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Impact of Stress Tolerant Rice Varieties in Flood Prone Regions of South Asia

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Introduction

- More than 557 million people rely on rice for their lives and livelihood *(Redfern et. al. 2012)*
- Most rice farmers in South Asia are smallholders and engage in subsistence agriculture
- The magnitude and frequency of natural disasters have increased due to climate change, threatening yield gains from the Green Revolution
- Stress Tolerant Rice Varieties (STRVs) were introduced with the goal to increase resilience to flooding

Fig 1: Rice plantation in Bangladesh

Justification

- RCTs indicate that increasing adoption of STRVs has a positive impact on yield resilience (*Dar et. al. 2013, Emerick et. al. 2016)*
- But there is a lack of wide-spread adoption of STRVs
- Also lack of large-scale, long-term evidence of impact from adoption

Objective

- We evaluate the impact of STRV adoption on reduction of yield loss resulting from flooding using nationally representative panel data from 2014 to 2017

Causal Pathway and Data

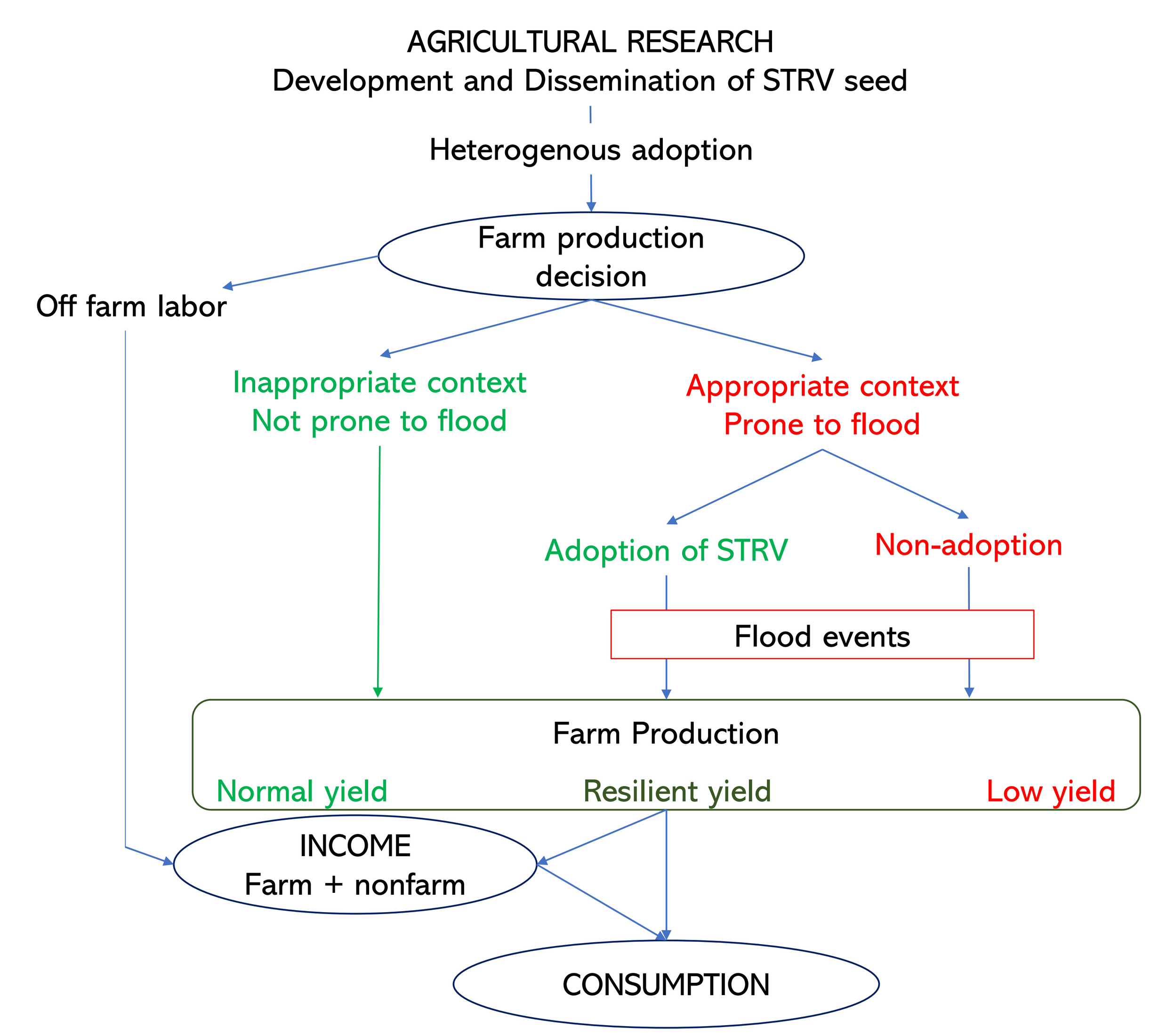

Fig 2: Flow chart of farmers' decision about adoption and it's impact on consumption

