Biotechnology for Sustainable Growth of Indian Agriculture and Poverty Eradication

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Status of Indian Agriculture Before Independence

Before British Rule


Kallanai Dam built during Chola Empire

- Indian Agriculture is 9000 years old, cultivating wheat, barley, millets, rice, sugar cane, cotton, pulses and fruit crops
- Irrigation and mixed farming practices date back to 4500 BC
- Two harvest per year were norm of the country (‘Indika’ by Megasthenes)
- Agriculture flourished with systematic farm practices
- Land management was strong under Chola Empire and Akbar The Great

Source: ‘History of Agriculture’ by NB Chauhan

Status of Indian Agriculture Before Independence

Under British Rule

- Indian Agriculture went global with Cotton, Indigo, Opium and Rice entering international trades
- Irrigation by canal network established in Punjab, Narmada Valley and Andhra Pradesh
- Established Department of Revenue and Agriculture in 1881

Imperial Agricultural Research Institute Pusa, Bihar

- Established Imperial Agricultural Research Institute in 1905
- Appointed Royal commission on Agriculture in 1926
- Agriculture performance during 1891 to 1946 was depressing with annual growth rate of 0.4% with stagnant food grain production.
- The situation was more pathetic in Bengal province

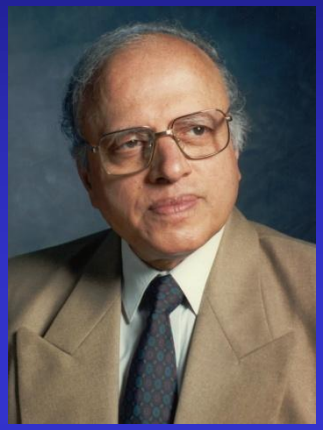
Source: 'History of Agriculture' by NB Chauhan
Lost People – An analysis of Indian Poverty by K Wasnik

The Bengal Famine 1943

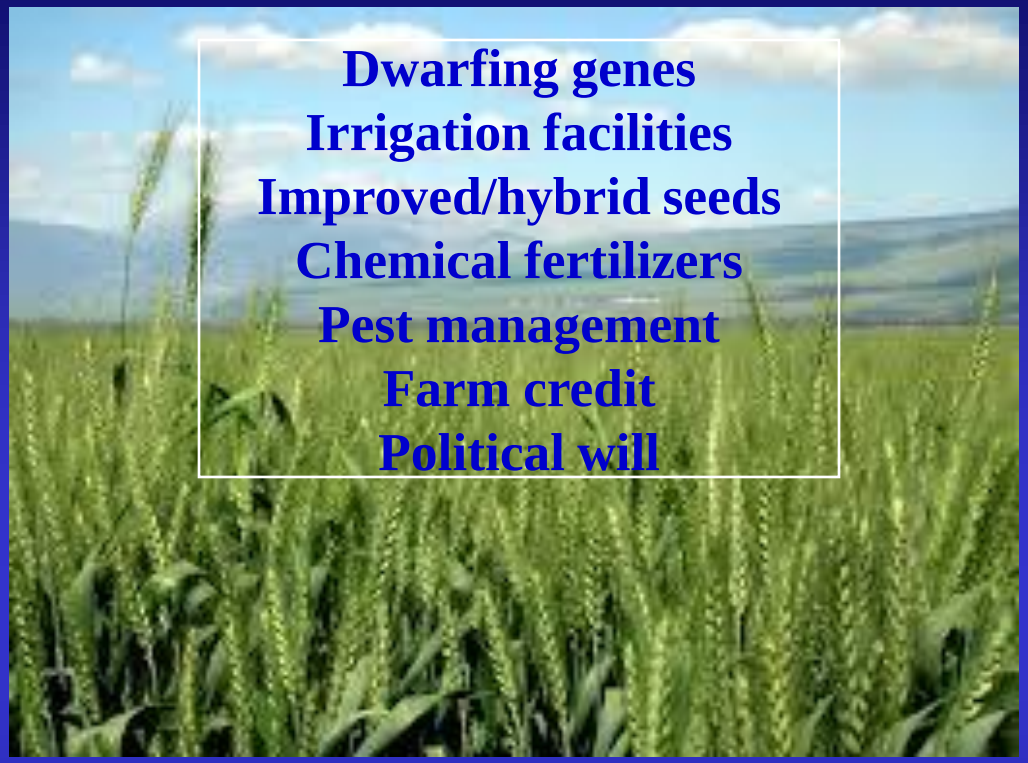
- The Bengal famine 1943 is the most devastating era of not only Indian Agriculture but the entire world
- Food output declined at an annual rate of 0.7% whereas population growth was at 1%
- More than 2 million people died due to food scarcity
- More than one million cattle either died or were sold off
- 0.5 million people became destitute and life standard of nearly 4 million deteriorated

