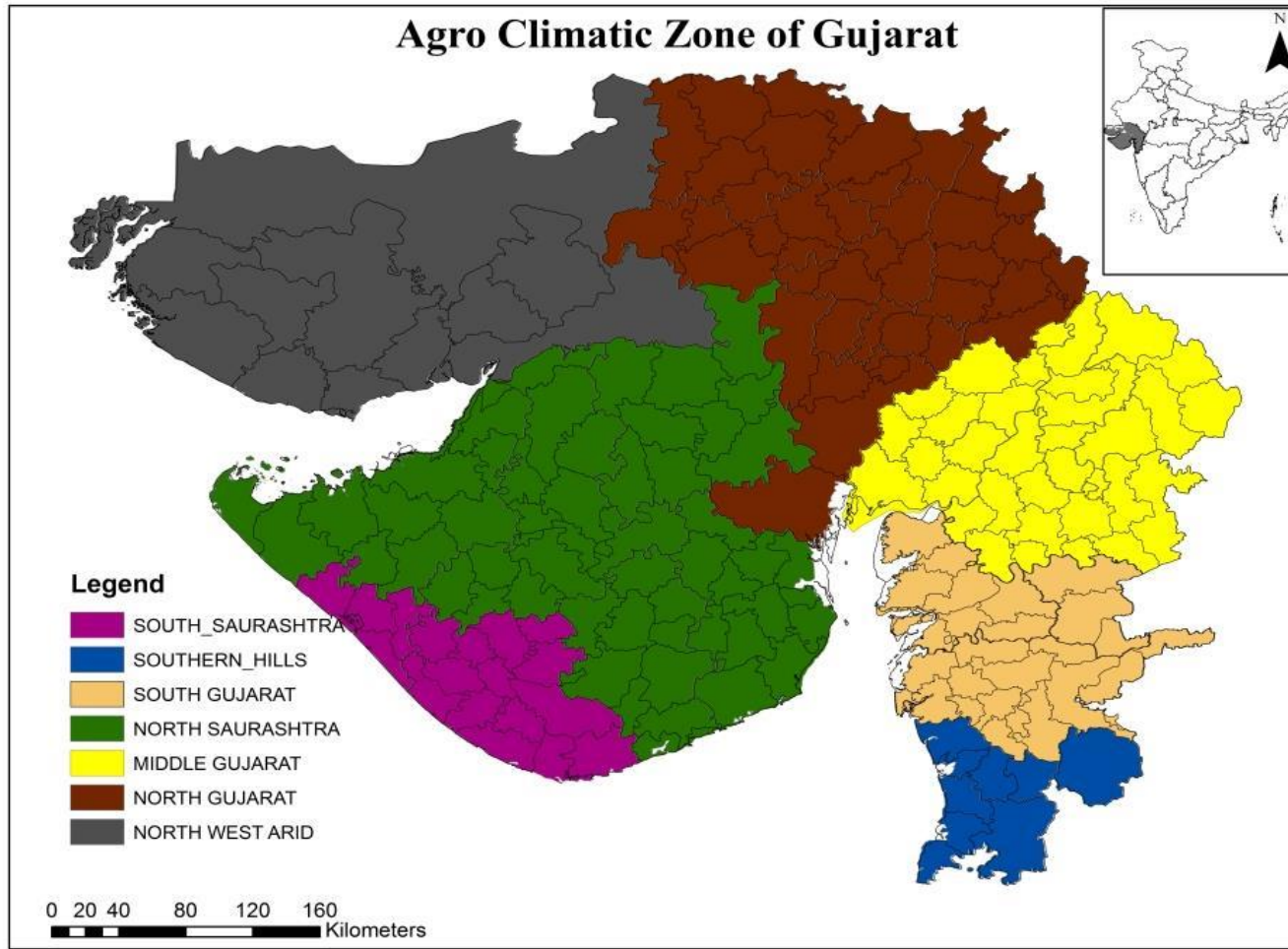


Diffusion of Micro-Irrigation Technologies in Gujarat, Western India: Do Institutions and Policies Matter?