- The framework *(Fig 2)* begins with the development and diffusion of STRVs
- The adoption of any farm technology is heterogeneous as each farmer optimizes their farm production decisions depending on input availability and different constraints
- A farmer who adopts STRVs and experiences flooding will have a higher yield and, as a result, higher income and consumption, than a farmer who did not adopt STRVs and experienced flooding

Study Area and Data Source

Study Area

- Bangladesh is the 4th largest rice producer in the world
- Vulnerable to climate change, especially flooding

Data Sources

- Rice Monitoring Survey (RMS): panel survey data on household and rice production related data
- Government of Bangladesh: administrative data on STRV seed production and dissemination from Bangladesh Agricultural Development Corporation (BADC)

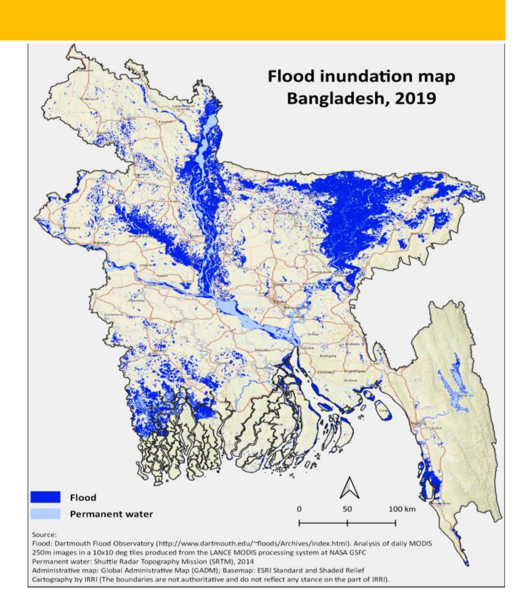

Fig 3: Study area - Bangladesh

Econometric Approach

We use a fixed effect panel instrumental variable (2SLS) regression model to control for the endogenous decision to adopt STRVs

$$\underbrace{STRV\ Adoption_{it}}_{\text{Instrumented Variable}} = \beta_0 + \beta_{1it}\ \underbrace{Cum.STRV_{it}}_{\text{Instrumental Variable}} + \beta_{2it}Year + \varepsilon_{it} \qquad \textit{(Stage 1)}$$

$$\underbrace{Yield_{it}}_{\text{Outcome Variable}} = \beta_0 + \beta_{1it}STRV\ Adoption_{it} + \beta_{2it}\,Year + u_{it} \qquad \textit{(Stage 2)}$$

Assumptions

- Stable Unit Treatment Value Assumption (SUTVA):
  The instrument is district level cumulative STRV seed production and dissemination ($Cum.STRV$). The amount of cumulative STRV seed production and dissemination in one district doesn't affect the $Yield$ and $STRV\ adoption$ of another district
- Exogeneity of the instrument
  - Unconfoundedness of $Cum.STRV$:
    Instrumental variable is not correlated with any unobservables that affect the outcome. So, the distribution of STRV seed maybe correlated with $STRV\ adoption$ through which $Yield$ is predicted
  - Exclusion restriction:
    There is no direct relationship between $Cum.STRV$ and $Yield$. The only relationship is through the $STRV\ adoption$. It is irrational to think that only $Cum.STRV$ can increase the $yield$ without adoption
- Non-zero effect of instrument on treatment:
  To fulfill this assumption, the first stage estimation coefficient for $Cum.STRV$ should be greater than zero
- Monotonic effect of $Cum.STRV$ on $STRV\ Adoption$:
  An increasing amount of $Cum.STRV$ can help to increase the $STRV\ adoption$