Source: 'The Bengal Famine' by PC Mehalanobis, The Asiatic Review, pp 3-7

Indian Agriculture: Post Independence



Prof. MS Swaminathan



Dr. NE Borlaug

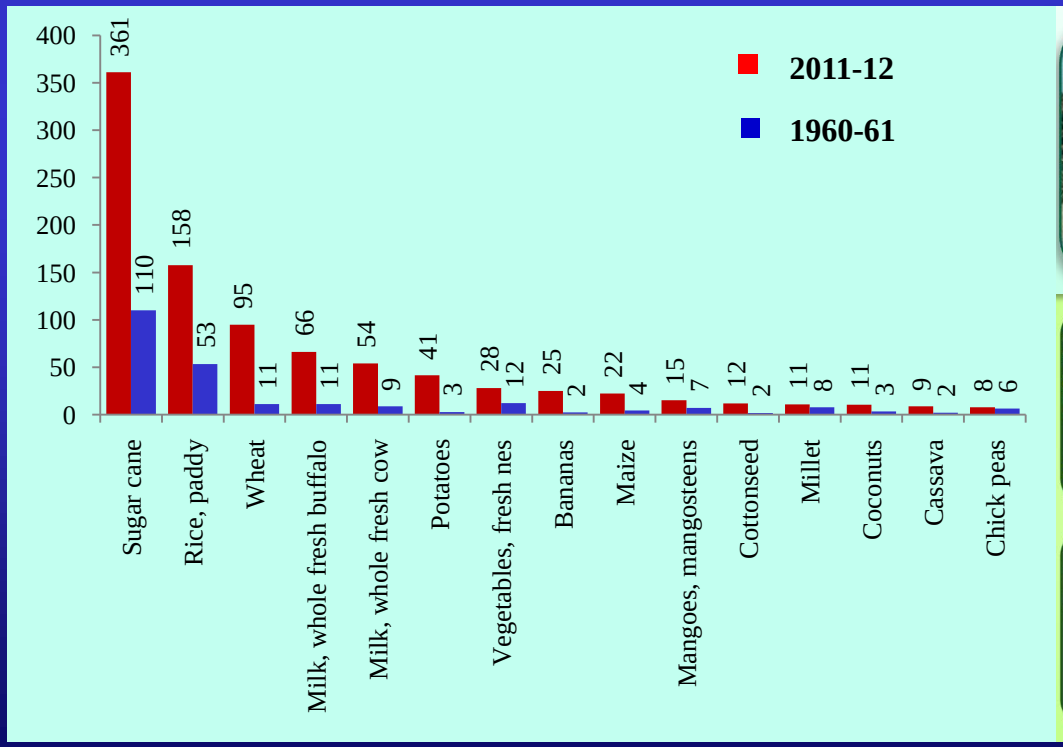
Green Revolution

Growth of Indian Agriculture

Between 1951 to till date

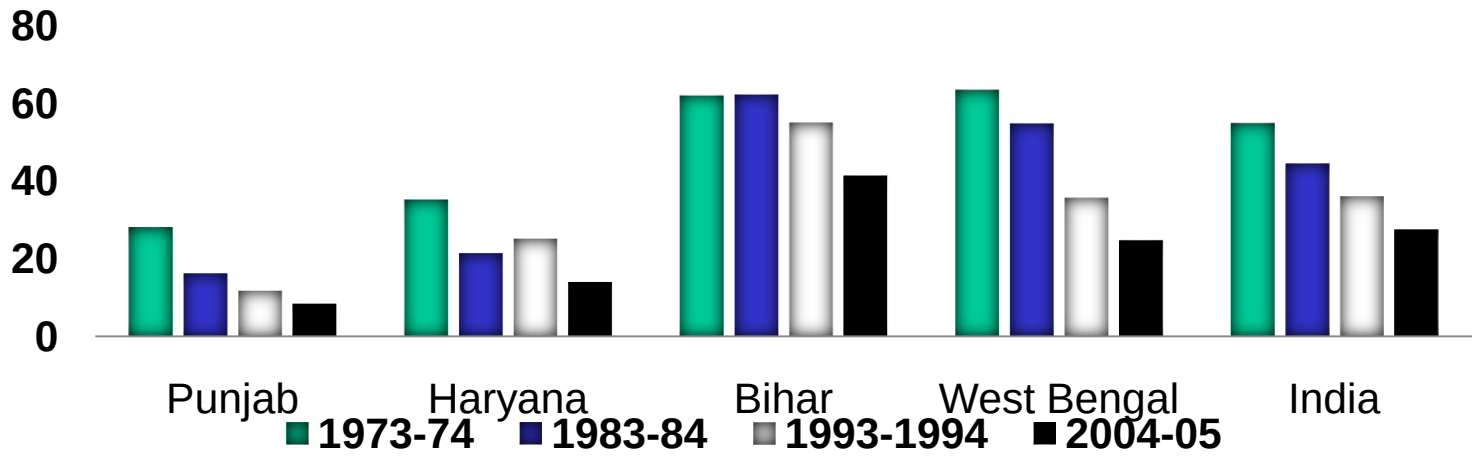
- Food grain production: 5X (51 to 257 MT)
- Milk production: 8X (17 to 127 MT - World No. 1)
- Fish production: 11X (0.75 to 8.4 MT)
- Horticulture : 6X
- Meat : 8X; Egg : 27X
- Poverty and hunger percentages more than halved

India has 2% of world's land, 4% fresh water but 16% of world's population and 10% of cattle.



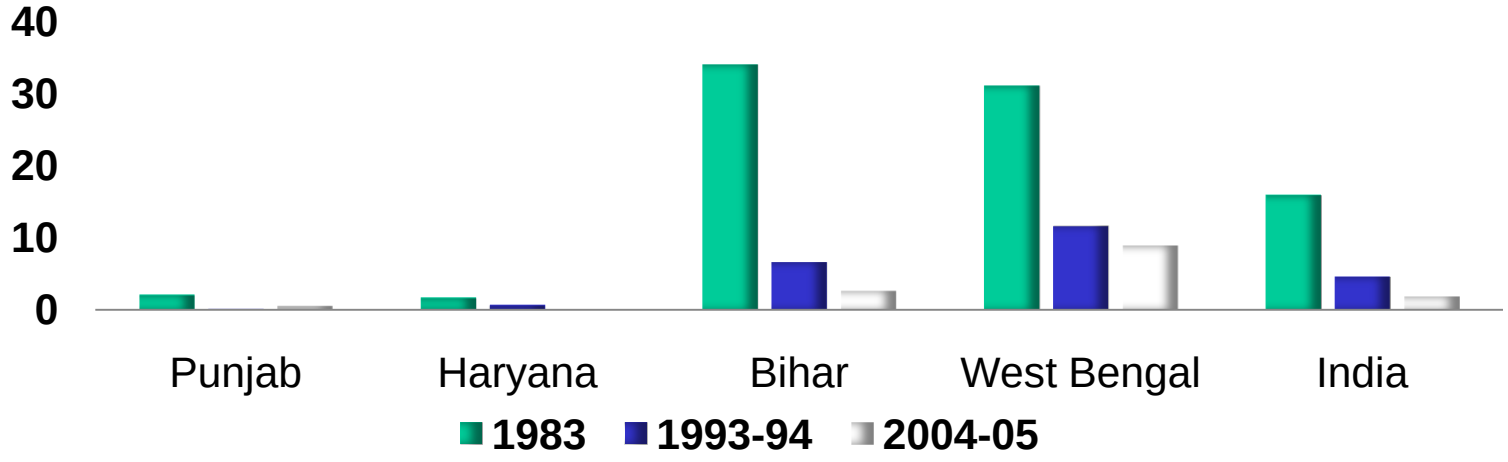
Source: FAOSTAT, 2014; State of Indian Agriculture, 2013-14