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12th Meeting of the International Water Resource Economics Consortium (IWREC)
Washington D.C.
September 13, 2016

Agro-Climatic Zones of Gujarat



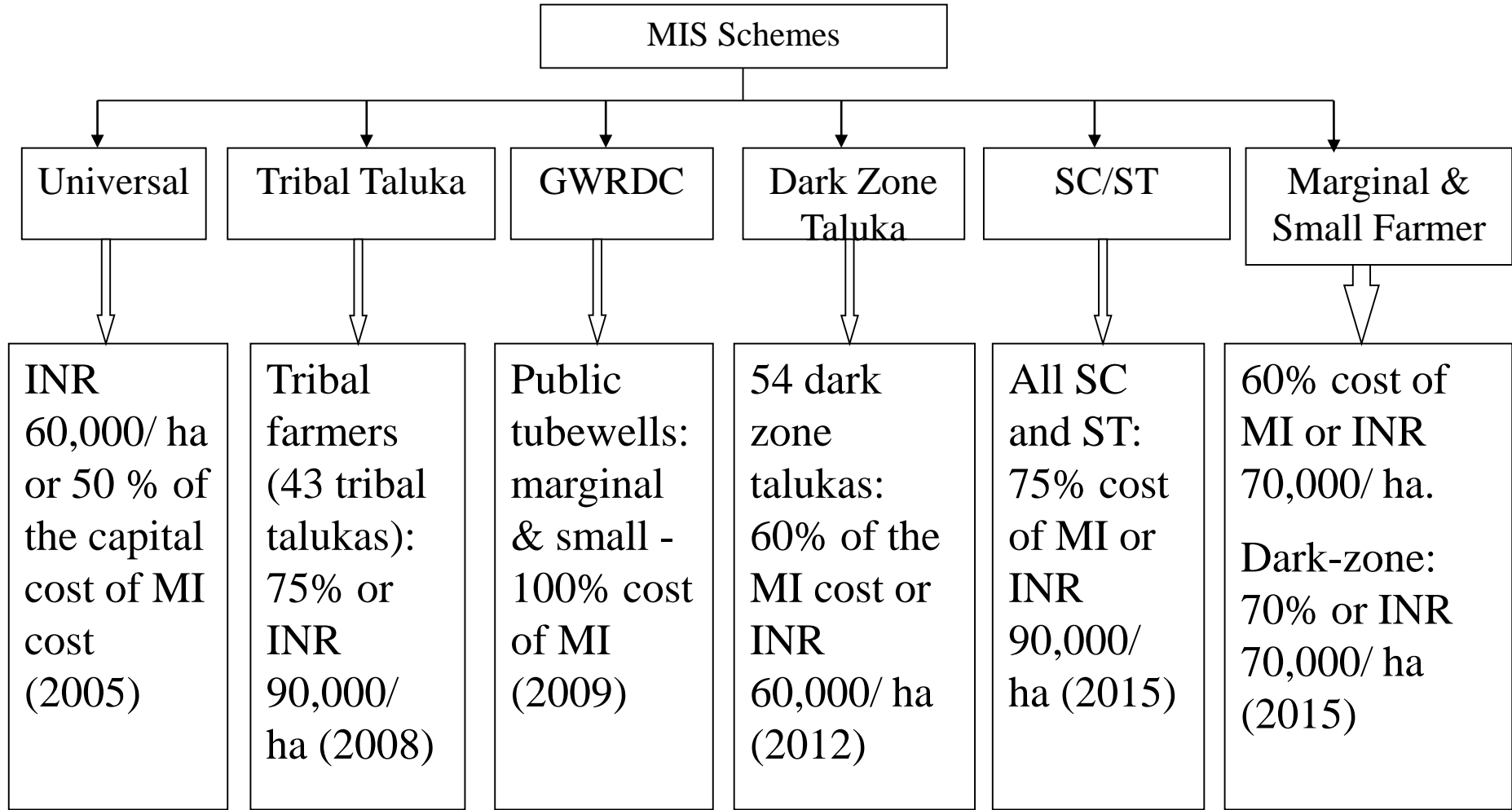
Mostly Arid and Semi-arid Agro-climatic zones

