

# Impact of Hybrid Rice on Food Security

A spatial equilibrium analysis of global adoption  
and diffusion of hybrid rice varieties

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**Quantify** the potential impact of future hybrid rice adoption on food security

in regard to **food availability** and **food affordability**

for selected countries:

Bangladesh, Cambodia, Lao PDR, Myanmar, and Vietnam



# **THEORETICAL BACKGROUND**

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# Hybrid rice as an agricultural innovation/ as an agricultural intensification

## Theory of Induced Innovation

Hayami and Ruttan (1985)

- Development of innovations is an economic activity that is mostly affected by economic conditions
- New technology is developed for facilitating the substitution of relatively scarce factors for relatively abundant factors

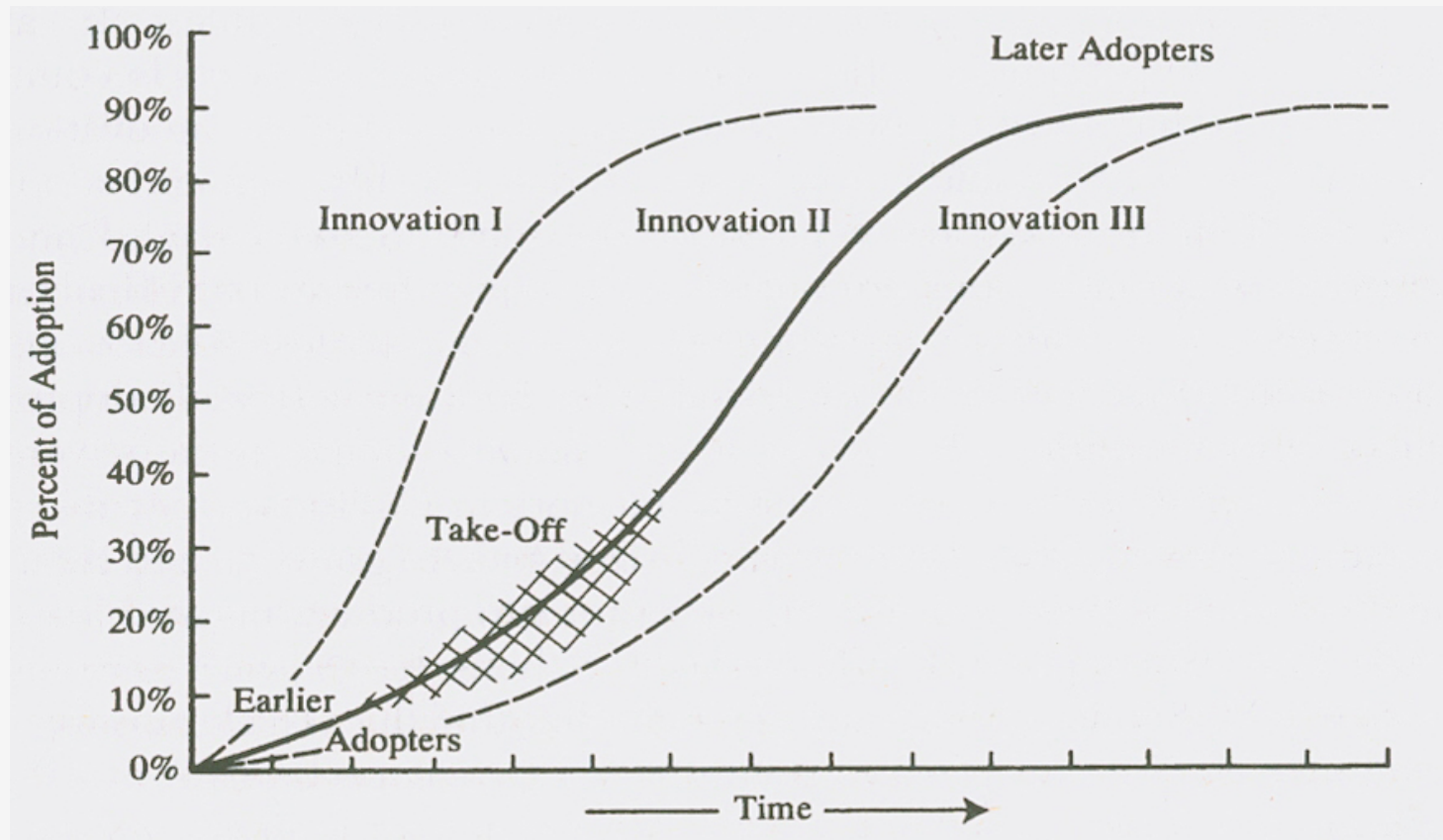
## Adoption and Diffusion Theory

Rogers (1962, 2003)