Status of poverty (in %) in the IGP

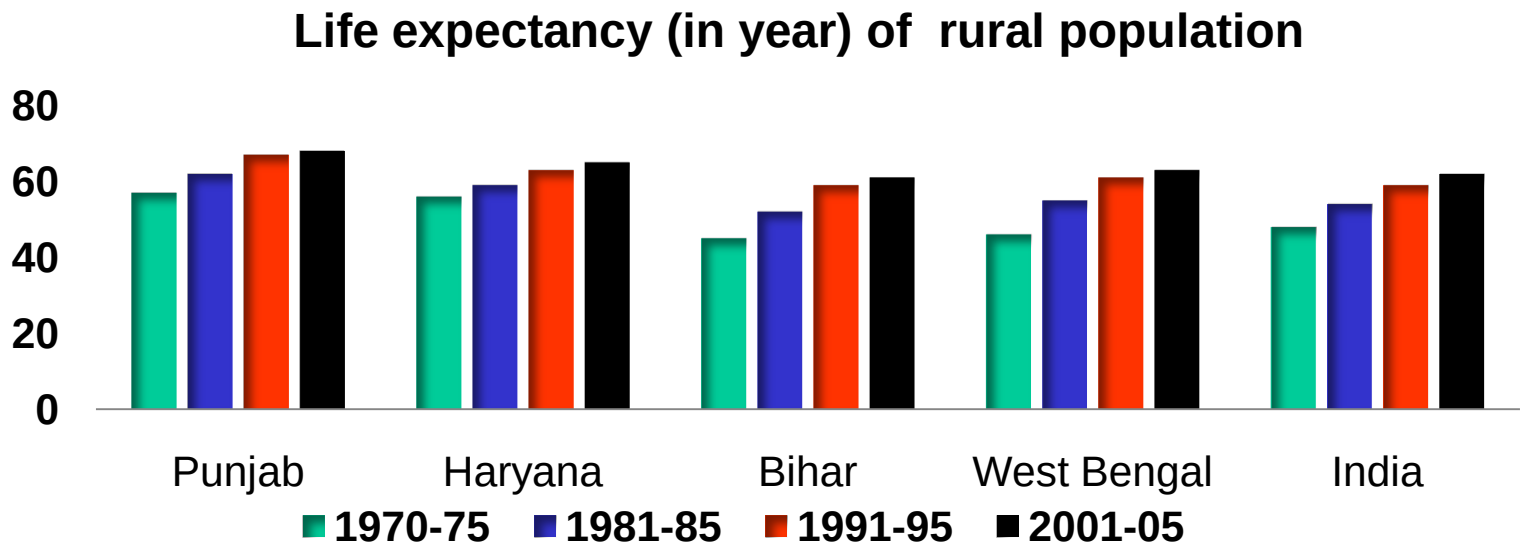


Source: Planning Commission, Government of India. IGP: Indo Gangentic Plains

Incidence of hunger (in %) in the IGP



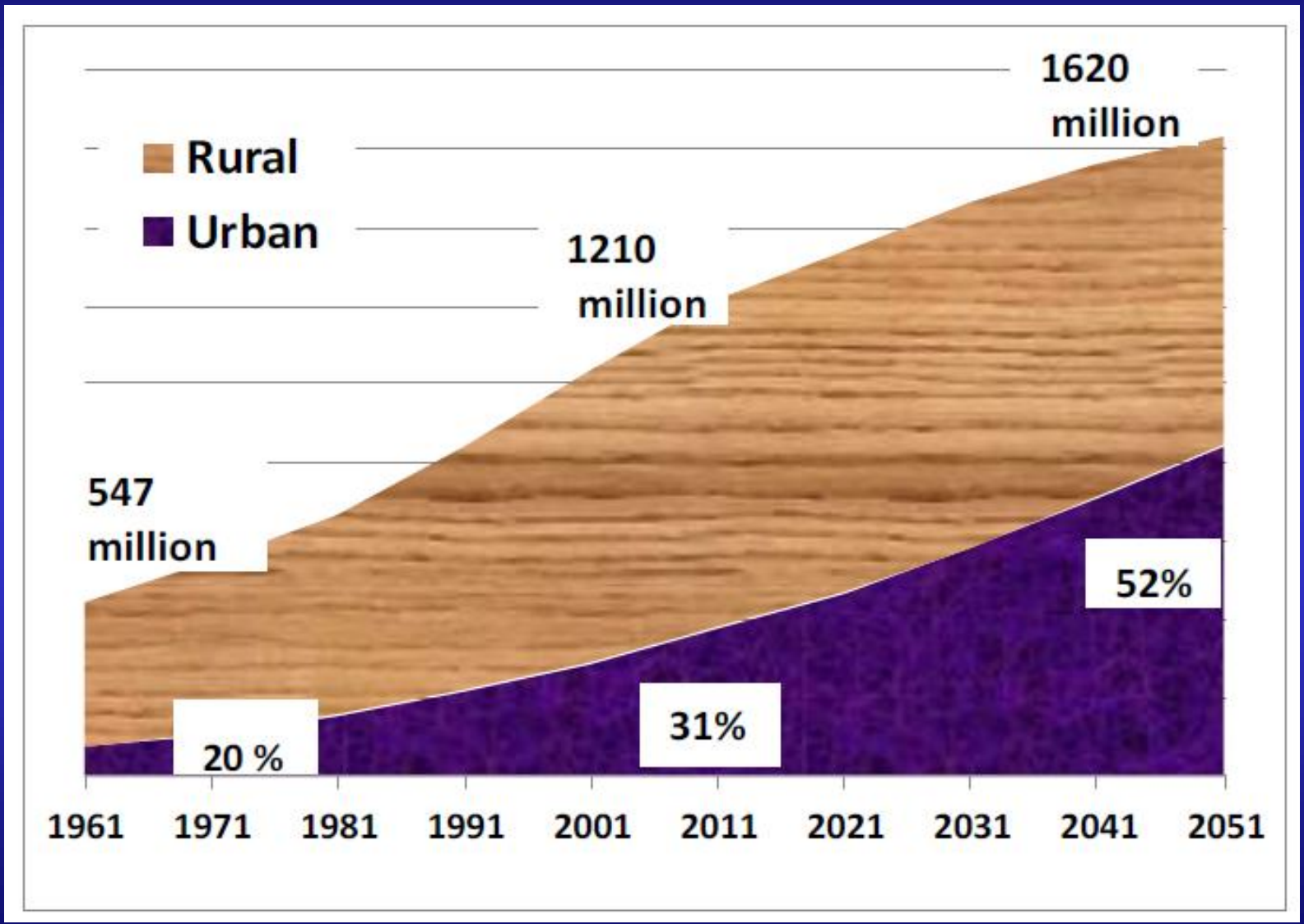
Source: National Sample Survey Organization (NSSO), Government of India, various rounds.



Source: Population Census, 1971, 1981, 1991 and 2001, Government of India.