Source: Authors' Map

Introduction

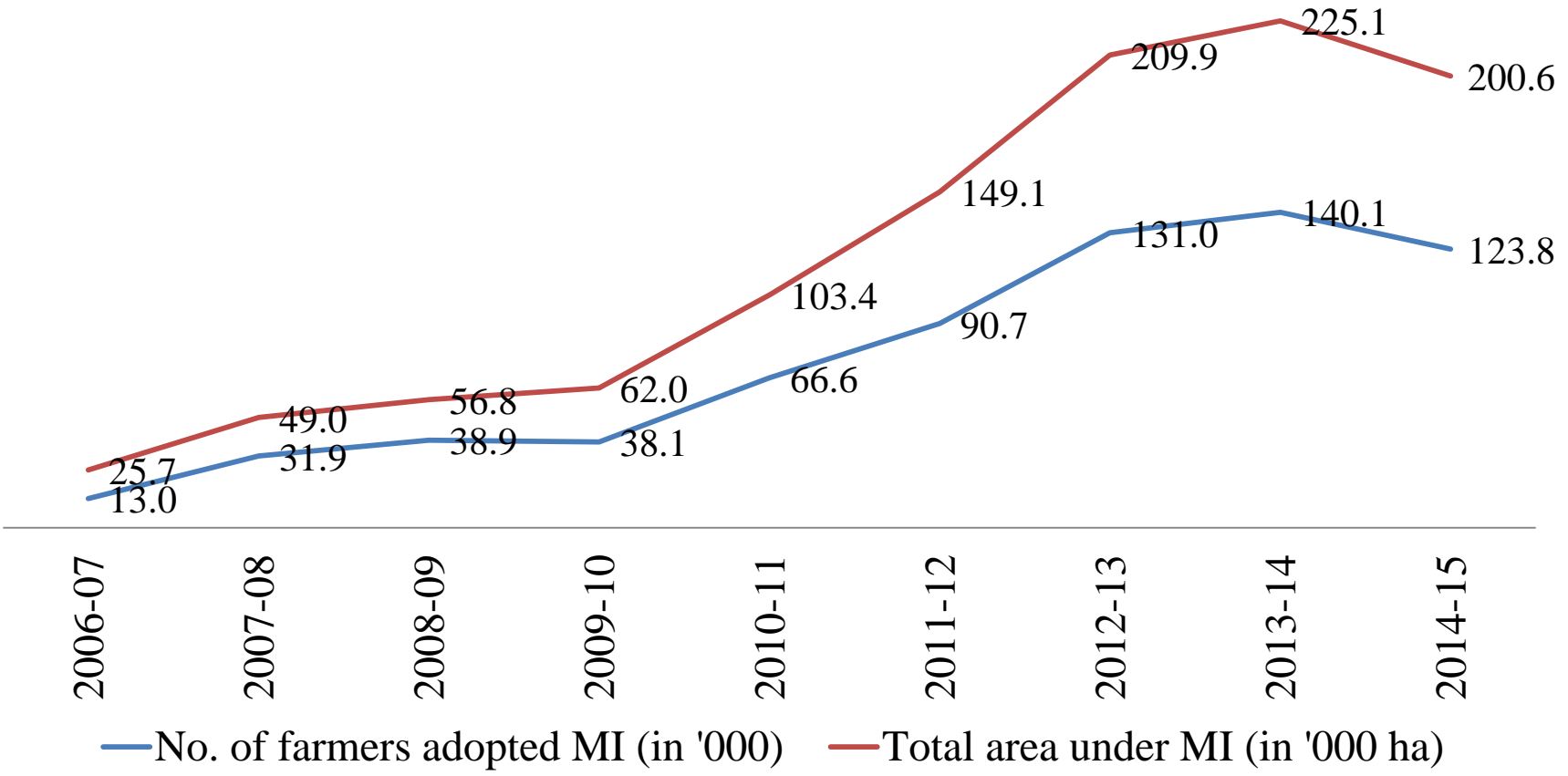
- Gujarat, Western India – Mostly Arid and Semi-arid region
- Water scarcity & depletion of groundwater (Kumar 2005; Narula et al 2011)
 - e.g., SGWD in state: 41% (2004), 75% (2009) & 67% (2011)
 - 9 districts: overexploited (SGWD>100%) and critical (SGWD>85%) (GoI 2014)
- MI: Drip and Sprinkler – ↓ groundwater extraction and energy use – ‘sustainable intensification’ (Fishman et al 2014)
- High likelihood of adoption – water scarce and groundwater based irrigation (Palanisami et al 2011)
- In Gujarat:
 - SPV: Gujarat Green Revolution Company Limited (GGRC) –2004-05
 - Subsidy Policy: caste, landholdings & geographical location
- Do Institutional Interventions and Subsidies enhance diffusion of MI technologies in Gujarat?

