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## **Projecting Policy for Long-Run Grain Market, Food Security, and Climate Change Analysis**

**Suhwan Lee, Adrienne Ohler, Wyatt Thompson**

*Selected presentation for the International Agricultural Trade Research Consortium's (IATRC's) 2023 Virtual Summer Symposium: Fields of Discord: Understanding the Intersection of Geopolitics and Agriculture, June 26, 2023.*

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# Projecting Policy for Long-Run Grain Market, Food Security, and Climate Change Analysis

IATRC Virtual Summer Symposium, June 26, 2023

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# Objective

- Long-run projections of agricultural commodity market are one of the key contribution of applied economist.
  - Climate change or food security analysis often extends farther into the future than the usual time horizon for business and policy decision-making  
Alston et al. (2010), Baldos et al. (2014), Hertel et al. (2016), Huffman et al. (2006), IPCC (2022), Thompson et al. (2019)
- However, the intersection of geopolitics and agriculture has not been incorporated into long-run projection of agricultural commodity market analysis

# Agricultural Market Distortion: Nominal Rates of Assistance (NRA)

- NRA is indicator of Agricultural Market Distortion (Anderson et al., 2013)
  - NRA\_B: Border market price support
  - NRA\_D: Domestic market price support
  - NRS\_I : Input market price support (Ex: Fertilizer, Seeds, Agricultural machinery)
- Empirical studies shows that agricultural policies tend to evolve as a country develops
  - Agricultural supports (NRAs) change as a country's per capita income rises (Anderson et al., 2013)
  - Income per capita affects border and producer support differently (Zhao et al., 2022)

## <India's Grain Market price supports (NRAs)>

Year	Maize			Rice			Wheat		
	NRA_B	NRA_D	NRA_I	NRA_B	NRA_D	NRA_I	NRA_B	NRA_D	NRA_I
2000 ~ 2005	0.00	0.00	0.10	-0.03	0.02	0.17	0.00	0.00	0.32
2006 ~ 2010	0.13	0.00	0.00	0.14	0.00	0.00	0.37	0.00	0.00

Data: Anderson & Nelgen (2013)

