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Towards Impact at Scale

# Adoption Gaps and Implications for Scaling Climate-Resilient and Biofortified Rice: Panel Evidence from Climate-Prone Areas of Bangladesh

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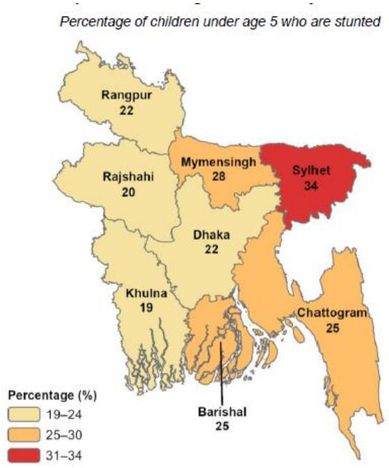
## ➢ Why Rice

- 58% of daily caloric intake
- 36% of protein intake per capita
- 92% of farming households cultivate rice

## ➢ Why Biofortified Zinc rice

- 55% of the population are zinc deficient
- Stunted Children: 24%
- Wasted Children: 11%
- Underweight Children: 22%




➢ BRRI and BINA have developed climate-stress-tolerant Rice Varieties (STRVs) and Biofortified rice

Submergence TRV:

- Level of Submergence tolerance 10-25 days

Salinity TRV:

- Level of salt tolerance 8-14 ds/m

Drought-tolerant/ escaping Rice Varieties:

- Short-duration Varieties or early-maturing varieties

➢ Zinc rice contains
- Zinc level 19-27.6 mg/kg
- Iron level 10.1 mg/kg

➢ Normal rice contains
- Zinc level 10.9 mg/kg
- Iron level 8 mg/kg

## ➢ Why Climate Stress Tolerant Rice Varieties (STRVs)

- Highly climate-vulnerable (World Bank, 2018)
- Farmers lose ~9% of rice harvest
- 41% of agricultural land is moderately to highly flood-affected
- Coastal salinity increased by 26–33% over last 35 years


Climate vulnerability and nutritional deficiencies in Bangladesh: Need a pathway toward resilient rice systems and food security

## Contexts

➢ Rice diversity in Bangladesh
- >1,000 traditional rice varieties (TVs)
- >130 modern varieties (MVs).

➢ Climate-resilient & biofortified varieties
- Mostly concentrated in two seasons: Aman (Rainfed) and Boro (Irrigated)
- 23 STRVs – stress-tolerant rice varieties
- 6 Zinc rice varieties – biofortified for nutrition

➢ STRV releases:
- Before 2010: 8 varieties
- 2011–2017: 11
- First zinc rice (BRRI dhan62) released in 2013

➢ Despite a decade of development, farmer-level adoption evidence is limited

## Objectives of the Study

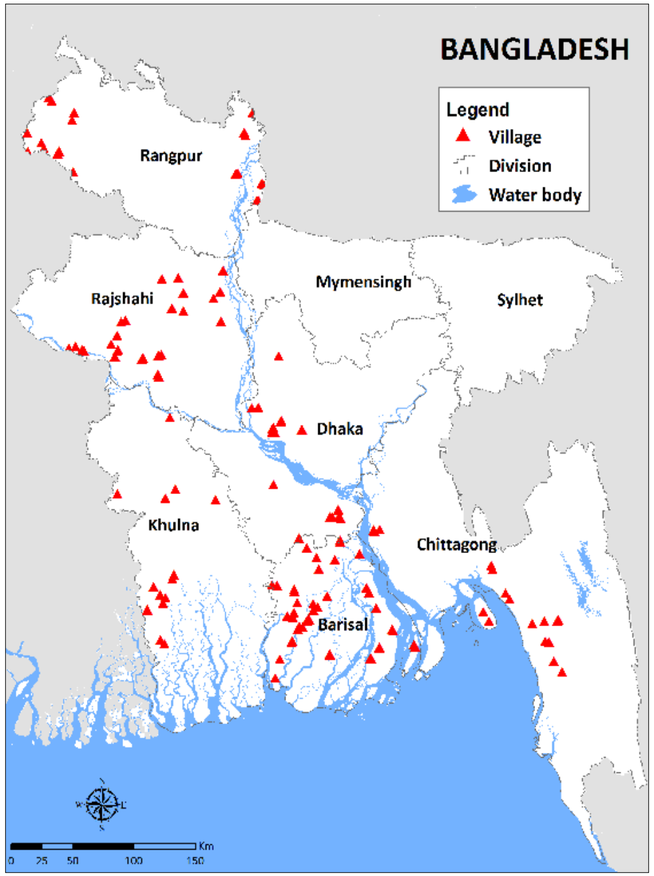
➢ Assess patterns and determinants of STRVs and biofortified rice adoption to identify key barriers, and opportunities, and policy actions to support sustainable scaling within Bangladesh’s food system.