Challenges Ahead

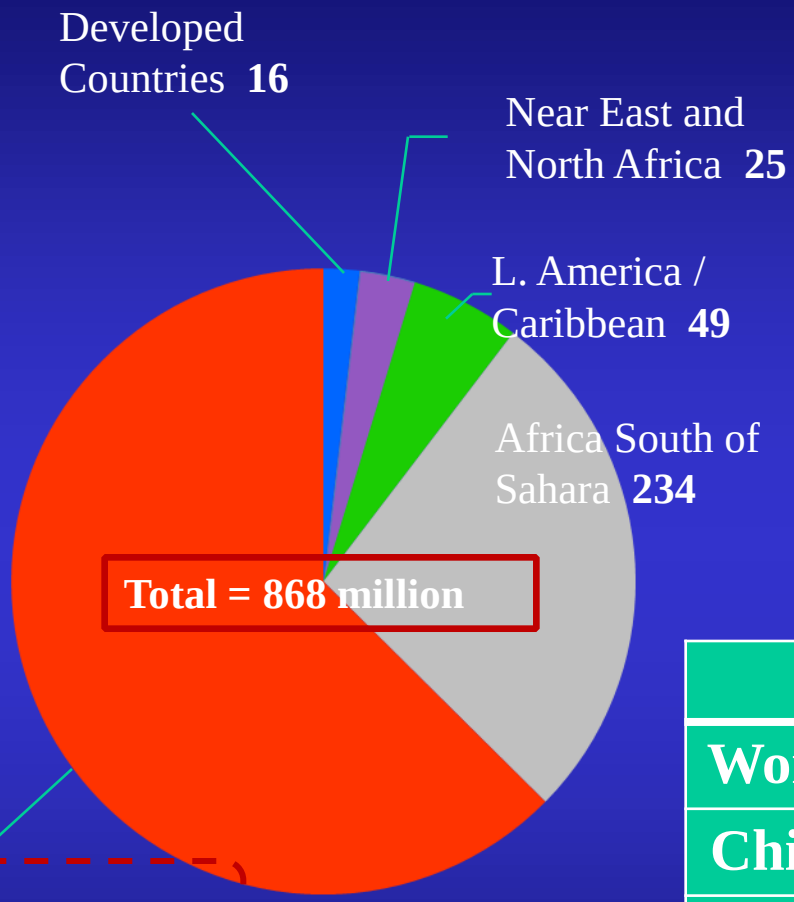
India's Population 1961 to 2051

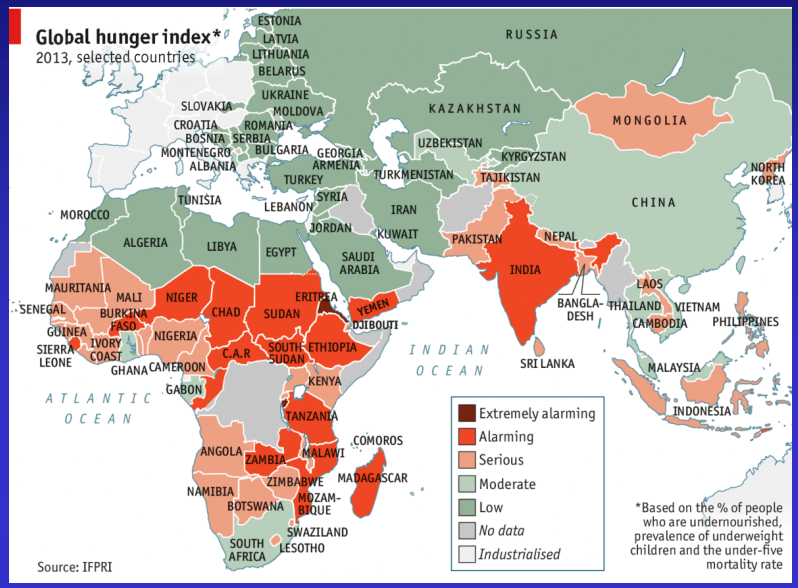


Source: NCAP, 2012

India's Global Hunger Index (GHI) Score

Majority (62%) of world's hungry live in Asia and 25% in India.





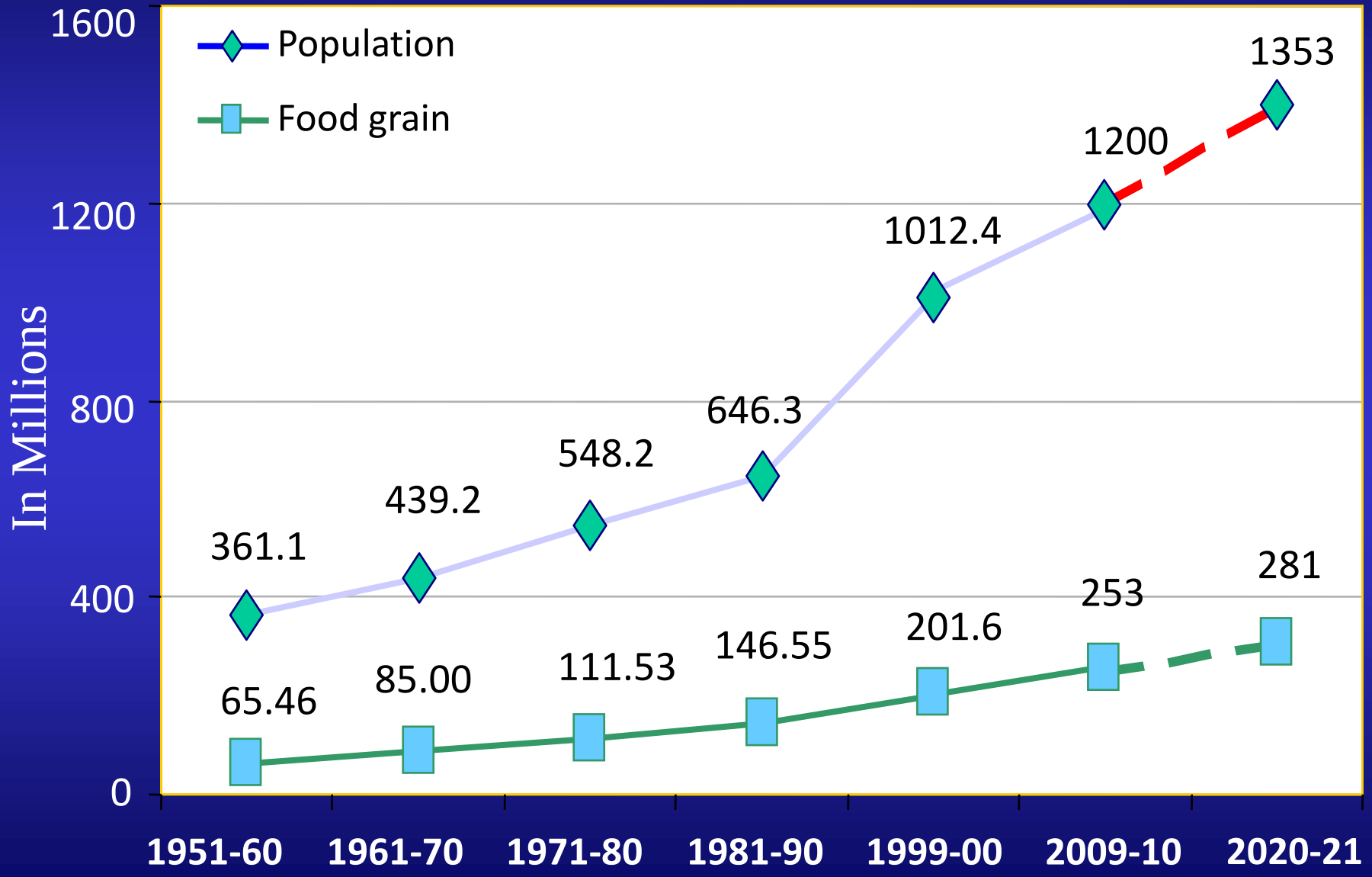
	1990	1996	2001	2011
World	19.7	17.0	16.0	14.6
China	11.7	9.1	6.8	5.5
Brazil	7.6	6.2	5.3	< 5
India	**30.4**	**22.9**	**24.1**	**23.7**