Descriptive Evidence

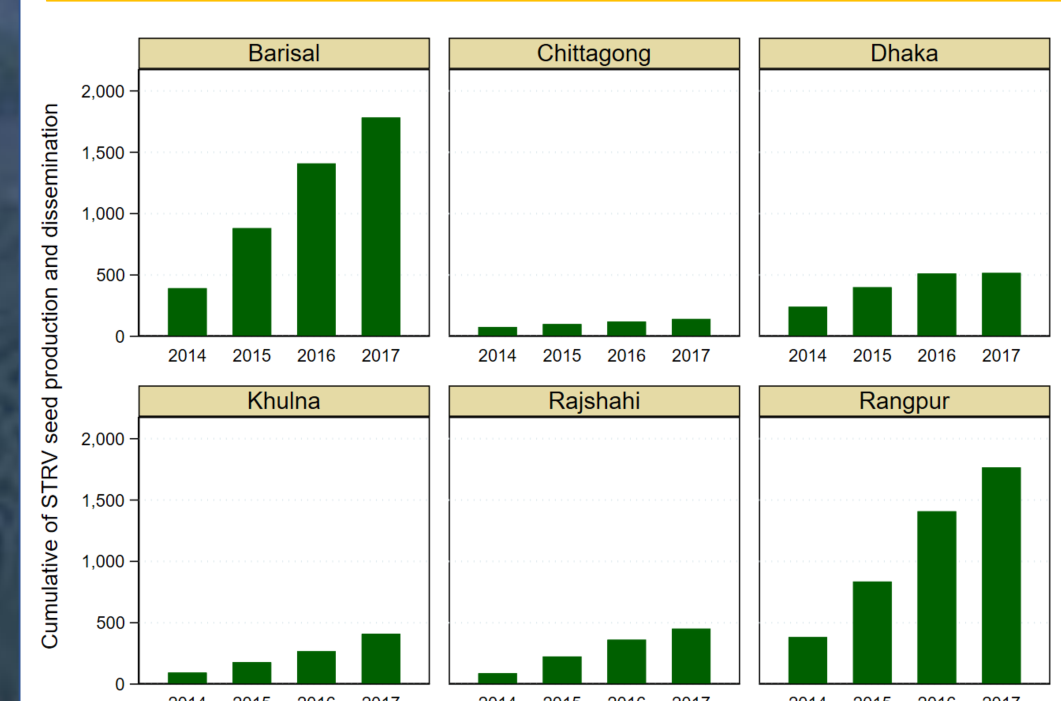

Fig 4: Division-wise STRV seed production and dissemination (2014-2017) calculated from BADC data

- There is an overall increasing trend in STRV seed production and dissemination *(fig 4)*
- Barisal and Rangpur division has the highest STRV adoption
- Chittagong division has the lowest STRV adoption over times

- Barisal division has the highest percentage of STRV adoption
- Comparatively STRVs adoption is higher in more recent years
- Omitted years don't have data in RMS *(fig 5)*