# Data

- The study uses three rounds of panel data from the Rice Monitoring Survey, conducted by the International Rice Research Institute (IRRI).
- The survey employed a multi-stage sampling method to select the divisions, districts, and villages.
- The total number of households surveyed was 1,485, with areas covering 150 villages, 75 thanas, and 16 districts of six divisions.

- Panel data:
- First-round survey: 2014
- Second-round survey: 2017
- Third-round survey: 2022
- Low attrition rates of 0.93% in 2017 and 1.07% in 2022

- Detailed information on plot-level rice varieties and production, household and plot characteristics, and experiences with submergence, salinity, and drought, among other factors.




Location of Sample Villages

# Methods

- A pooled multinomial logit (MNL) model was estimated to examine how household decision-making types influence the probability of adopting, or stress-tolerant rice varieties, biofortified rice, modern varieties (HYV+HYV) and traditional varieties.
- To address unobserved household heterogeneity that may correlate with observed covariates, we adopt a Mundlak approach, including household means of time-varying explanatory variables as additional regressors (Mundlak, 1978).
- The latent utility that household $i$ plot $p$ and time $t$ derives from choosing variety $j \in \{S, Z, M, T\}$ as:

$$\mathrm{U_{ijpt}} = \alpha_j + \beta_\mathrm{j} \mathrm{D_{ipt}} + \delta_\mathrm{j} C_{\mathrm{i,t-1}} + X'_{ipt}\gamma_j + \bar{X}'_i\theta_j + \varepsilon_{\mathrm{ijpt}}$$

- Where, $\mathrm{U_{ijpt}}$ is the latent utility in the household $i$ plot $p$ and time $t$.

  $C_{\mathrm{i,t-1}}$ is prior-period experience of climate stress (submergence, drought, salinity) by the household's plot.

  $X_{ipt}$ is vector of plot and household-level characteristics,

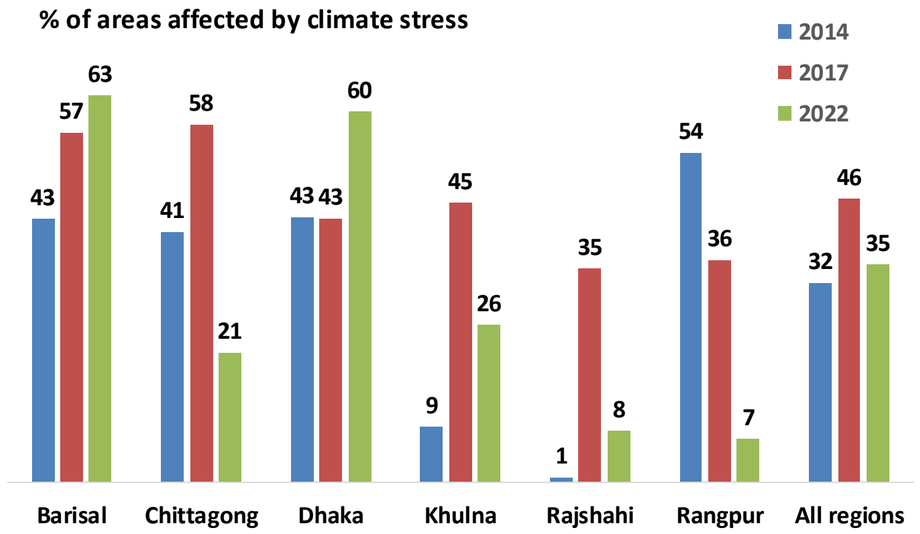
  $\bar{X}_i$ is Mundlak terms which is household level means of time-varying covariates, and