MI Subsidy Policy in Gujarat



Source: Authors' based on various GOs of GoG

Trends in MI adoption in Gujarat (2006-07 to 2014-15)

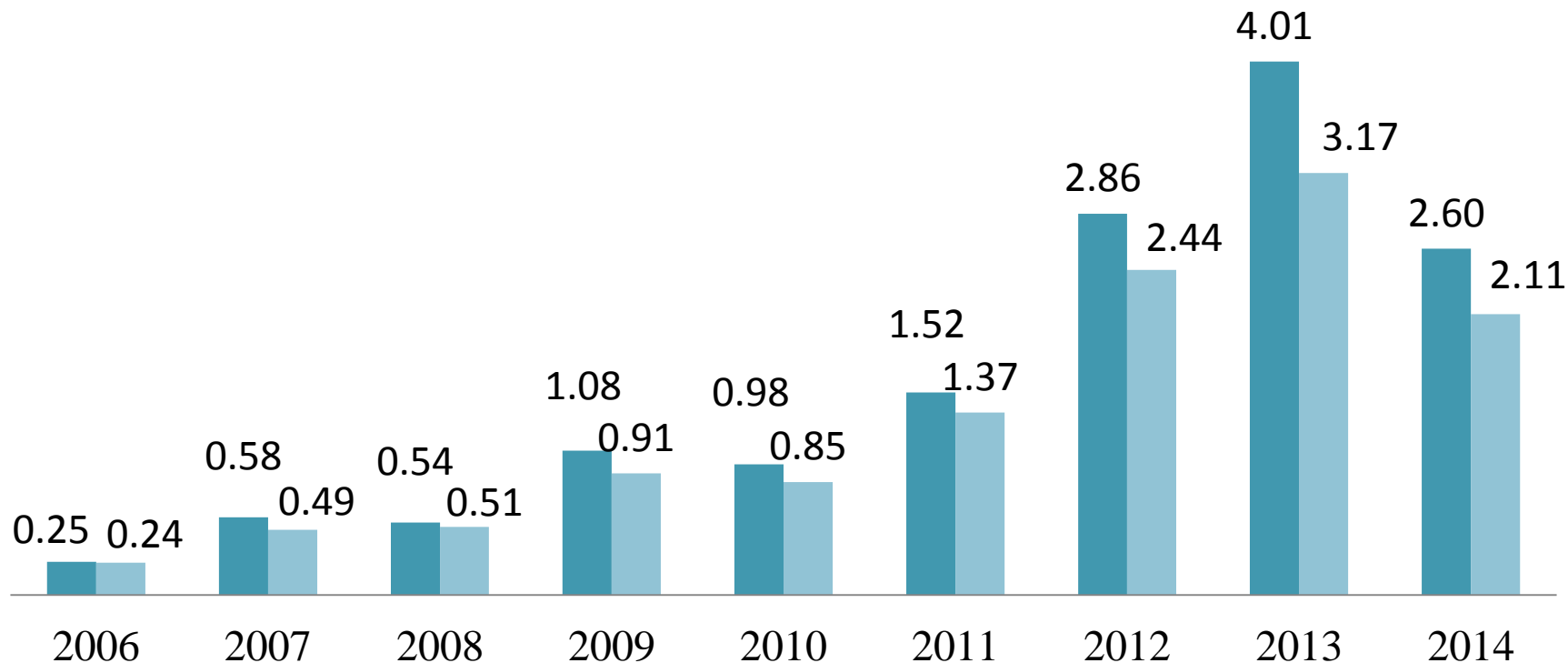


Source: Authors' figure based on data collected from GGRC

Diffusion of MI in Dark-zone Region

Percentage of Farmers and NSA under MI

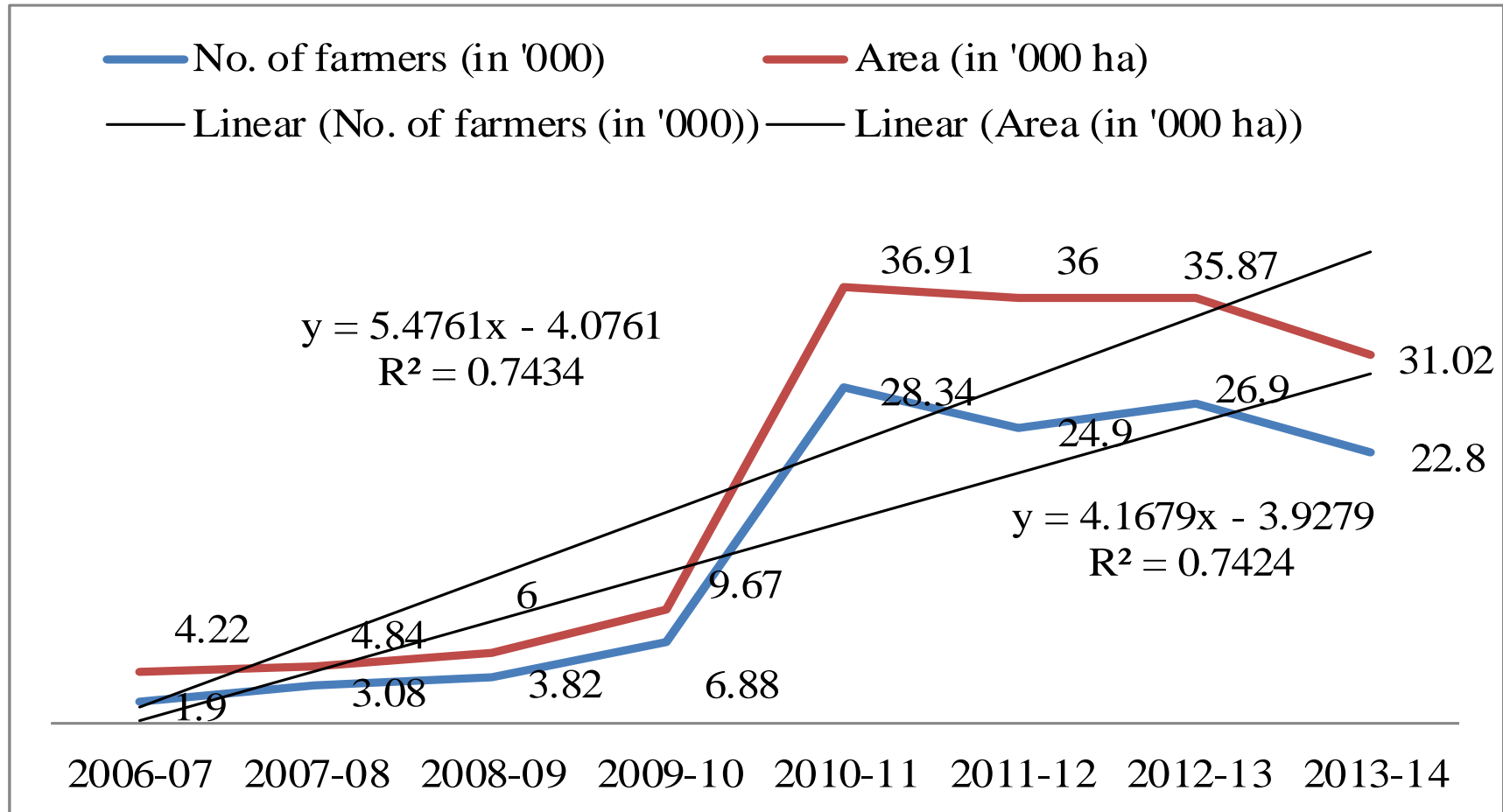
■ % of Farmers ■ % of total NSA



Source: Authors' figure based on data compilation from GGRC

Note: the year 2006 represents the financial year, i.e., April 2006 to March 2007, and it is same up to 2013, and the data for 2014 covers between April and December; NSA- Net Sown Area

Diffusion of MI in Tribal Talukas



Source: Authors' figure based on data compilation from GGRC

Incentives and Diffusion of MI: Empirical Approach

- Additional subsidy – sharp discontinuity in between dark and adjacent talukas
- Following RDD approach, the effects of treatment is estimated as:

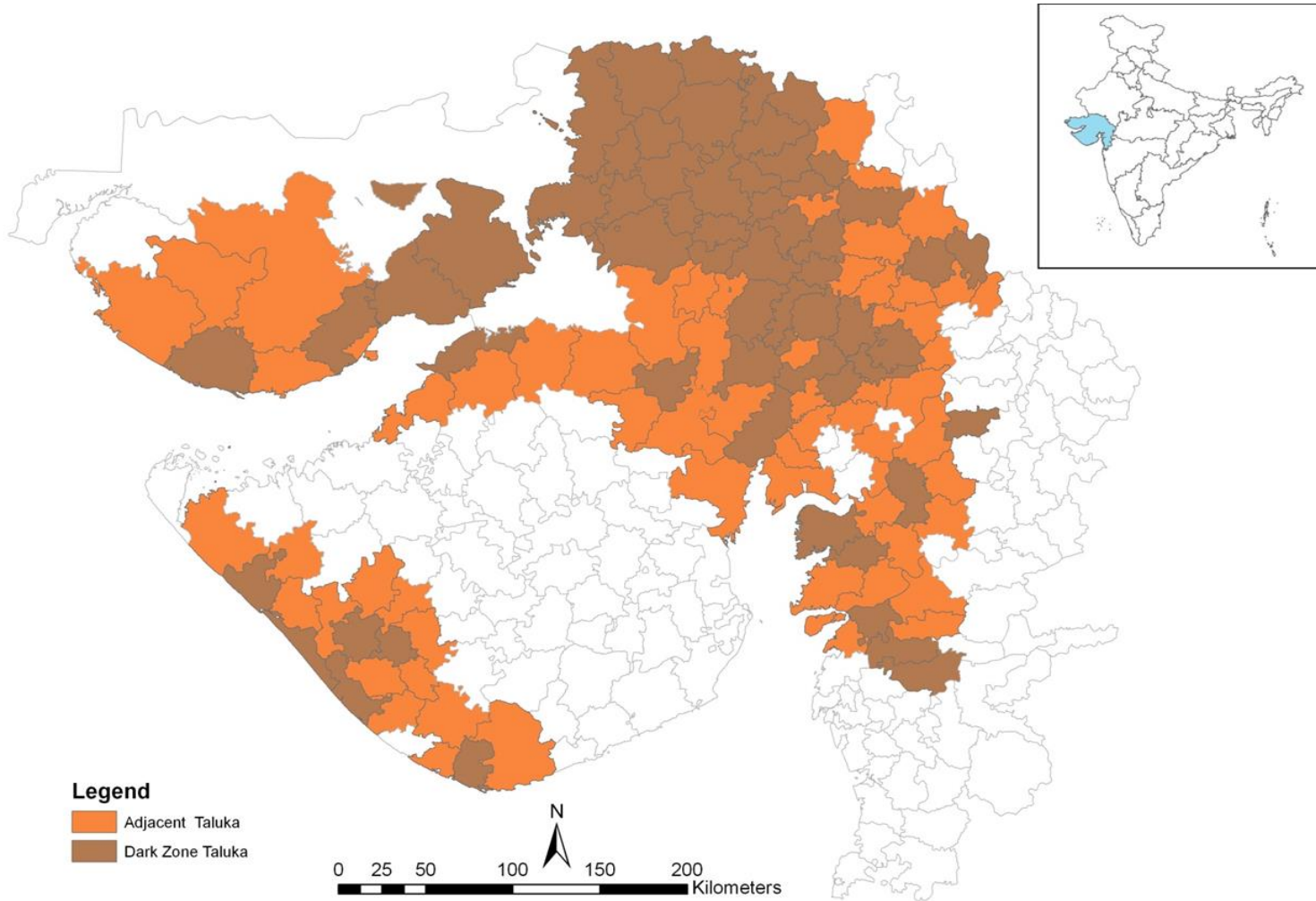
$$Y_{vt} = \alpha_0 + \alpha_1 T_{vt} + \alpha_2 X_{vt} + u_{vt}$$

- Where Y_{vt} - adoption rate of MI and area under MI in village 'v' at time 't'
 T_{vt} - treatment indicator (=1 if village access to extra subsidy)
 X_{vt} - captures other covariates and u_{vt} - error term

- i. All the villages
- ii. Border villages - share border with the adjacent talukas
- iii. Pair-wise difference within border villages