- “Diffusion is the process in which innovation is communicated through certain channels over time among the members of social system” (2003, p. 5)
- Adoption is the focus on behavior if and when individuals adopt innovations
- Cochrane added, early adopters benefit more than late adopters in terms of distribution of rents (Cochrane, 1979)

## 2. Theoretical Background

The diffusion process in a S-shaped curve



Source: Rogers 2003, p. 11

## 2. Theoretical Background



# **ANALYTICAL FRAMEWORK**

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# RICEFLOW

is a model by Durand-Morat and Wailes (2010),  
which is written in GEMPACK

and which is a multi-product, multi-region spatial  
partial equilibrium framework

that is based on behavioral equations,

and that can be run deterministically and  
stochastically.

# Assumptions/ Specifications

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**multi-product:**

Primarily 9 commodities (MG, LG, FR) (P,B,W)

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**multi-region:**

60 regions

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**partial equilibrium:**

one “other” commodity

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**behavioral equations:**

Leontief for production, CDE for demand (according to given elasticities),  
factors of production (elastic labor and capital, inelastic land; elastic  
intermediate inputs)

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market clearing conditions

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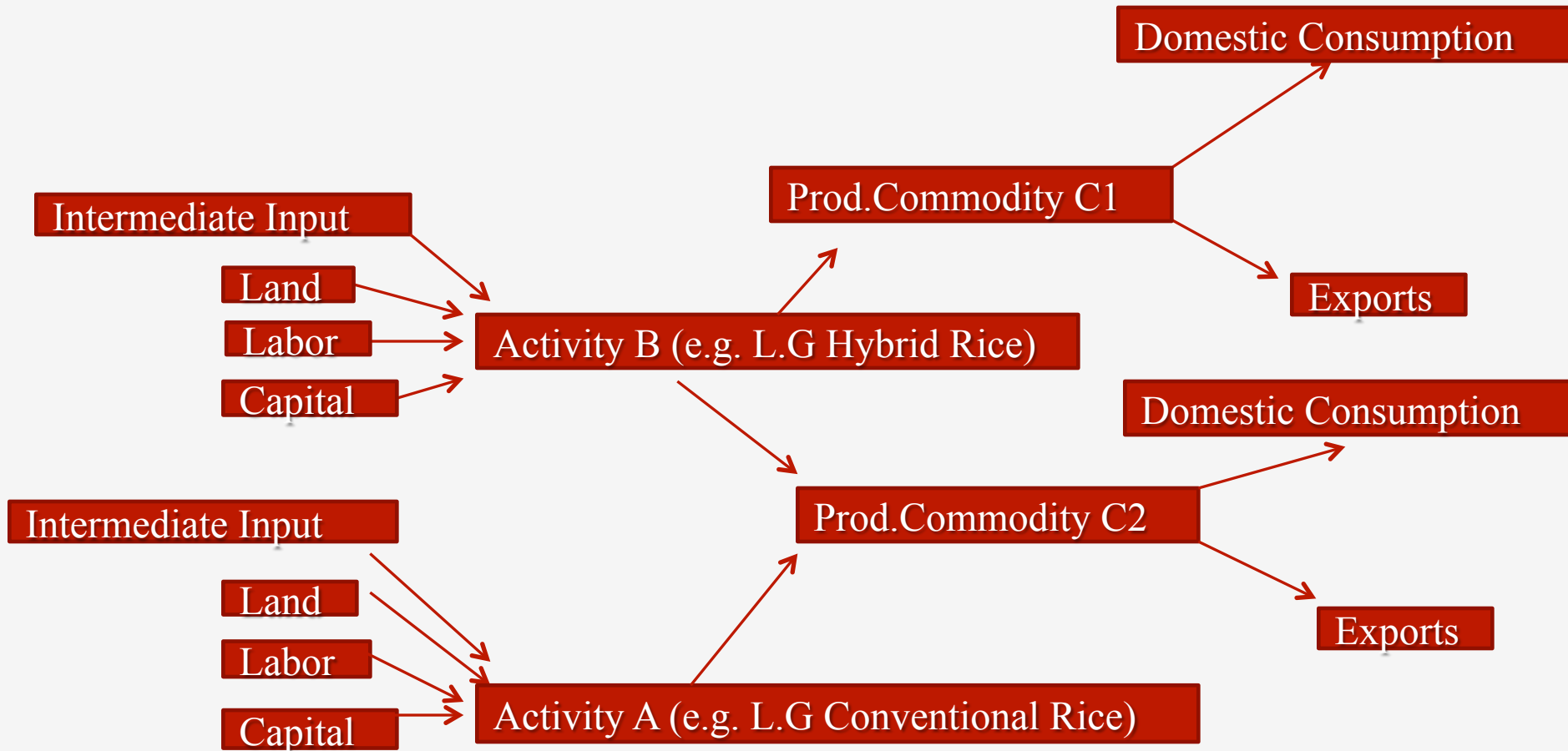
non-profit conditions

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baseline of 2009

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### 3. Value Chain of RICEFLOW Model Flow Diagram

Main differences of hybrid rice are assumed to be in

- production costs, and
- yield.