Among BRICS Countries, India has Alarming Level of GHI

Source: IFPRI, 2011; FAO, 2012

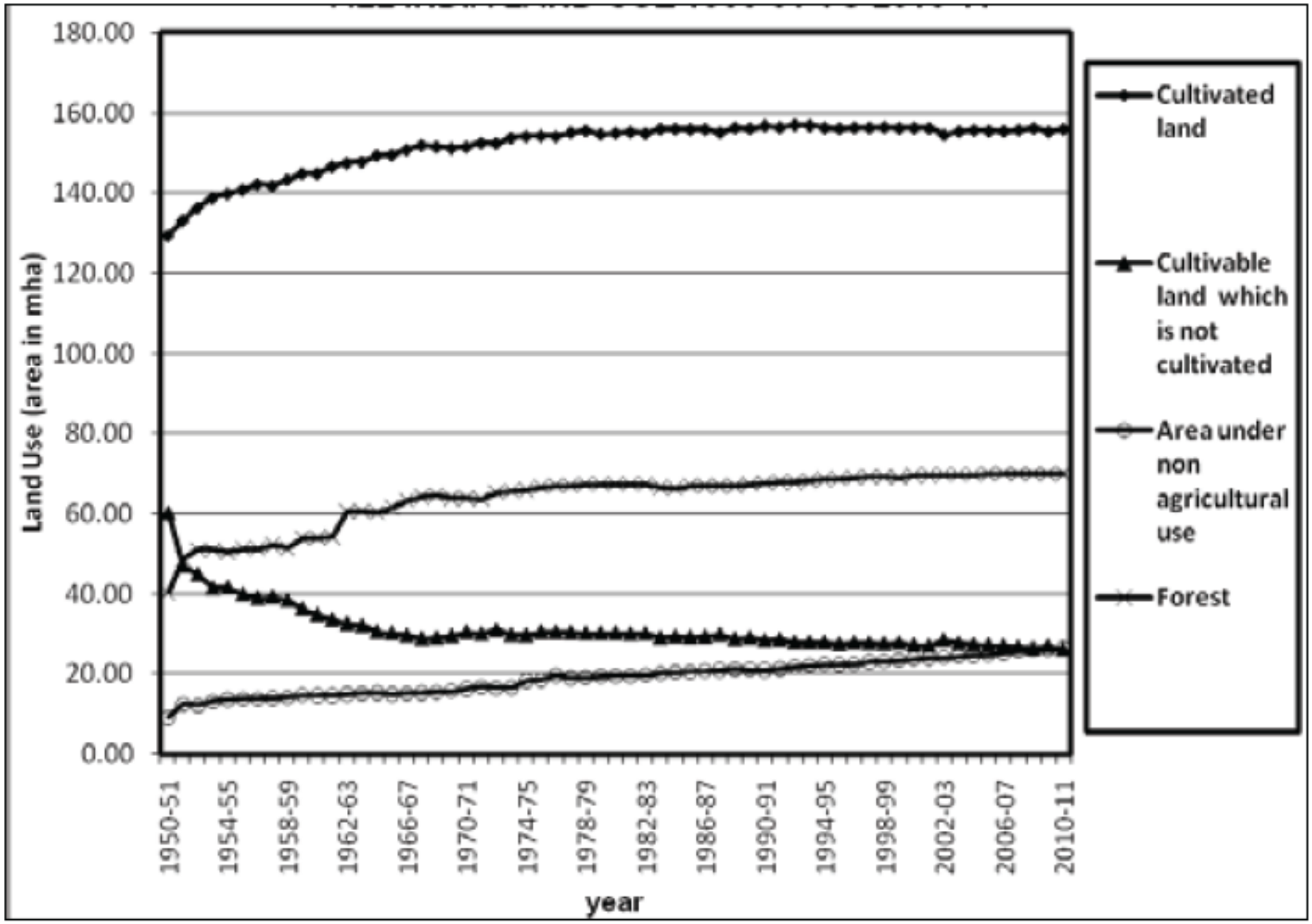
Population and Production of Food Grains

Trends and Projections



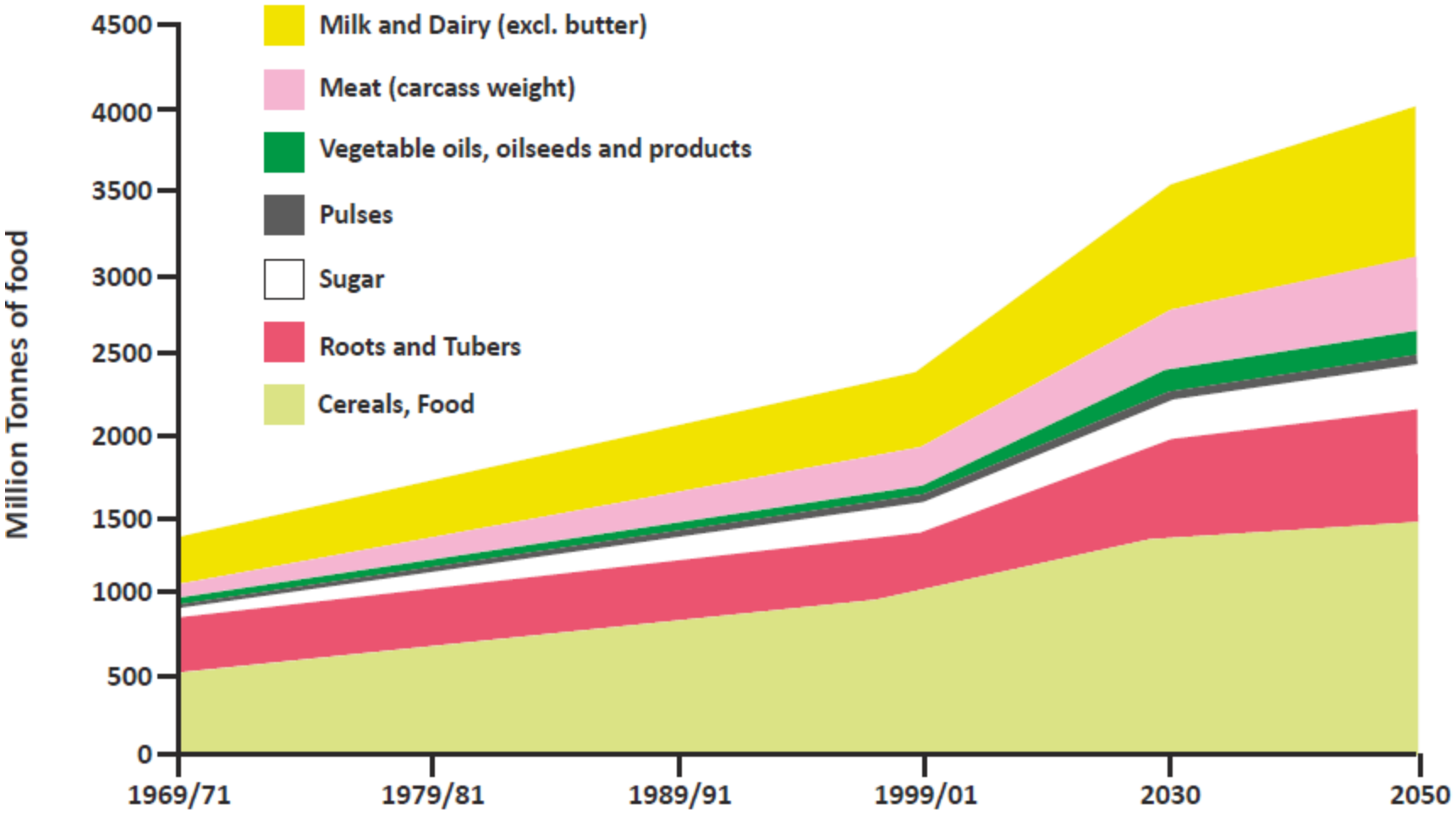
Source: http://populationpyramid.net/india/; NCAP, 2009