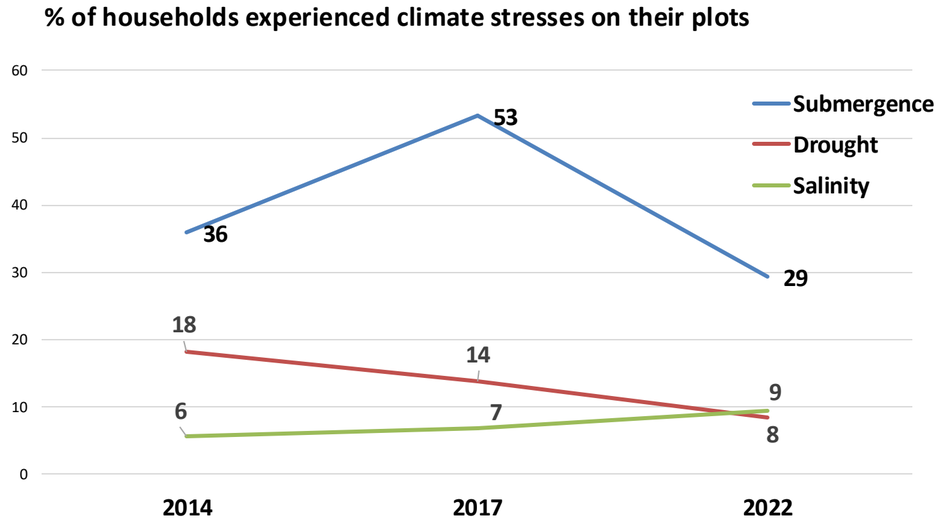
  $\varepsilon_{ijpt}$ is an idiosyncratic error term.

- Year fixed effects capture time-specific shocks common to all households and cluster-robust standard errors at the household level correct for intra-household correlation of errors across plots and varieties.
- MNL models were estimated separately for these two seasons (Rainfed and Irrigated) to capture potential differences in adoption behavior across growing periods.