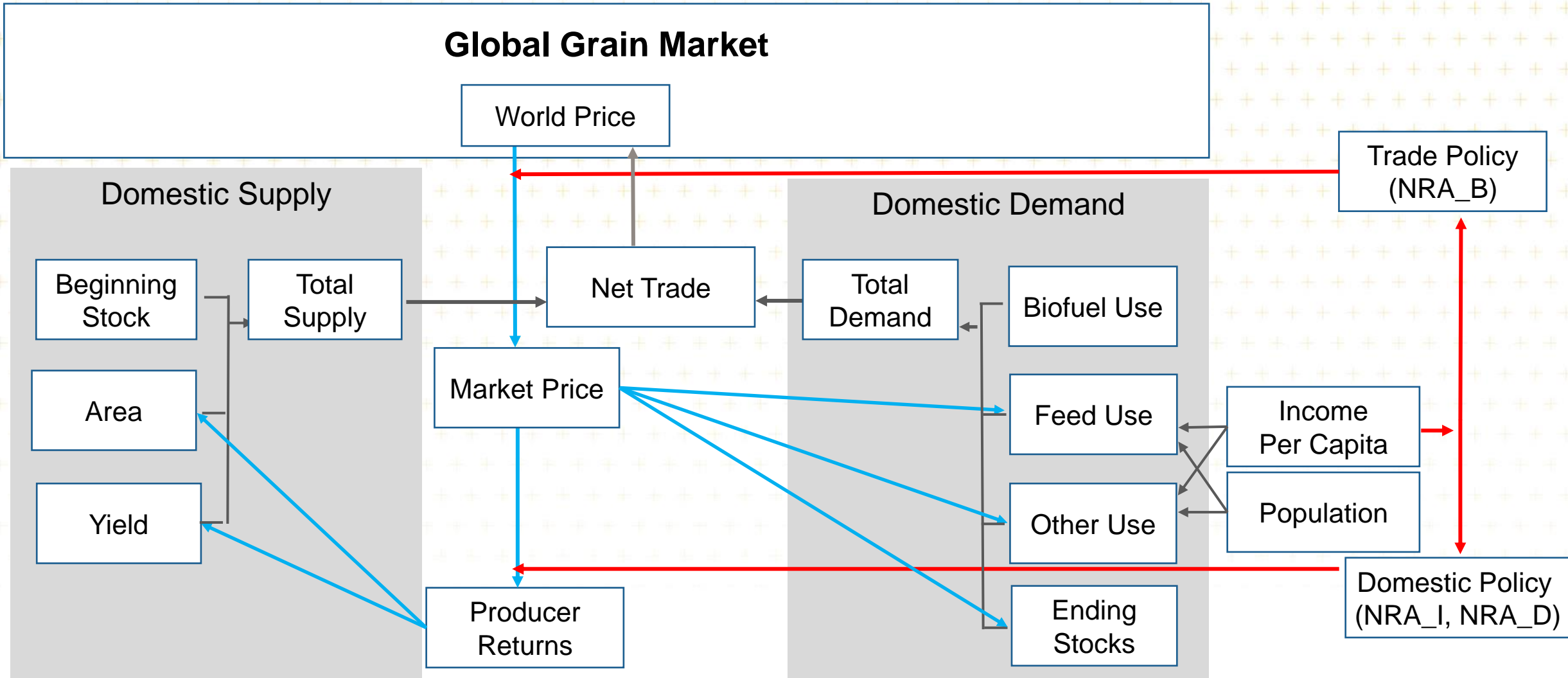
## Preliminary Experiment : India

### ■ India: A key Country in the Global Economy

- **Population:** Second most populous country in the world (over 1.3 billion people)
- **Agriculture:** Wide range of crops and livestock  
(Major commodities: Rice, Wheat, Dairy products, and Spices)
- **Economic Growth:** Experienced significant economic growth in recent years  
(Technology, Services, Manufacturing, and Infrastructure)
- **GDP per capita:** Rise more than five-fold in 2100
- **Policy:** Economic development leads us to expect different amounts and forms of support



# Framework for The Long-Run Grain Market Model



# Data

## ■ Grain Commodities (8)

- Wheat, Corn, Rice, Barley, Millet, Oats, Sorghum, Rye

## ■ Data source

- Supply & Demand Data: USDA's Production, Supply, and Distribution (PSD Online)
- Price Data: OECD STAT
- Policy Data (NRAs): World bank Agricultural Distortions Database
- Macro Economic Data: International Institute for Applied System Analysis (IIASA)

USDA International Macroeconomic Data





# Long-Run Grain Market Model

- Monte Carlo simulation drawing on elasticities of supply & demand and trend parameters
  - Elasticities : Herter et al. (2016), Muhammad et al. (2017), OECD (2010a, 2010b), Valin et al. (2014), Saunders et al. (2019)
- Price elasticity of demand that evolves as income per capita rises
  - David Abler (2010)
- Applying agricultural policy (NRAs) in the Long-run Grain market model
  - Anderson et al. (2013), Zhao et al. (2022)

# Supply and Demand Elasticities for the Long-run Grain Market Model

< Grain Supply Parameter Range >

Variable	Parameter	Country	Value
Area	RHTE	USA	0.04 ~ 0.06
		India	0.04 ~ 0.06
		ROW	0.08 ~ 0.12
	Lag	USA	0.16 ~ 0.24
		India	0.20 ~ 0.30
		ROW	0.20 ~ 0.30
Yield	Short term Own price	USA	0.08 ~ 0.12
		India	0.08 ~ 0.12
		ROW	0.08 ~ 0.12
	Long term Own price	USA	0.93 ~ 1.03
		India	1.01 ~ 1.24
		ROW	1.01 ~ 1.16

< Grain Demand Parameter Range >

Variable	Parameter	Country	Value
Feed Use	Income	USA	0.23 ~ 0.33
		India	0.31 ~ 0.54
		ROW	0.31 ~ 0.46
	Own price	USA	-0.23 ~ -0.13
		India	-0.44 ~ -0.21
		ROW	-0.36 ~ -0.21
Other Domestic Use	Income	USA	0.03 ~ 0.13
		India	0.11 ~ 0.34
		ROW	0.11 ~ 0.26
	Own price	USA	0.00 ~ -0.08
		India	-0.01 ~ -0.24
		ROW	-0.01 ~ -0.16

# Long-run Grain Market Model: Policy Scenarios Analysis

## Case 1 (Base Scenario)

- India's agricultural market supports (NRAs) are evolving as income changes
- If India's agricultural market supports (NRAs) are influenced by the changing income per capita until the year 2100?