Hybrid rice is commercially produced in 7 countries (in 2009):

- Bangladesh, China, India, Indonesia, Philippines, USA, Vietnam

The analysis of the impact of hybrid rice future adoption was assumed only for these countries and according to explicit S-curves for each country

### Benchmark Scenario

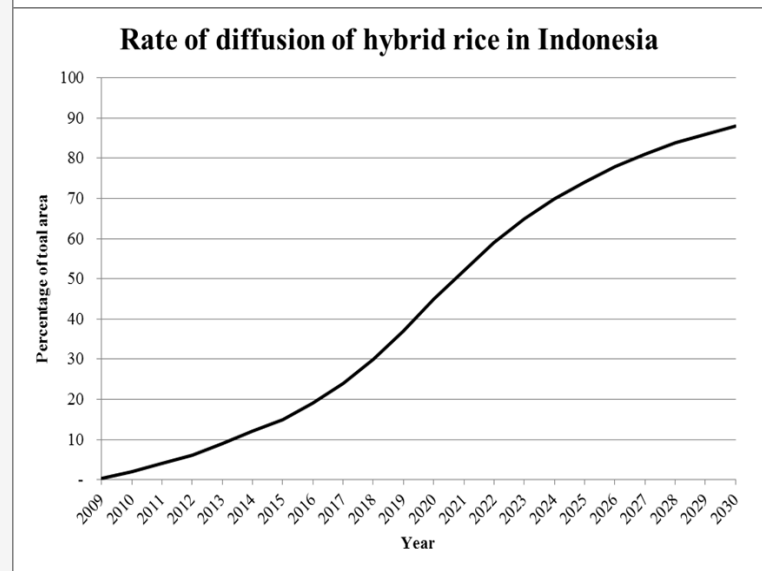
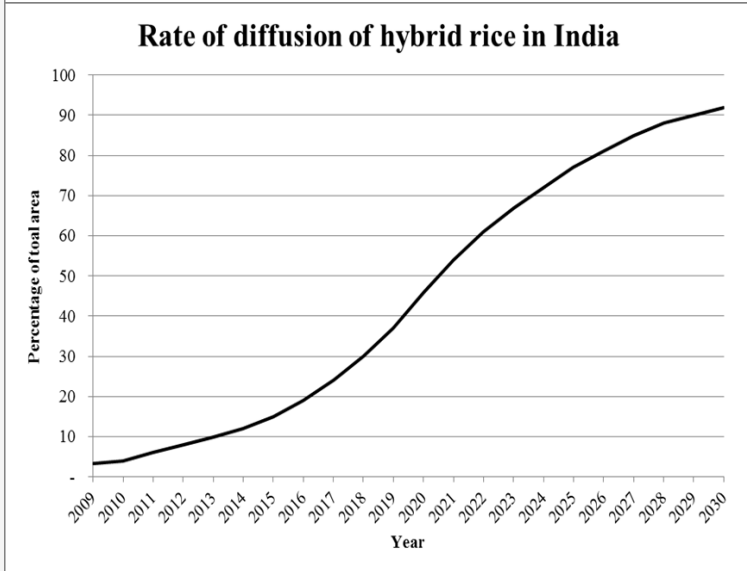
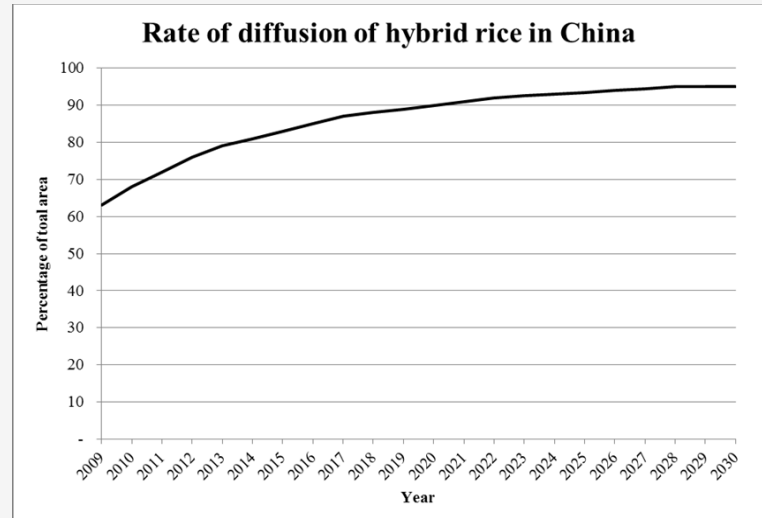
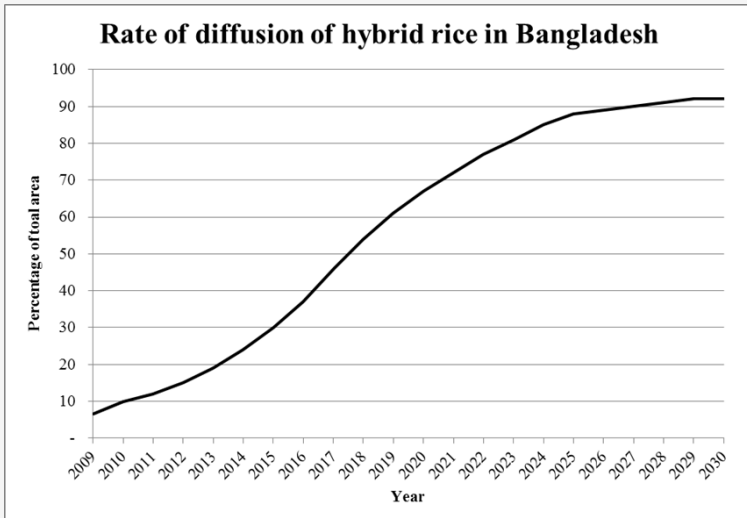
- Assumes no increase in hybrid rice adoption. Yields and costs increase based on historical growth rates. Key drivers are baseline increases in exogenous variables for all countries in model
- Per capita income and population growth rates