# Results

## Climate Stress (Submergence, Drought, Salinity) patterns: Flood Dominance and Rising Salinity

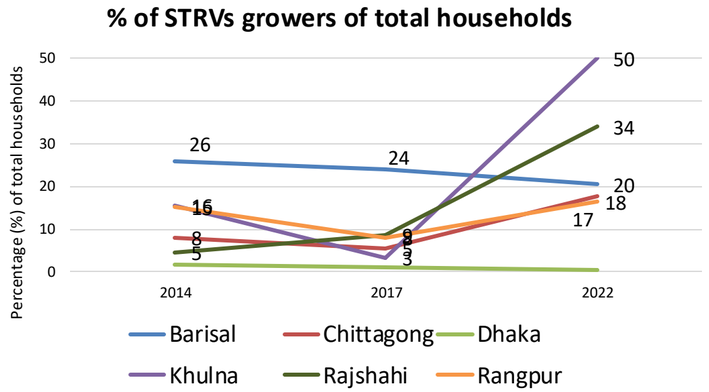


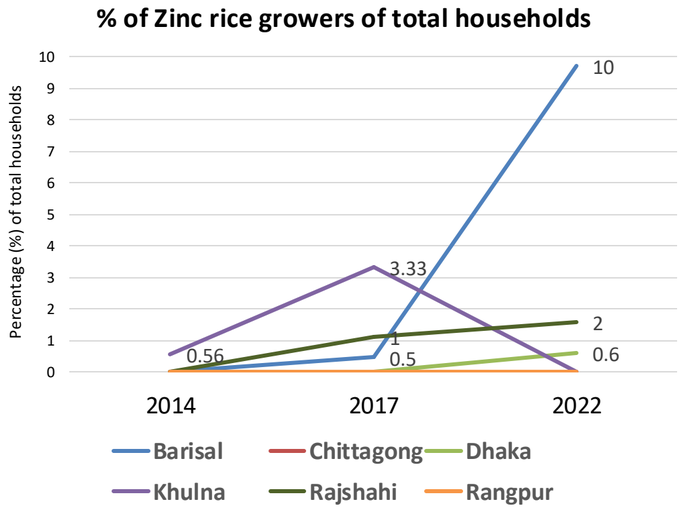

- Climate stress remains high and volatile across Bangladesh
- Climate stress is persistent and recurrent
- Regional fluctuations, significant upward trends in Barisal and Dhaka
- Flooding drives most climate stress, while salinity risk is creeping upward despite declining drought.

# Farmers adoption | Emerging but uneven uptake of climate-resilient and biofortified zinc rice across regions

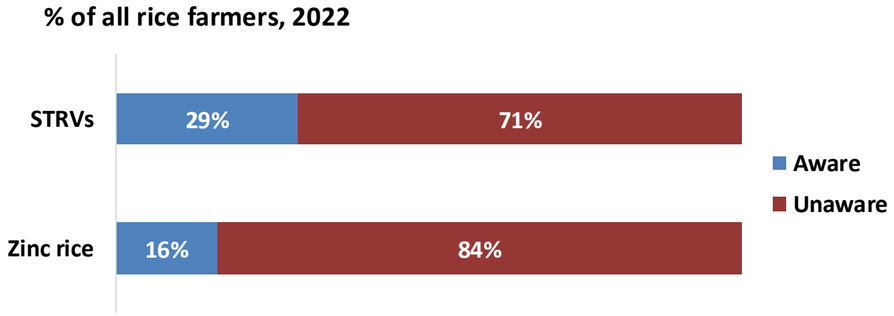
| Rice Varieties | % of households adopted STRVs rice | | |
|---|---|---|---|
| | 2014 | 2017 | 2022 |
| Submergence TRV | 6.6 | 7.3 | 13.8 |
| Drought TRV | 1.4 | 0.6 | 7.9 |
| Salinity TRV | 5.3 | 4.0 | 3.4 |
| STRVs | **13.8** | **11.4** | **23.7** |
| Zinc Rice | 0 | **1.0** | **3.3** |

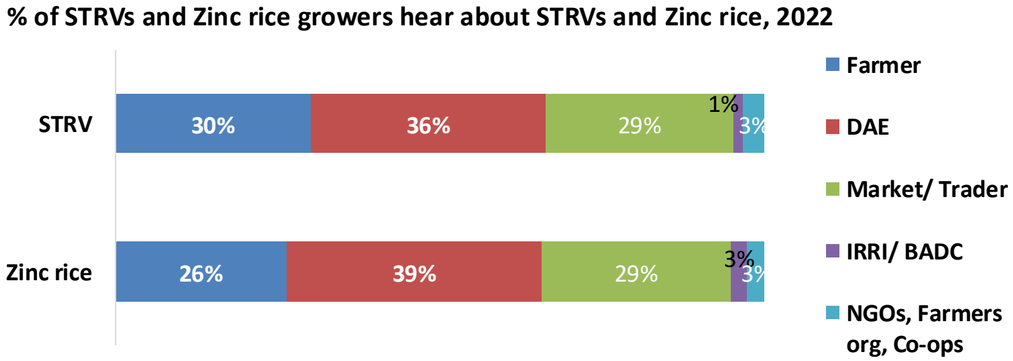



- Submergence-tolerant varieties show the strongest growth
- Adoption of Climate-Resilient Rice Rises—Submergence and Drought Traits Lead, Salinity Lags
- STRV adoption increased substantially, especially in Khulna and Rajshahi
- Zinc rice uptake by farmers is low but accelerating, most notably Barisal
- Barisal shows varietal switching→ STRVs use declines while Zinc rice adoption rises.
- Dhaka remains consistently low, although more exposed to climate stresses