## Case 2 (No Policy)

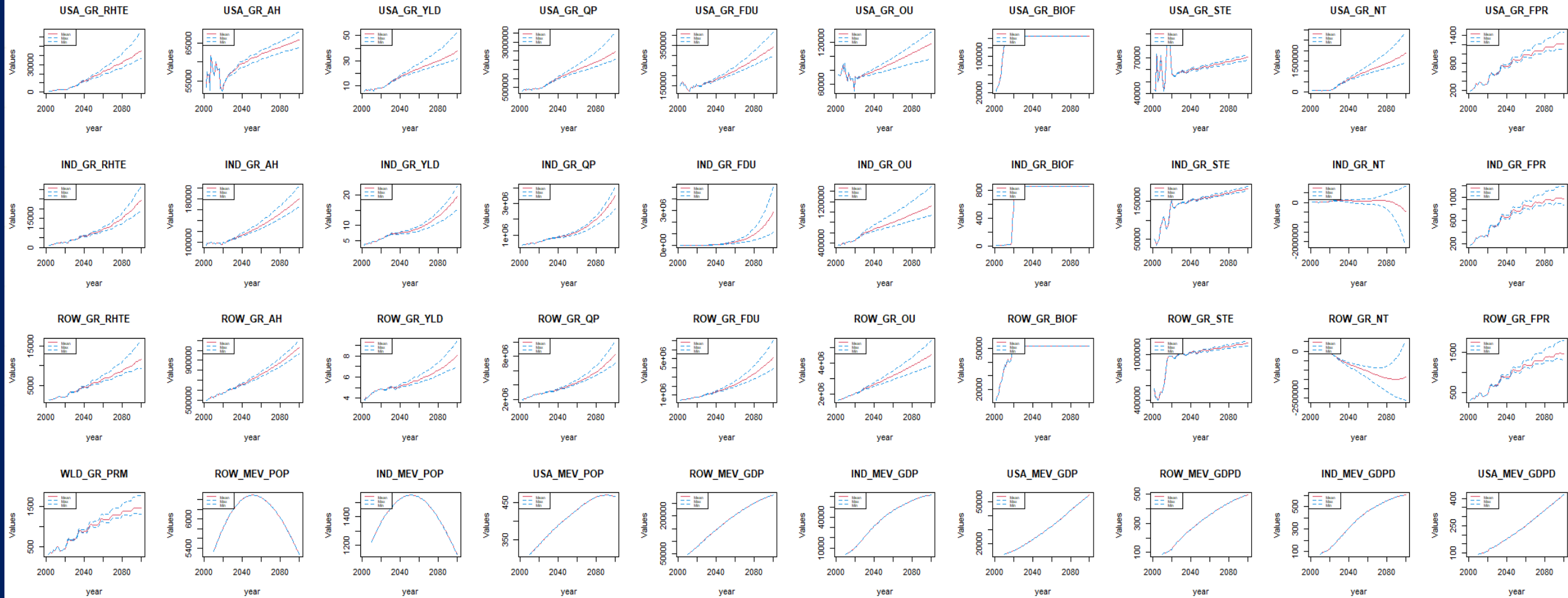
- India's price market supports (NRAs) are constant
- If India's price market supports (NRAs) remain constant at their 2010 values until the year 2100 ?

## Case 3

- India's grain trade is exogeneous
- If India will engage in trade for 5% of their grain production until the year 2100 ?

# Long-Run Grain Market Model Results (1,000 Monte Carlo simulations)

## Simulation Results: (Case 1) India's price market supports (NRAs) are evolving as income changes



# (Case 1) India's price market supports (NRAs) are evolving as income changes

## < Projection of India's NRA\_B ,D, and I >

India	Border market price support (NRA_B)	Domestic market price support (NRA_D)	Input market price support (NRA_I)
2010	0.61	0.00	0.00
2015	0.65	0.04	0.00
2020	0.67	0.08	0.01
2025	0.67	0.12	0.01
2050	0.61	0.21	0.03
2100	0.46	0.29	0.06

## < Grain Production >

Unit: Million MT

	India			Rest of World		
	Min	Mean	Max	Min	Mean	Max
2025	663	670	678	2,856	2,880	2,907
2050	908	991	1,043	3,686	3,826	4,078
2100	2,661	3,509	4,090	7,031	8,296	10,189