### Global Impact Scenario

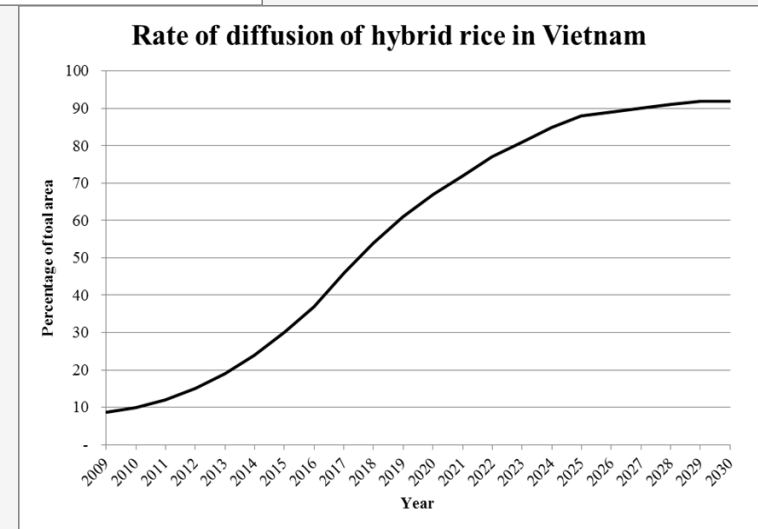
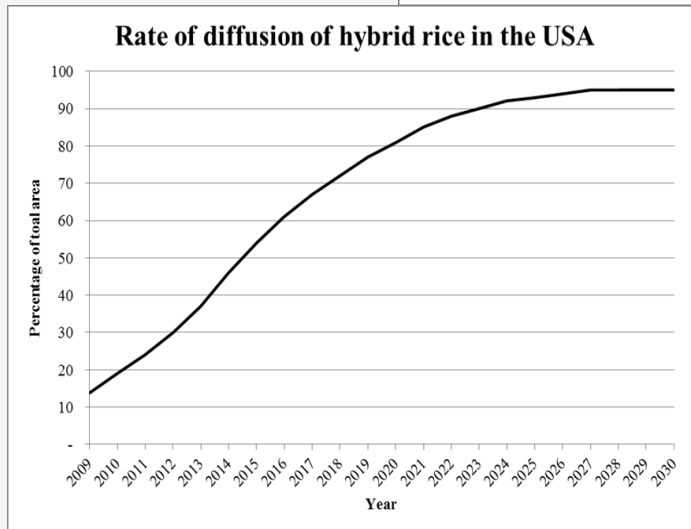
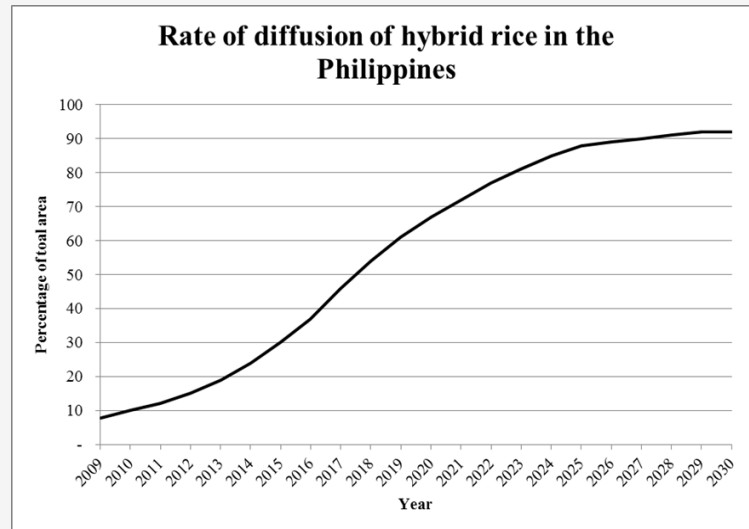
- All assumptions from Benchmark Scenario are retained except--
- Further diffusion of hybrid rice assumed in all 7 hybrid rice producing countries.