Area under cultivation in India Since 1950



Bhalla, 2014

The Future demand for food products



Choudhary *et al*., Plant Biotechnology Journal (2014)

Beginning of Biotech Era in Indian Agriculture

First Biotech product in India: Pusa Jai Kisan

A High Yielding Mustard Variety: Developed at NRCPB

Features
High yielding - 17-20%
Avg Yield - 19-25Q/ha
Early Maturity - 115-125 days
Lodging resistant, shattering resistant
Suitable for both timely and late sown conditions
Suitable for irrigated conditions of North West Zone comprising Gujarat, Rajasthan and Maharashtra

- A somaclonal variant (Bio-902) of Varuna
- Released in 1994 as ‘Pusa Jai Kisan’
- One of the top three cultivated varieties till date

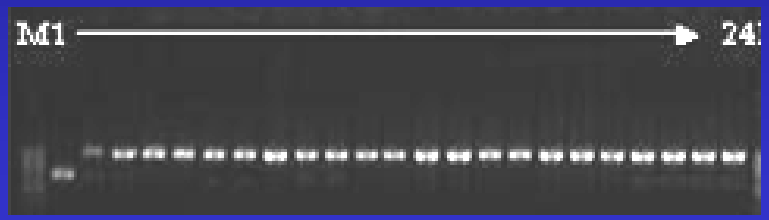
Development of Mustard Hybrid

- The *Moricandia* based CMS and fertility restorer lines have been developed and distributed to the public as well as licensed to private companies
- *Moricandia* system contributed to commercial production of mustard hybrids **NRC Sankar Sarson** (DRMR, Bharatpur**)** and **Coral 432** (Advanta India**)**

First MAS derived Rice Variety developed at NRCPB

Improved Pusa Basmati 1: BLB Resistant Rice Variety (2007)

Pusa Basmati 1 + *xa13* + *Xa21*



MAS for *Xa21*

MAS for *xa13*

Genotype	% yield superiority of IPB1 at 100 Kg N/ha
Pusa Basmati1 (Check)	11.9
Taraori Basmati (Check)	33.53

Improved Samba Mahsuri Pyramided with 3 Genes for BLB Resistance (2008)

xa5, xa13 and *Xa21*

Euphytica (2008) 160:411 422
DOI 10.1007/s10681 007 9564 6

Marker assisted introgression of bacterial blight resistance in Samba Mahsuri, an elite indica rice variety

Raman M. Sundaram • Manne R. Vishnupriya •
Sunil K. Biradar • Gouri S. Laha • Gajjala Ashok Reddy •
N. Shobha Rani • Nukala P. Sarma •
Ramesh Venkata Sonti

'Improved Samba Mahsuri' has good agro-morphological features (figures a & b) and has excellent grain quality parameters (figures d & f) similar to Samba Mahsuri (figure c & d)

QPM Hybrid in Maize (2008)

Vivek MH 9 Vivek QPM 9

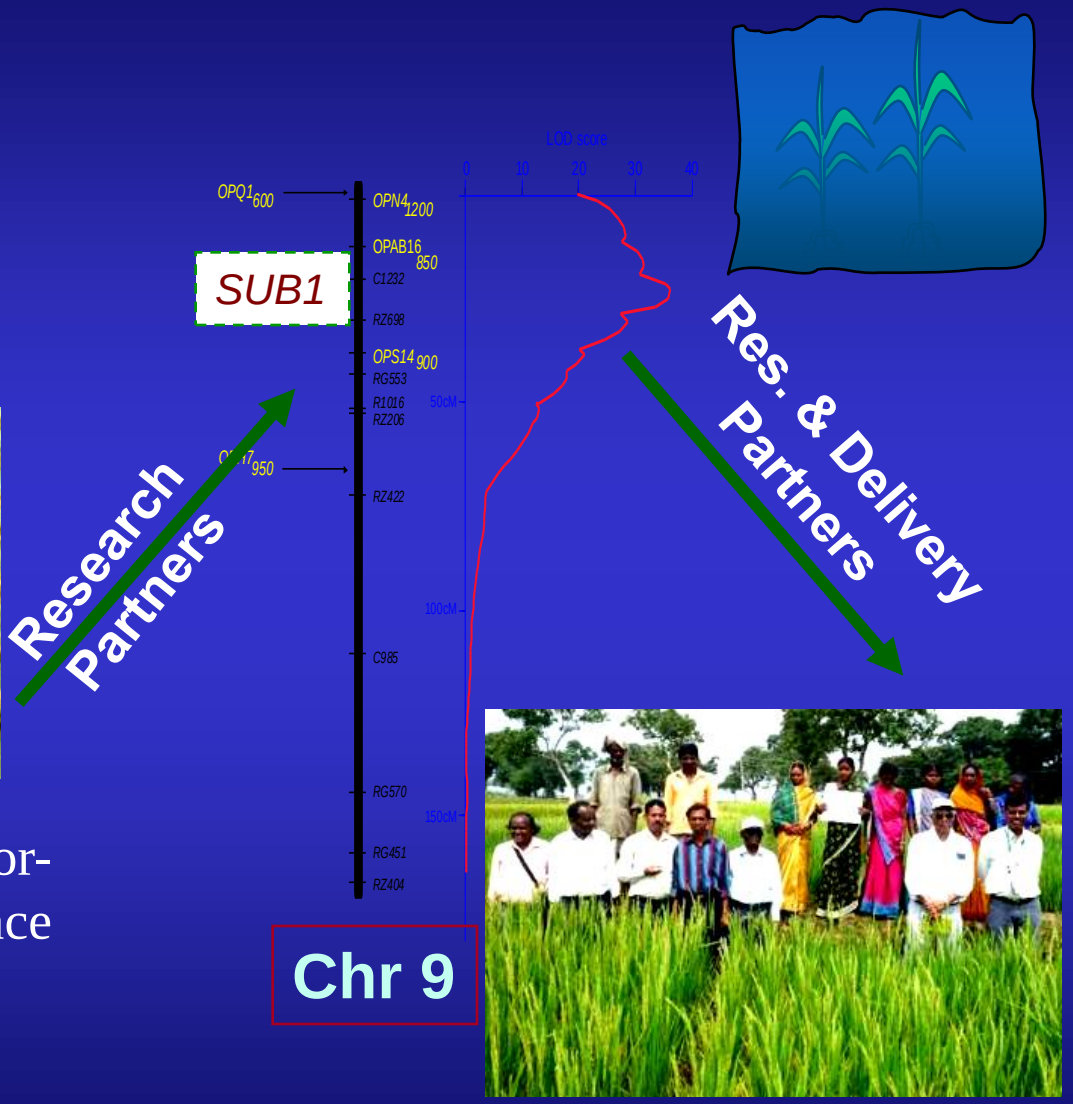
Hybrids/ Yield (Q/ha)	CVRC (Z1, Identified)	SVT (Uttarakhand) Released
Vivek 9	61.18	39.27
FQH 4567 (QPM)	63.60	42.75

Besides, 10 MAS derived QPM inbreds developed and registered

Submergence Tolerant Rice with SUB1 QTL

- 1970s: Donors identified
- 1990: Breeding lines, mapping
- 2006: *SUB1* cloned, MABB
- 2009: Sub1 varieties released

Sub1A, an Ethylene-response-factor-like Gene Confers Submergence Tolerance. Xu et al. (2006) Nature.