## < Grain Domestic Use (Feed, Biofuel, Other) >

Unit: Million MT

	India			Rest of World		
	Min	Mean	Max	Min	Mean	Max
2025	554	567	585	3,079	3,116	3,162
2050	809	917	1,088	4,365	4,684	5,118
2100	2,069	3,960	6,559	7,776	9,686	12,476

## < Grain Market price >

Unit: \$/ MT

	India			Rest of World		
	Min	Mean	Max	Min	Mean	Max
2025	505	513	524	664	675	689
2050	727	763	821	990	1,039	1,118
2100	863	970	1,184	1,304	1,466	1,789



# Comparison: NRAs are evolving (case 1) vs. No policy (or Trade is exogeneous)

## Grain Production

	India		Rest of World	
	No Policy (Case 2)	Trade is exogeneous (Case 3)	No Policy (Case 2)	Trade is exogeneous (Case 3)
2025	-1.0%	-9.3%	0.1%	2.0%
2050	-10.5%	-2.6%	1.8%	0.5%
2100	-9.5%	15.5%	2.1%	-5.7%

## Grain Domestic Use (Feed, Biofuel, Other Use)

	India		Rest of World	
	No Policy (Case 2)	Trade is exogeneous (Case 3)	No Policy (Case 2)	Trade is exogeneous (Case 3)
2025	0.0%	1.7%	-0.1%	-0.2%
2050	-0.6%	-0.2%	-0.2%	0.0%
2100	-2.5%	-2.8%	-0.1%	0.6%

## Grain Market price

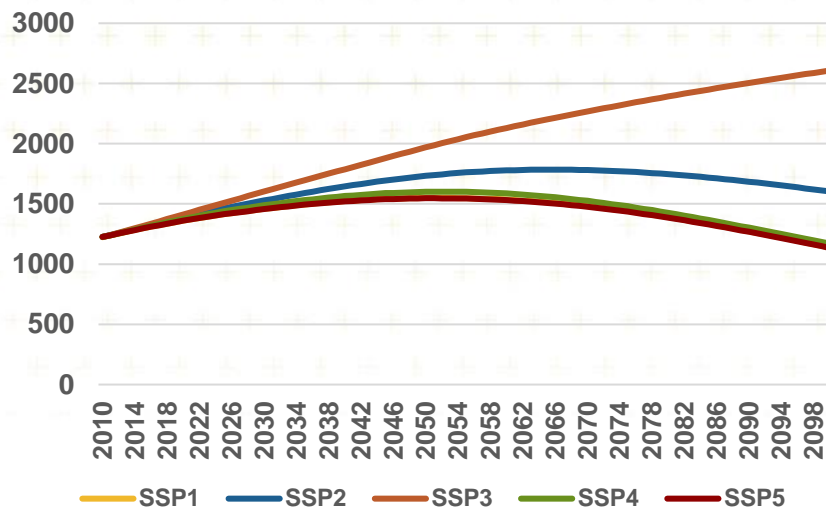
	India		Rest of World	
	No Policy (Case 2)	Trade is exogeneous (Case 3)	No Policy (Case 2)	Trade is exogeneous (Case 3)
2025	0.2%	-7.9%	0.3%	0.8%
2050	4.6%	1.2%	1.1%	-0.1%
2100	16.0%	13.4%	1.1%	-4.7%



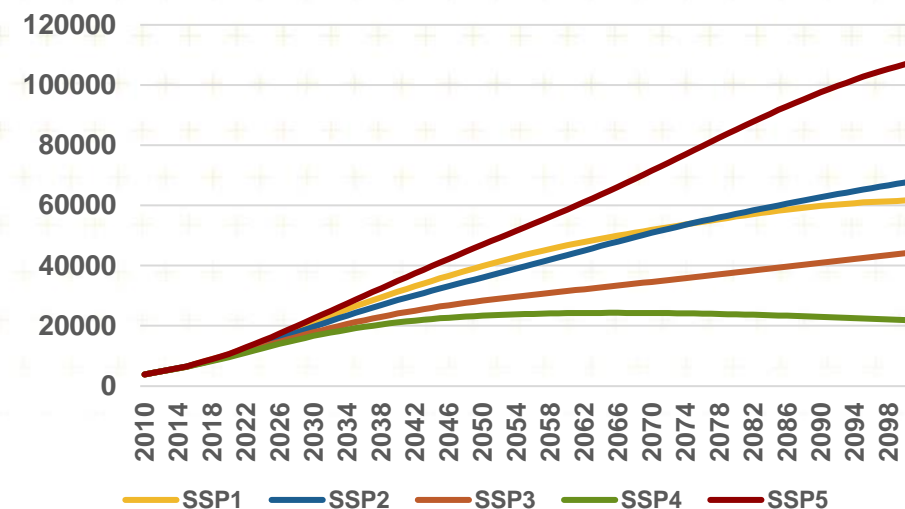
# Different GDP & Population Projection Scenarios (India)