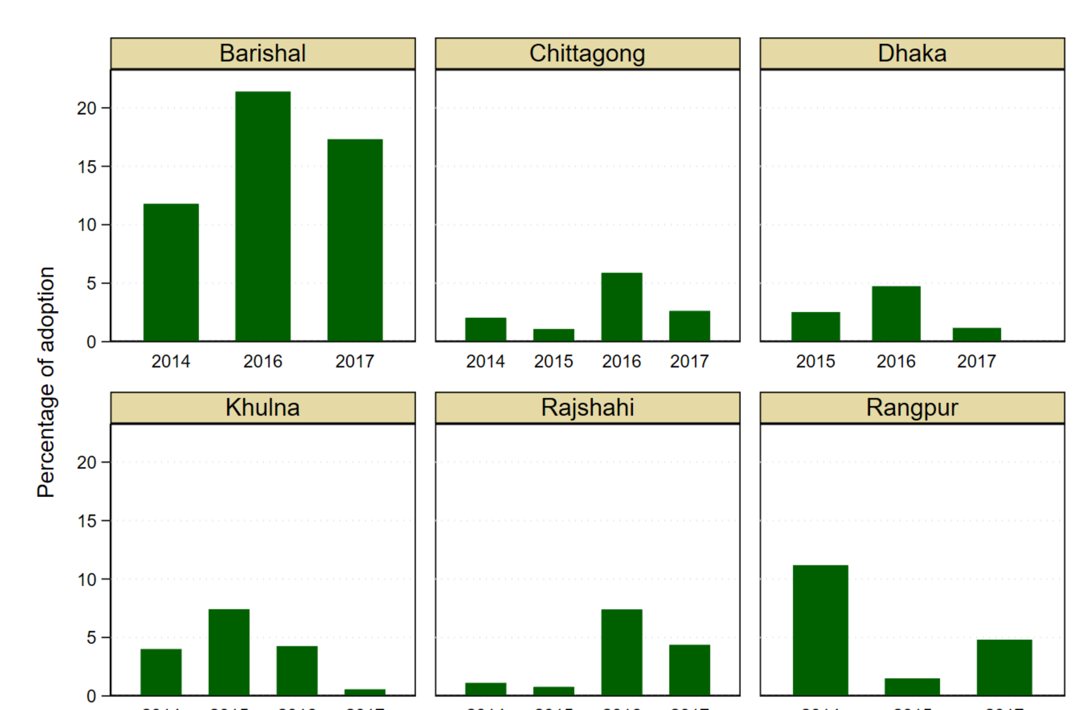

Fig 5: Division-wise STRVs Adoption over the years (2014 - 2017) calculated from RMS data

Descriptive Evidence Continued

- From 2014 to 2017, more than 6.5% farmers have adopted STRV in Bangladesh *(fig 6)*

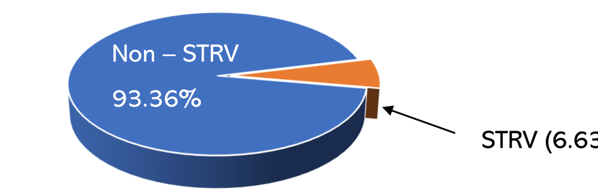

Fig 6: Overall STRV adoption (2014 - 2017) calculated from RMS data

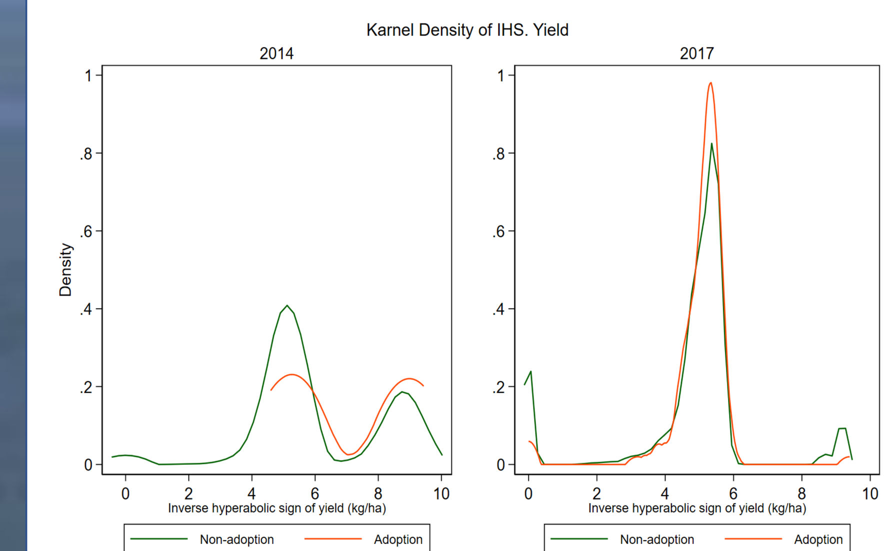

Fig 7: Distribution of inverse hyperbolic sign (IHS) transformation of yield calculated from RMS data

- We have divided the IHS. yield by year (2014 and 2017) and STRVs adoption (STRV and Non-STRV) *(fig 7)*
- STRV adopter farmers have a higher IHS. yield than non-adopter farmers

Econometric Evidence

First stage estimation

STRV Adoption	Coefficient	Robust Std. Error	*p*-value	95% Confidence Interval	
				Lower	Upper
Cum. STRV Production and Distribution	0.000093	0.00003	0.003	0.00003	0.00015
Year Indicator	-0.006278	0.00894	0.483	-0.02382	0.01126

- Cumulative production and distribution of STRV seed has a positive effect on adoption decision

Second stage estimation

Yield	Coefficient	Robust Std. Error	*p*-value	95% Confidence Interval	
				Lower	Upper
STRV Adoption	3.356	1.829	0.067	-0.228	6.940
Year Indicator	-1.324	0.077	0.000	-1.475	-1.172

- STRV adoption has a positive effect on rice yield
- This result supports the causal pathway framework

Conclusion

We find that:

- Total STRV seed production and dissemination is a significant predictor for STRV adoption
- STRV adoption can increase rice yield
- The causal relationship in our causal pathway framework section is statistically established

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