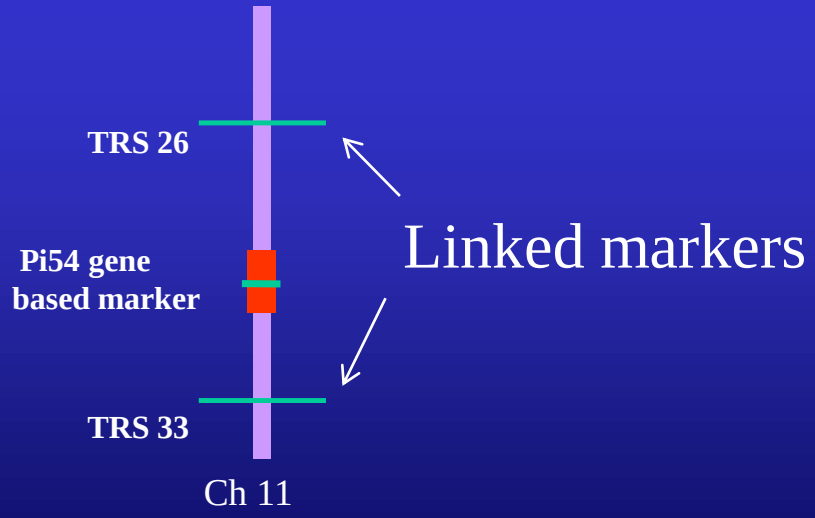
SUB1 on Chr 9 provides protection for 10-18 days of flooding

Developed Blast Resistant Varieties of Rice

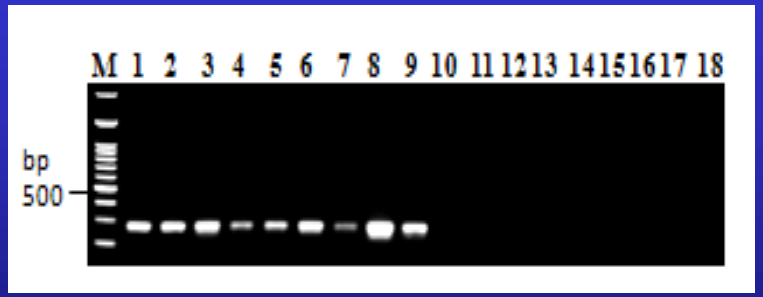
Blast Susceptible line

Resistant Donors

Pi54 gene

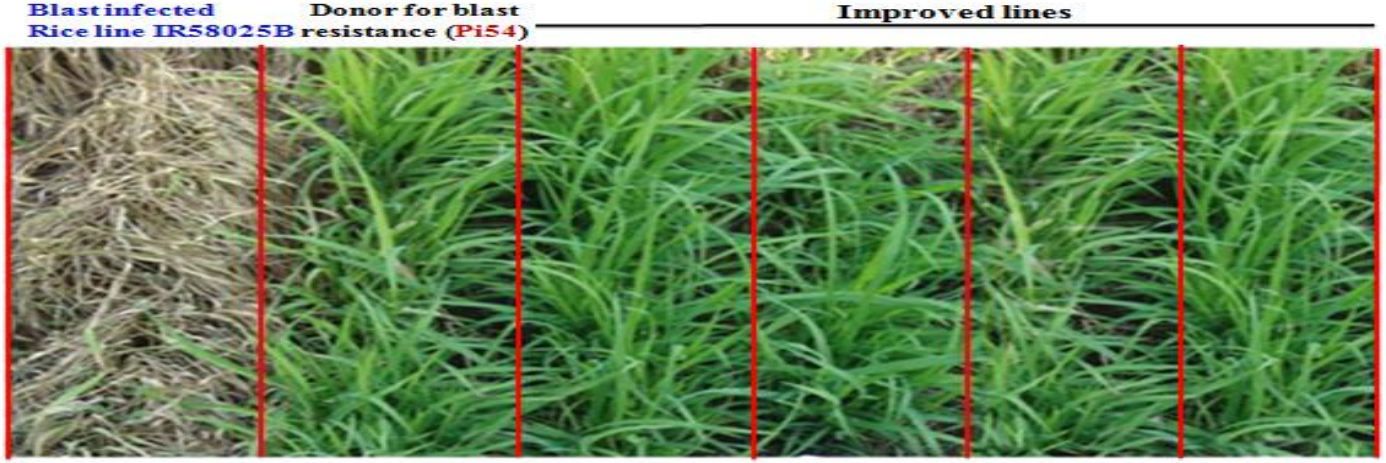


Gene based and linked DNA markers



Developed advanced breeding lines containing rice blast resistance gene *Pi54* using MAS at DRR Hyderabad

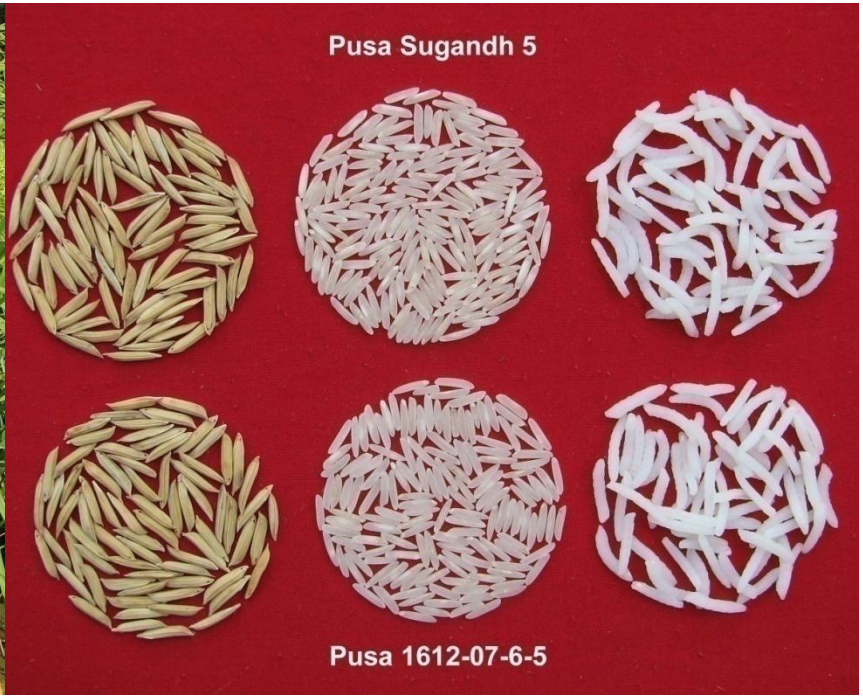
Courtesy: Dr. MS Prasad, DRR, Hyderabad



Improved lines containing *Pi54* gene and resistant to rice blast developed at DRR Hyderabad using DNA markers developed at NRCPB. IR 58025B is used in Rice Hybrid development (Plant Breeding, doi:10.1111/pbr.12056.)