- Unbalanced Panel model

Study Talukas, Gujarat

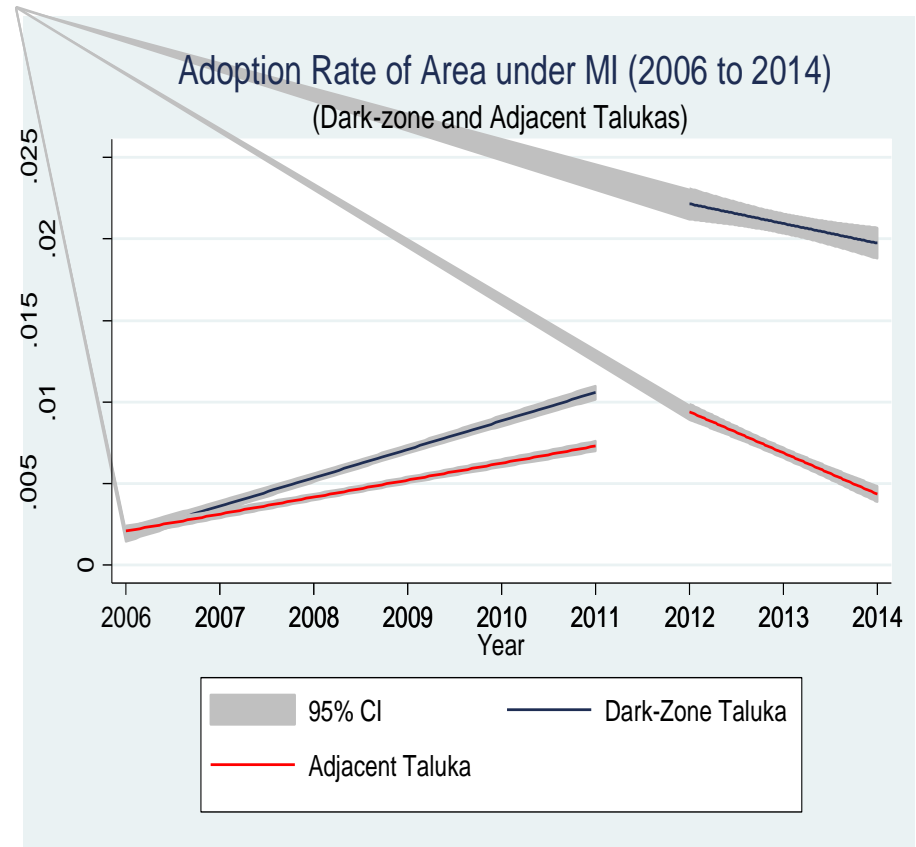
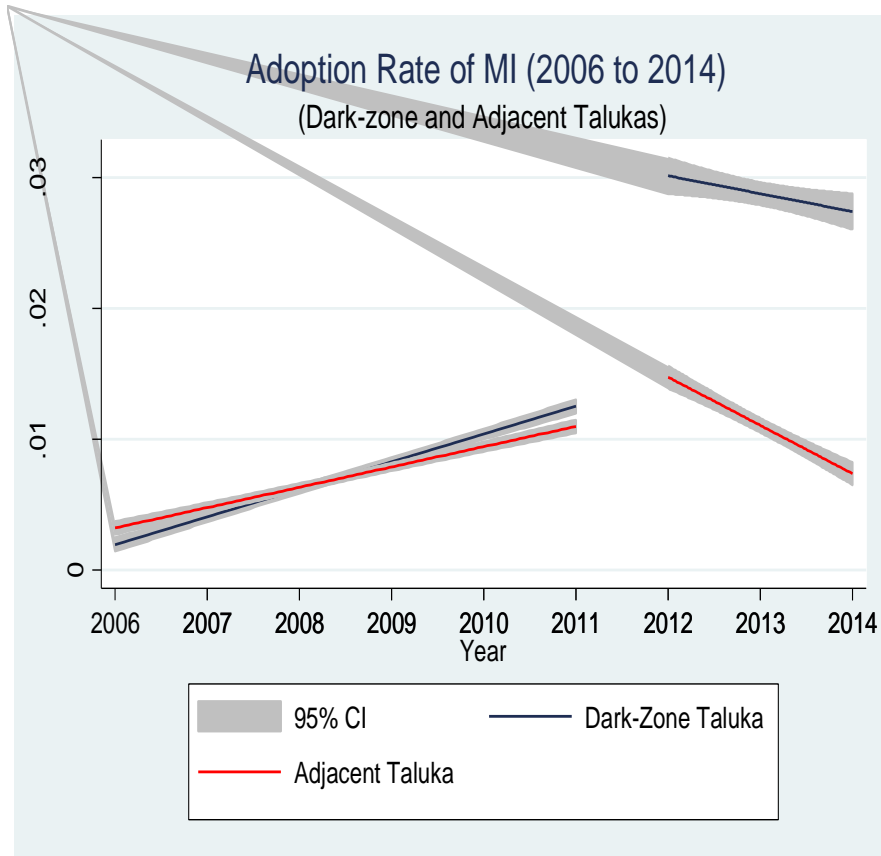


Source: Authors' Map

Data and Methods

- Dark-zone Talukas (52) and Adjacent Talukas (58) – 110 Talukas
- Villages & Towns: 8073 – 4019 in Dark-zone and 4054 in Adjacent
- Border Villages & Towns: 1456 – 855 in Dark-zone and 601 in Adjacent
- Data:
 - GGRC : no. of farmers adopted MI and area (in ha) – 2006-07 to 2014
 - Census (2011): no. of households & village area (in ha)
 - Government reports: taluka wise SGWD (overexploited, semi-critical, critical & safe categories)