### Country Impact Scenarios

- All assumptions from Benchmark Scenario are retained except--
- Diffusion of hybrid rice assumed for only an individual country: China and Vietnam.



## 3. Analytical Framework: S-Curve Assumptions



## 3. Analytical Framework: S-Curve Assumptions

- Scenarios for 2010-2025
- 1 Benchmark Scenario, deterministic
- 3 Impact Scenarios:
  - Impact Scenario, Global, deterministic
  - Impact Scenario, China, deterministic
  - Impact Scenario, Vietnam, deterministic

*recently:*

- Impact Scenario, Vietnam, **stochastic**
- Stochastic simulation used detrended time series data 1980-2009 with **50** iterations per projected year



# **RESULTS**

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Table 1. Comparison of production changes for LGP rice.

Country	Rice production					Hybrid rice difference from benchmark scenario to impact scenario
	2009 (1000 t)	Benchmark Scenario		Impact Scenario		
	2009 (1000 t)	2025 (1000 t)	% change from 2009	2025 (1000 t)	% change from 2009	
Bangladesh	47,723	55,094	15.44%	56,443	<b>18.27%</b>	2.45%
China	170,705	166,396	<b>-2.53%</b>	164,244	-3.79%	-1.27%
India	129,198	139,365	7.87%	165,768	<b>28.31%</b>	18.95%
Indonesia	64,399	66,202	2.80%	69,634	<b>8.13%</b>	5.18%
Philippines	16,266	17,866	9.84%	20,535	<b>26.25%</b>	14.94%
USA	7,551	9,587	26.96%	10,002	<b>32.46%</b>	4.33%
Vietnam	38,895	43,196	11.06%	52,154	<b>34.09%</b>	20.74%
TOTAL	474,738	530,957	4.84%	538,779	<b>13.49%</b>	1.47%
Global	613,517	655,250	6.80%	690,749	<b>12.59%</b>	5.42%

LGP: Long Grain Paddy Rice

## 4. Results. Global Impact Scenario



Table 1. Comparison of rice consumption changes for LGW rice.

Country	Rice consumption					% change between scenarios
	Benchmark Scenario			Impact Scenario		
	2009 (kg/capita)	2025 (kg/capita)	% change from 2009	2025 (kg/capita)	% change from 2009	
Bangladesh	215.13	208.26	-3.19%	210.02	<b>-2.37%</b>	0.85%
Cambodia	234.05	193.77	-17.21%	194.61	<b>-16.85%</b>	0.43%
Laos	227.36	180.61	-20.56%	184.22	<b>-18.97%</b>	1.99%
Myanmar	228.83	224.25	-2.00%	224.64	<b>-1.83%</b>	0.17%
Vietnam	220.36	161.24	-26.83%	173.53	<b>-21.25%</b>	7.62%