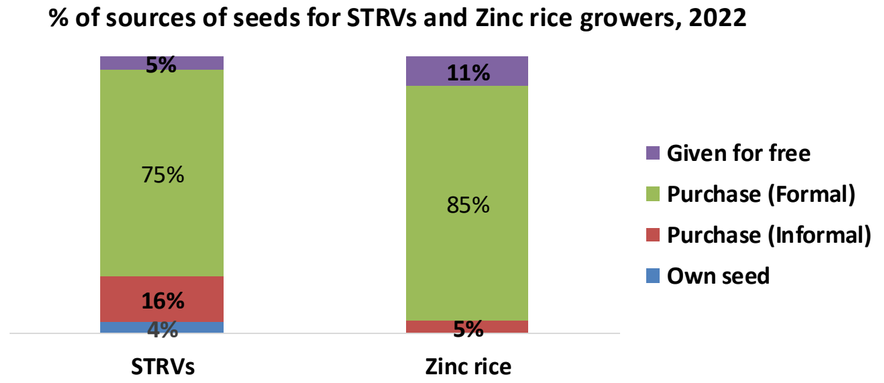
# Farmers Awareness| Farmers have low awareness about the availability and value proposition

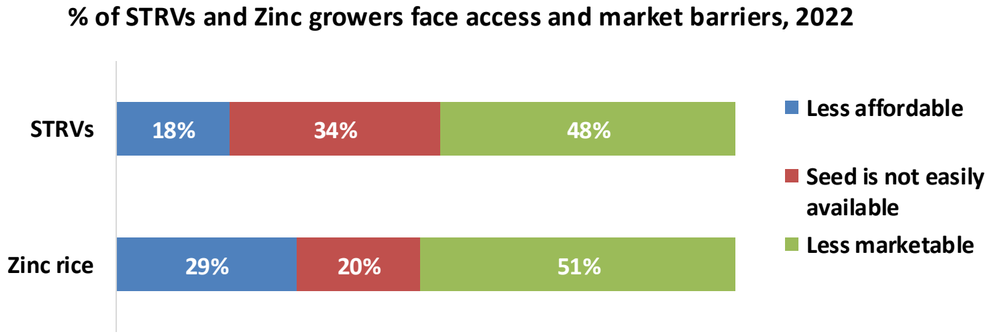



- Most farmers are unaware of the Zinc rice varieties, and in case of STRVs, awareness is also very low
- Farmers hear about STRVs and Zinc rice through extension (DAE)

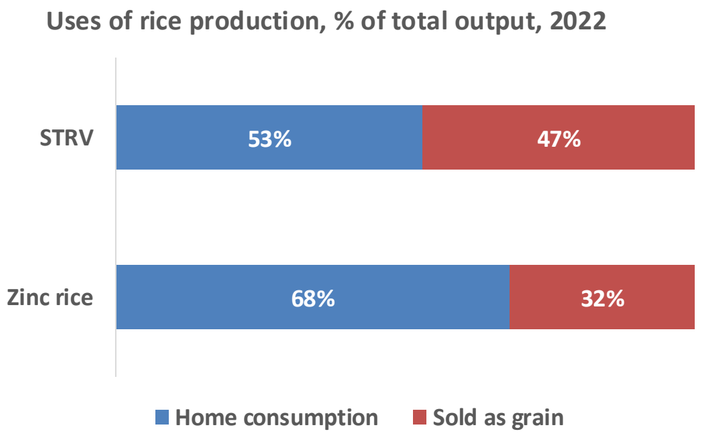
# Seed Access Challenges | Formal sources dominate, but barriers limit adoption




- Seed access and adoption barriers are misaligned
- Farmers buy seeds mainly from formal markets, and face poor marketability, affordability, and availability of STRV/Zinc seeds.