- IIASA SSP (Shared Socioeconomic Pathways) framework provides different range of projection scenarios for both GDP and Population
  - Different GDP and Population scenarios are developed based on varying assumptions (Population growth, Technological advancements, Policy interventions, and Other socioeconomic factors)
- IIASA SSP framework encompasses five distinct scenarios: SSP1, SSP2, SSP3, SSP4, SSP5

India Population Scenarios



India GDP Scenarios



# Different GDP and Population Projection Scenarios for India

**\*\*Base scenario: SSP 1**

< Projection for India's NRA\_B ,D, and I >

India	NRA_B				
	SSP1	SSP2	SSP3	SSP4	SSP5
2025	0.67	0.67	0.67	0.67	0.67
2050	0.61	0.64	0.67	0.67	0.59
2100	0.46	0.52	0.66	0.65	0.25

India	NRA_D				
	SSP1	SSP2	SSP3	SSP4	SSP5
2025	0.12	0.11	0.10	0.10	0.12
2050	0.21	0.19	0.15	0.15	0.23
2100	0.29	0.26	0.16	0.17	0.35

India	NRA_I				
	SSP1	SSP2	SSP3	SSP4	SSP5
2025	0.01	0.01	0.01	0.01	0.02
2050	0.03	0.03	0.02	0.02	0.04
2100	0.06	0.05	0.02	0.03	0.09

< Grain Production Changes >

	India				Rest of world			
	SSP2	SSP3	SSP4	SSP5	SSP2	SSP3	SSP4	SSP5
2025	-0.4%	-0.9%	-0.8%	0.1%	0.0%	0.0%	0.0%	0.0%
2050	-1.2%	-5.4%	-5.3%	1.3%	0.4%	0.8%	0.8%	-0.2%
2100	2.2%	-6.1%	-4.5%	-7.1%	0.4%	0.7%	0.8%	0.7%

< Grain Domestic Use (Feed, Biofuel, Other) Changes >

	India				Rest of world			
	SSP2	SSP3	SSP4	SSP5	SSP2	SSP3	SSP4	SSP5
2025	-0.4%	-1.1%	-1.0%	0.2%	0.0%	0.0%	0.0%	0.0%
2050	1.1%	-0.9%	-0.6%	0.1%	0.0%	-0.1%	-0.1%	0.0%
2100	2.9%	-3.2%	-1.6%	-4.2%	0.0%	-0.1%	-0.1%	0.0%

< Grain Market Price Changes >

	India				Rest of world			
	SSP2	SSP3	SSP4	SSP5	SSP2	SSP3	SSP4	SSP5
2025	0.2%	0.4%	0.4%	0.0%	0.1%	0.1%	0.1%	0.0%
2050	2.1%	4.2%	4.2%	-1.8%	0.3%	0.7%	0.7%	-0.2%
2100	5.0%	14.9%	14.4%	-13.5%	0.3%	0.6%	0.7%	0.5%





# CONCLUSION

## ■ Long-run Grain market Supply and Demand Elasticities

- Demand elasticities that evolve as income rise
- Draw on elasticities and trend parameters in Monte Carlo simulation

## ■ Applying Agricultural policy (NRAs) for India in Long-run Grain market projection

- Changes ( $\Delta$  %): Production (-9.5% ~ -1.0%), Domestic use (-2.5% ~ 0.0%), Market price (0.2% ~ 16.0%)

## ■ Long-run Grain market projection varies depend on GDP & Population projections

- Changes ( $\Delta$  %): Production (-7.1% ~ 2.2%), Domestic use (-4.2% ~ 2.9%), Market price (-13.5% ~ 14.9%)



# Q & A

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