LGW: Long Grain White Rice

## 4. Results. Global Impact Scenario

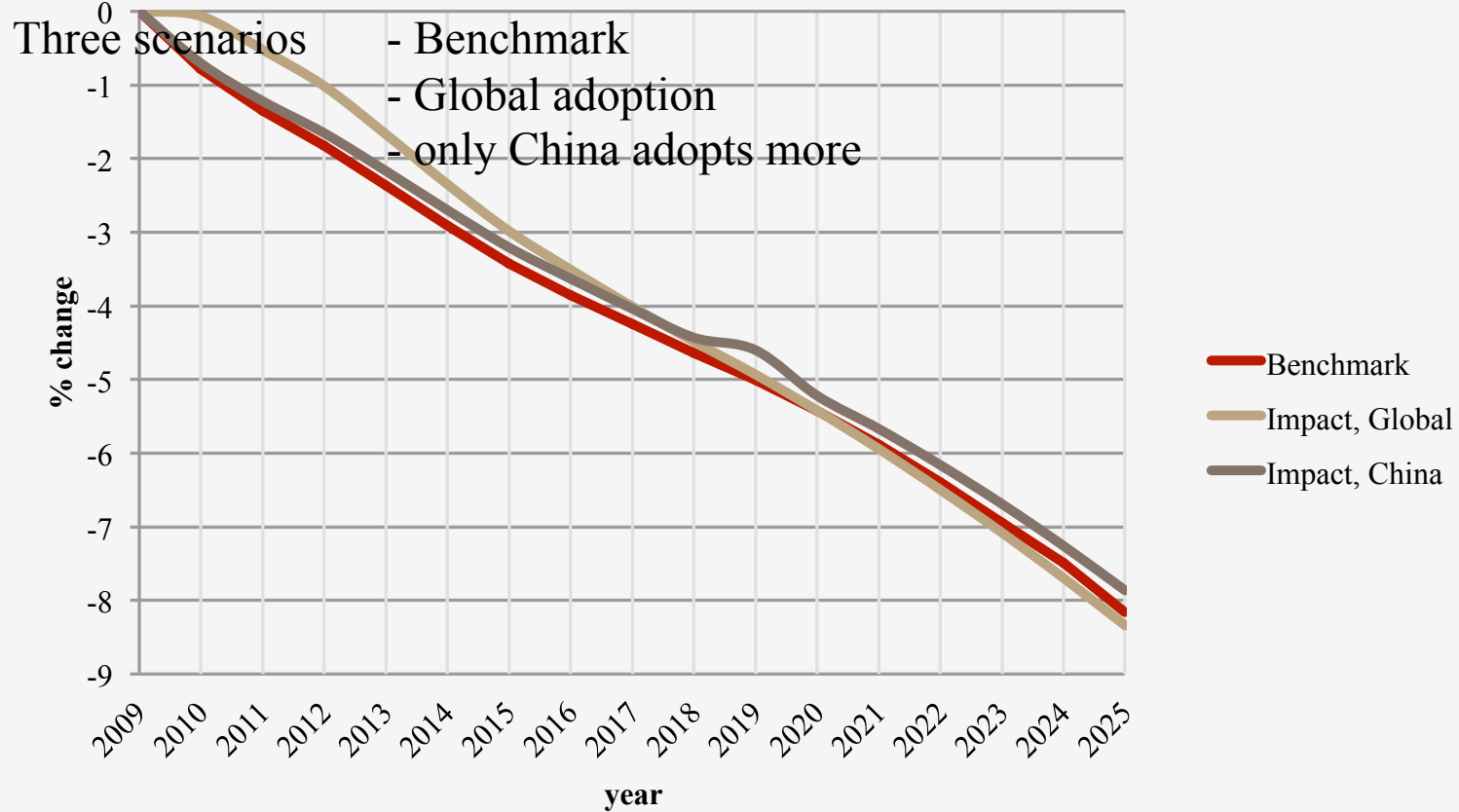
Table 1. Comparison of nominal retail price percent changes for LGW rice

Country	Retail price changes for 2025		Hybrid rice difference from benchmark scenario to impact scenario
	Benchmark Scenario	Impact Scenario	
Bangladesh	127.34%	<b>-6.69%</b>	-134.03%
Cambodia	3.27%	<b>1.04%</b>	-2.23%
Laos	13.06%	<b>2.42%</b>	-10.64%
Myanmar	179.79%	<b>174.89%</b>	-4.90%
Vietnam	73.34%	<b>20.04%</b>	-53.3%