# Farmers Preferences for Rice Seeds |Farmers adopt variety that perform economically and are market-acceptable




## ➢Primary traits looked for in rice seed

➢Rice production for own consumption
- Consumption traits (grain size, shape, taste)
- High yield

➢Rice production for sale in market
- High yield
- High market price

- Zinc rice is grown for farmers own consumption

## ➢ STRVs

- BRRI 51 & BRRI 52 lead among STRVs, favored for high yields and reliable submergence tolerance in rainfed season.
- BRRI 75 and BINA17 most popular drought escaping varieties. offer good yield and market price in rainfed season.

## ➢ Zinc rice

- BRRI 74 dominates Zinc rice adoption: BRRI 74 and BRRI 84 offer competitive yields but farmers may view consumption traits less favorably.
- BRRI 74 coarse grain limits market expansion in regions preferring fine/slender rice in Boro season.

## ➢ Regional preferences

- BRRI 74 (Zinc rice), and BRRI 52 (STRVs) uptake is concentrated in Barisal, a division that prefers coarse rice.

| Rice Varieties | 2014 | 2022 | Expected Yield (ton/hectare) | Characteristics of Grain | Adoption level (2014 to 2022) |
|---|---|---|---|---|---|
| | % Uptake among of STRVs growers | | | | |
| | Submergence tolerant rice varieties | | | | |
| BRRI dhan 51 | 9.5 | 29.1 | 4.5 | m.Slender | ↑ |
| BRRI dhan 52 | 32.8 | 24.7 | 5.5 | m.Bold | ↑ |
| | Drought tolerant rice varieties | | | | |
| BRRI dhan 56 | 6.6 | 0 | 4-4.5 | Bold | ↓ |
| BRRI dhan 57 | 2.1 | 0.6 | 4.0 | Slender | ↓ |
| BRRI dhan 75 | 0 | 18.8 | 5.5 | m.Slender | ↑ |
| BINA dhan 17 | 0 | 12.8 | 7.0 | Slender | ↑ |
| | Salinity tolerant rice varieties | | | | |
| BRRI dhan 41 | 9.5 | 1.6 | 4.5 | Long Bold | ↓ |
| BRRI dhan 47 | 18.3 | 3.4 | 6.1 | m.Bold | ↓ |
| BRRI dhan 67 | 0 | 3.4 | 6.0 | m.Slender | ↑ |
| BINA dhan 8 | 12.9 | 0 | 5-7.5 | Bold | ↓ |
| | % Uptake among of Zinc Rice growers | | | | |
| BRRI 62 | 0 | 4.65 | 4.5 | Slender | ↑ |
| BRRI 84 | 0 | 11.63 | 6.5 | m.Slender | ↑ |
| BRRI 74 | 0 | 83.72 | 7.1 | Bold | ↑ |

# Climate shocks and extension services drive STRVs adoption, while gender shape Zinc rice uptake in Rainfed/ Aman season

- **Marginal Effects of Determinants of STRV Adoption (Pooled Multinomial Logistic with Mundlak approach) for Aman**

| | Stress Tolerant Rice Varieties (STRVs) | Zinc Rice | Modern Varieties (MVs) | Traditional Varieties (TVs) |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Lagged Climate Stress experience (Yes=1) | 0.074*** | 0.001 | -0.072*** | -0.003 |
| | (0.021) | (0.001) | (0.022) | (0.015) |
| Meet extension officer (Yes=1) | 0.041** | 0.0001 | 0.014 | -0.054*** |
| | (0.021) | (0.002) | (0.025) | (0.019) |
| Female-headed household | -0.025 | -0.024*** | 0.024 | 0.025 |
| | (0.044) | (0.008) | (0.050) | (0.038) |
| Joint significance of mean of time varying covariates $\chi^2(30)$ | 211.77 | | | |
| Prob> $\chi^2(30)$ | 0.0000 | | | |
| Number of Observations | 8683 | | | |
| Pseudo R-squared | 0.146 | | | |
| Year fixed effects | Yes | | | |
| Control variables | Yes | | | |

**Notes:** Robust standard errors clustered at the household level are in parentheses. *p < 0.10, **p < 0.05, ***p < 0.01. Mundlak means of time-varying covariates included
**Control variables**: Log of total Owned land (ha), Age of the hh head, Education of of hh head, Number of rice plot, tenure status, Access to irrigation. Land elevation, Household size.