Diffusion of MI in Study Talukas



Source: Authors' Figure

Descriptive Statistics

	Full Sample	Dark-zone	Adjacent	Border Village	Difference*
Parameter	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Adoption Rate of MI	0.011 (0.031)	0.014 (0.035)	0.008 (0.025)	0.011 (0.030)	0.005 (0.060)
Area under MI	0.008 (0.021)	0.011 (0.025)	0.005 (0.015)	0.008 (0.019)	0.005 (0.023)
Extra Subsidy	0.163 (0.370)	0.328 (0.470)	0 (0)	0.192 (0.394)	-
Overexploited	0.304 (0.460)	0.61 (0.488)	0 (0)	0.30 (0.459)	-
Critical	0.121 (0.326)	0.124 (0.33)	0.118 (0.323)	0.157 (0.364)	-
Semi-Critical	0.179 (0.383)	0.096 (0.294)	0.261 (0.439)	0.184 (0.387)	-
Safe	0.396 (0.489)	0.17 (0.375)	0.621 (0.485)	0.358 (0.48)	-

Source: Authors' computation

Note: Overexploited (SGWD > 100%); Critical (SGWD: 85-100%), Semi-Critical (SGWD: 65-85%); Safe (SGWD < 65%); *-village pair-wise difference

Effect on Adoption Rate of MI

	Adoption Rate of MI				Δ adoption rate
Extra Subsidy	0.018*** (0.001)	0.012*** (0.001)	0.016*** (0.001)	0.012*** (0.002)	0.018*** (0.001)
(ARMI) _{t-1}	-	0.055 (0.137)	-	0.334*** (0.074)	-
(ARMI) _{t-2}	-	0.015 (0.070)	-	0.108*** (0.019)	-
<i>Region Dummy</i> ^a					
Overexploited	-	0.096 (0.091)	-	-0.001 (0.022)	-
Critical	-	0.251*** (0.088)	-	0.051 (0.048)	-
Semi-Critical	-	0.012 (0.068)	-	0.005 (0.040)	-
R^2 / Wald χ^2	0.124	1835.12***	0.130	1158.07***	0.018
AR(2) z statistics (Pr>z)	-	0.766 (0.444)	-	0.782 (0.434)	-
No. of Obs.	72597	56460	13080	10172	7443
Year FE	Yes	Yes	Yes	Yes	No
Model	OLS(FE)	AB	OLS(FE)	AB	OLS(RE)
Sample	Full	Full	Border	Border	Border

Source: Computed from primary data;

Note: a- the omitted category is safe; the figures in the parentheses indicate village level cluster robust standard error in case of OLS and WC- robust estimator for AB Model;*** p<0.01, ** p<0.05 and * p<0.1 respectively

Effect on Adoption Rate of Area

	Adoption Rate of Area under MI				Δ adoption rate of Area
Extra Subsidy	0.013*** (0.000)	0.008*** (0.001)	0.010*** (0.001)	0.007*** (0.001)	0.011*** (0.001)
(ARMI) _{t-1}	-	0.460*** (0.033)	-	0.203*** (0.077)	-
(ARMI) _{t-2}	-	0.137*** (0.026)	-	0.027 (0.046)	-
<i>Region Dummy</i> ^a					
Overexploited	-	0.003 (0.008)	-	-0.030 (0.026)	-
Critical	-	0.044** (0.022)	-	0.129*** (0.048)	-
Semi-Critical	-	0.039*** (0.015)	-	0.016 (0.056)	-
R^2 / Wald χ^2	0.126	5235.30***	0.120	716.97***	0.052
AR(2) z statistics (Pr>z)	-	0.493 (0.622)	-	2.424 (0.015)	-
No. of Obs.	71927	55944	13034	10136	7317
Year FE	Yes	Yes	Yes	Yes	No
Model	OLS(FE)	AB	OLS(FE)	AB	OLS(RE)
Sample	Full	Full	Border	Border	Border

Source: Computed from primary data;

Note: a- the omitted category is safe; the figures in the parentheses indicate village level cluster robust standard error in case of OLS and WC- robust estimator for AB Model;*** p<0.01, ** p<0.05 and * p<0.1 respectively.

Concluding Observations

❖ Major findings:

- I. Significantly increased adoption of MI technologies in the recent years, especially in dark-zone and tribal talukas
- II. Institutional Reforms and Subsidy Policies have been played an important role for observed rapid diffusion
- III. Major Determinants: Additional Subsidy and Social Learning – latter has higher impact
- IV. Less adoption in over-exploited region: ‘use it or lose it’ rule

➤ Policy Suggestion

- I. Promote the existing institutions and also provide subsidy for wide scale adoption in the state
- II. Scaling up this model across the country through recently launched ‘Pradhan Mantri Krishi Sinchayee Yojana’

Thank You

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