LGW: Long Grain White Rice

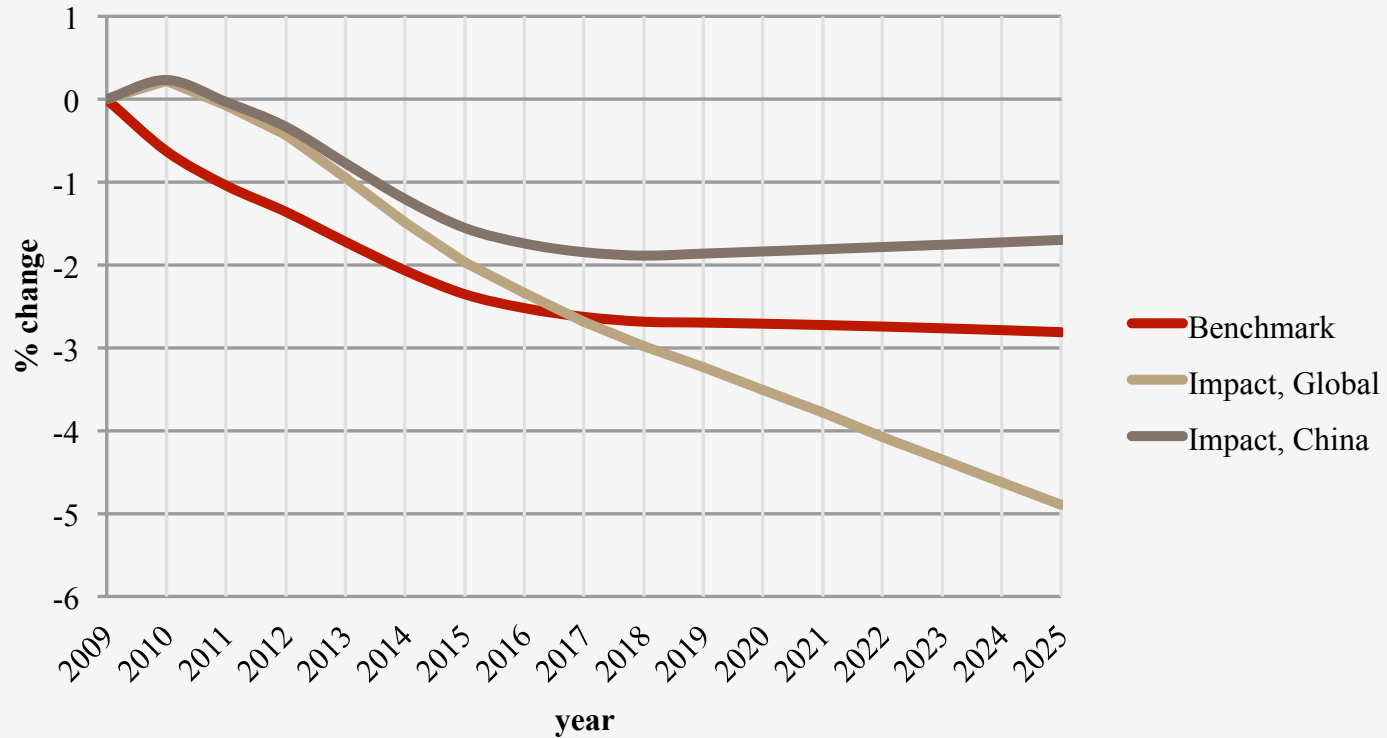
## Consumption percent changes of LGW rice for China

Closer look on China:

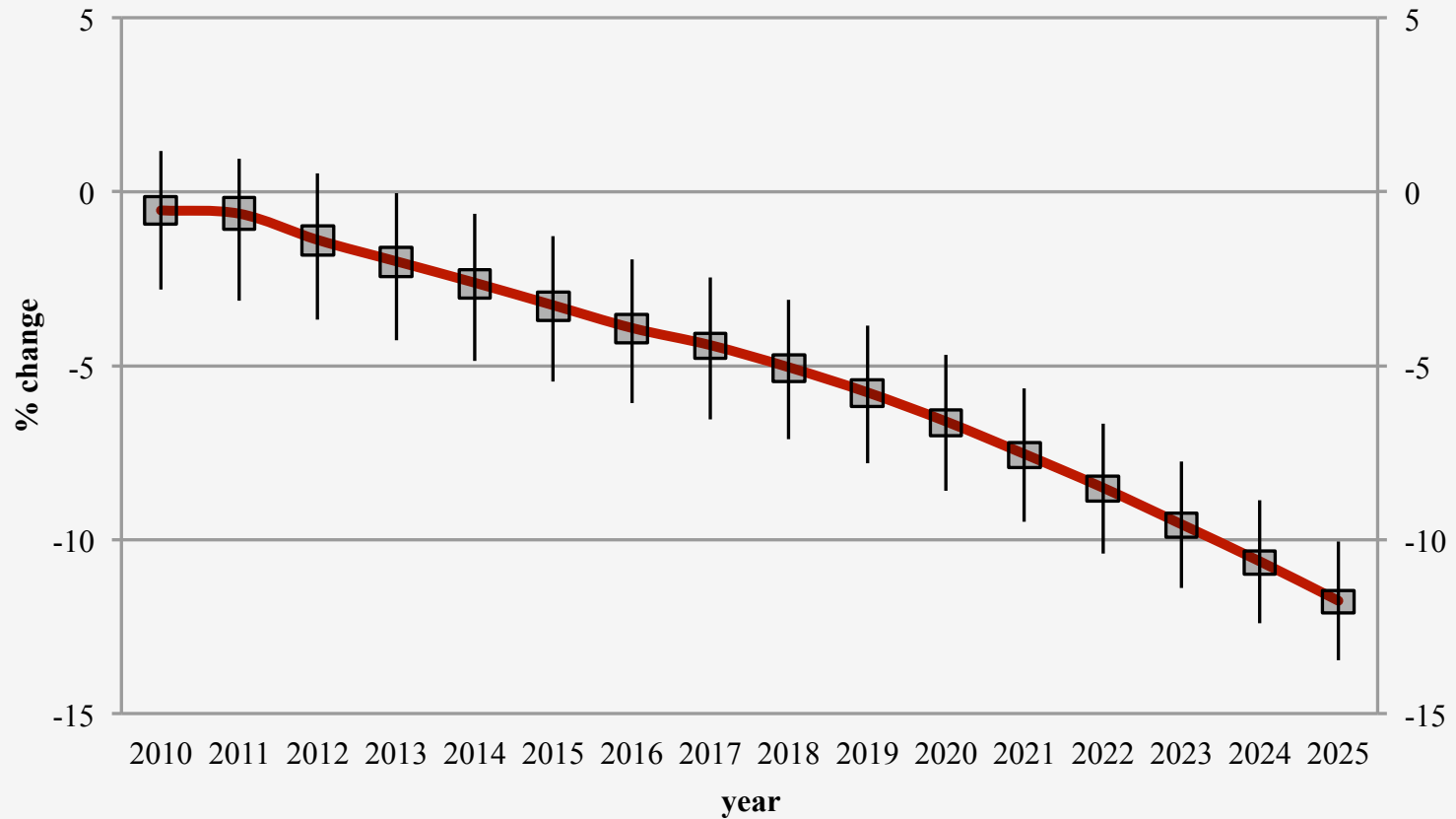


## 4. Results. Impact Scenario, China

**Production percent change of LGP in China**



**Stochastic consumption percent changes of LGW rice for Vietnam**



## **4. Results. Impact Scenario, Vietnam**

*Table 1.* Comparison of rice consumption changes for LGW in Vietnam, based on stochastic simulation.

Year	Scenario	Rice consumption (kg/capita/year)	Difference to baseline	Difference from scenario to benchmark
2009	Baseline	220.36	-	-
2015	Benchmark	195.85	-11.12%	-
	Mean	200.40	-9.06%	<b>2.32%</b>
	Worst case	196.35	-10.90%	<b>0.25%</b>
2020	Benchmark	181.68	-17.55%	-
	Mean	185.63	-15.76%	<b>2.17%</b>
	Worst case	177.26	-19.56%	-2.43%
2025	Benchmark	166.81	-24.30%	-
	Mean	170.12	-22.80%	<b>1.98%</b>
	Worst case	161.23	-26.83%	-3.35%

## 4. Results. Stochastic Scenario Vietnam, cont.



# **CONCLUSIONS**

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- RICEFLOW proved to be an adequate tool to estimate impact of hybrid rice on food security
- Further adoption of hybrid rice as agricultural innovation with certain positive characteristics can have a positive impact on food security in a clearly consumer oriented way
- Further hybrid rice adoption can induce up to 10.8% higher LGP rice production globally
- Rice consumption per capita can be improved between 0.17% and 7.62% in countries that are most dependent on rice as a staple food crop
- Retail price for rice can be reduced between 2.23% and 134.03% in countries that are most dependent on rice as a staple food crop

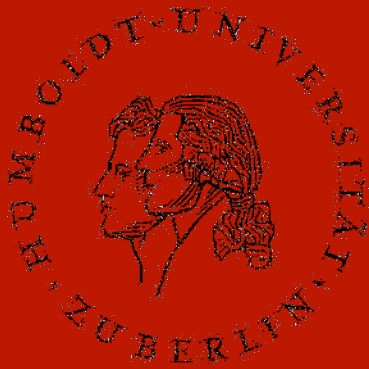


## Limitation of Research

- Analytical framework specifications
- Assumptions within specifications
- Elasticities as core of the model
- Insufficient data

## Future Research

- Rice harvesting seasons
- Income level groups
- Inclusion of substitutable commodities
- More elaborate stochastic simulations
  - More runs
  - Yield variability of hybrid vs conventional



**THANK YOU FOR YOUR  
ATTENTION**

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