- The experience of climate stress in the previous year significantly increases the likelihood of STRV adoption.
- Extension significantly increases adoption of STRVs in aman season.
- Extension no effect on Zinc Rice, which contributes to lower adoption in Aman.
- Gendered adoption reflects risk preferences: males adopt Zinc Rice under uncertainty (Aman).

# Climate shocks and gender shape Zinc Rice uptake in Boro/ Irrigated, while STRVs are less responsive to these factors

- **Marginal Effects of Determinants of STRV Adoption (Pooled Multinomial Logistic with Mundlak approach) for Boro**

| | Stress Tolerant Rice Varieties (STRVs) | Zinc Rice | Modern Varieties (MVs) | Traditional Varieties (TVs) |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Lagged Climate Stress experience (Yes=1) | 0.001 | -0.075** | 0.082** | -0.008 |
| | (0.014) | (0.032) | (0.038) | (0.026) |
| Meet extension officer (Yes=1) | 0.008 | -0.016 | 0.049* | -0.042* |
| | (0.016) | (0.011) | (0.029) | (0.024) |
| Female-headed household | 0.018 | 0.023* | -0.008 | -0.033 |
| | (0.013) | (0.012) | (0.050) | (0.047) |
| Joint significance of mean of time varying covariates $\chi^2(30)$ | 120.03 | | | |
| Prob> $\chi^2(30)$ | 0.0000 | | | |
| Number of Observations | 5638 | | | |
| Pseudo R-squared | 0.199 | | | |
| Year fixed effects | Yes | | | |
| Control variables | Yes | | | |

**Notes:** Robust standard errors clustered at the household level are in parentheses. *p < 0.10, **p < 0.05, ***p < 0.01. Mundlak means of time-varying covariates included
**Control variables**: Log of total Owned land (ha), Age of the hh head, Education of of hh head, Number of rice plot, tenure status, Access to irrigation. Land elevation, Household size.

- Farmers do not respond to climate stress on Boro STRVs.
- The experience of climate stress in the previous year significantly decreases the likelihood of Zinc Rice adoption.
- Extension has little or no effect on STRVs, which contributes to lower adoption in Boro.
- Female-headed households are more likely to adopt zinc rice, while extension is not currently effective.
- Strong MV incumbent varieties (e.g. DRRI 28, BRRI 29) dominate Boro cultivation. Farmers are reluctant to switch from these high-yield, market-trusted varieties, which reduces the adoption space for new STRVs and Zinc rice.

# Policy Recommendations

## Climate-Resilient STRVs

- Promote submergence/drought-tolerant varieties in high-risk regions (Barisal, Dhaka, Khulna, Rajshahi).
- Promote STRVs as high-yielding varieties that perform well under normal conditions and remain resilient under climate stress.
- Intensify extension & awareness → link stress-tolerant traits with yield and climate resilience.
- Strengthen seed systems → formal and community-based seed supply, ensure availability and affordability.
- Market incentives → encourage farmers to maintain adoption through risk-reducing tools (crop insurance, subsidies).

## Biofortified Zinc Rice

- Increase awareness & nutrition messaging → highlight dietary benefits.
- Intensify extension & awareness
- Improve agronomic competitiveness → yield, grain type, and local preferences.
- Strengthen seed systems → formal and community-based seed supply, ensure availability and affordability
- Develop supply chains → differentiated channels for millers and aggregators; prevent mixing with other rice.
- Targeted incentives & programs → subsidies, social protection programs, demand-generation partnerships.
- Promote value-added products → branded or packaged zinc rice for market uptake.

# Policy Recommendations

- Adoption patterns differ by season, variety, gender, and climate stress exposure. Scaling STRV and Zinc rice requires aligning seed access, information delivery, and market incentives—not just releasing new varieties.

- Policy interventions should be season-specific and gender-targeted, prioritizing STRVs in climate-stress prone areas and promoting Zinc rice via female-focused extension.