Courtesy: Dr.Sundaram, DRR, Hyderabad

Pusa 1612: A MAS derived blast resistant NIL of Pusa Sugandh 5 released (2013)



- Carries genes *Piz5* and *Pi54* conferring resistance to blast disease
- First MAS derived variety in India to be released through NIL trial
- Released in Region II (Punjab, Haryana, Delhi and Jammu & Kashmir) of the Basmati growing areas of north-western India
- Will save more than Rs 60.0 Crores (~10.0 Million USD)spent on fungicide spray

Source: Dr AK Singh, IARI

Genetically Modified Crops

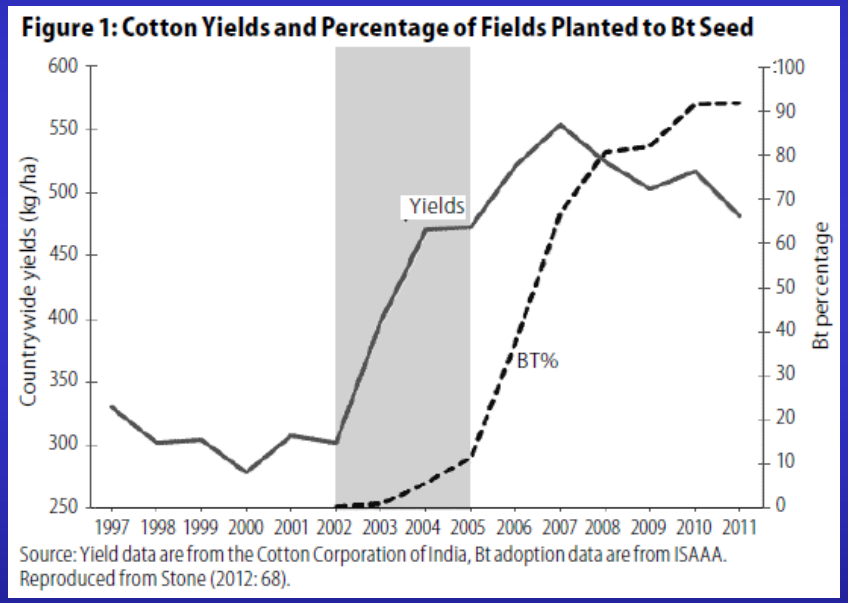
Bt Cotton in India: A Success Story

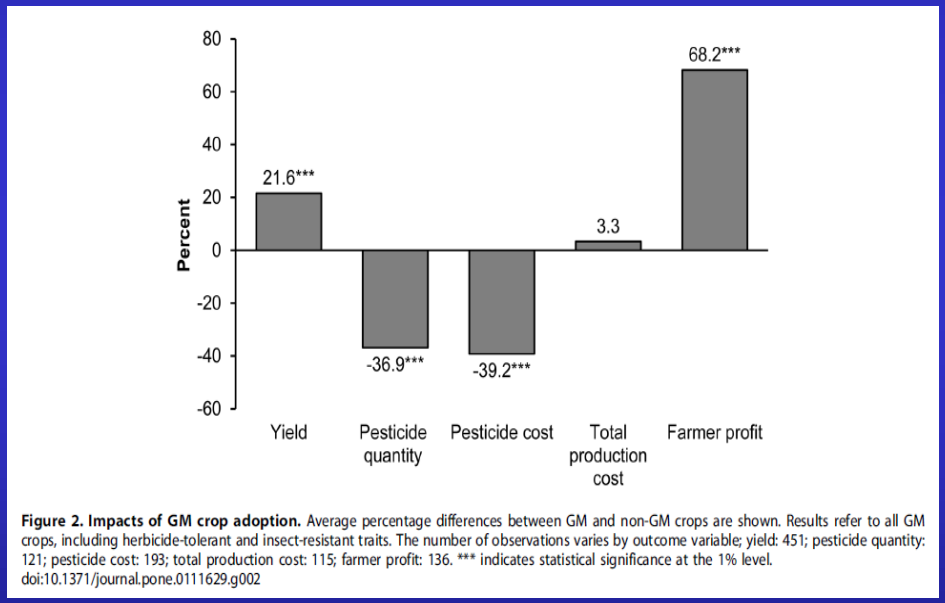
Indicators	2001-02	2012-13
Events	01	06
Hybrids	03	1095
Yield/ha (Kg)	308	550
Production (M bales)	13.6	37
Area (Mha)	0.5	11
Farm income (Million USD)	14.6	2100
Companies	01	40
ExIm (Million MT)	-4.25	+1.25
Pesticide spray on cotton (MT)	5748	222

Source:
James, 2013;
Mayee and Choudhury, 2013;
Brookes and Barfoot, 2014

Role of Bt Cotton in Poverty Eradication

On an average, GM technology adoption has reduced chemical pesticide use by 37%, increased crop yields by 22%, and increased farmer profits by 68%.





Ronald J Herring (2013) Reconstructing Facts in Bt Cotton Why Scepticism Fails. Economic & Political Weekly, August 17.

Klumper W and Qaim M (2014) A Meta-Analysis of the Impacts of Genetically Modified Crops. PLoS One 9 (11), e111629

Bt Cotton and Calorie Consumption

- Income gains from Bt adoption have improved household access to food, leading to higher calorie consumption and better dietary quality.
- The introduction of Bt technology has reduced food insecurity by 15 – 20% among Indian cotton growers.
- Bt cotton adoption has raised consumption expenditures, a common measure of household living standard, by 18% during the 2006–2008 period.

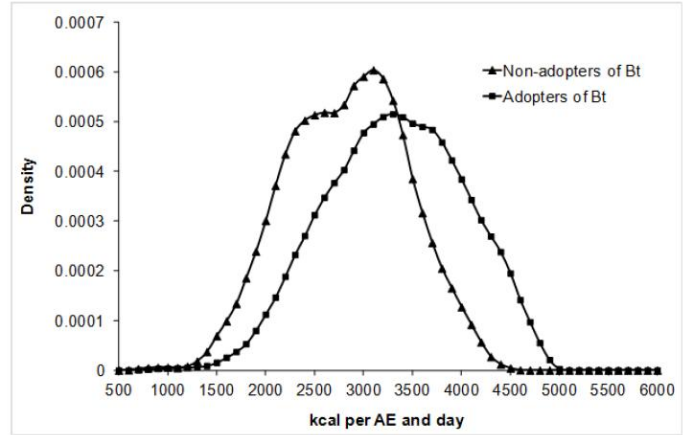


Figure 1. Distribution of household calorie consumption for adopters and non-adopters of Bt cotton.
AE: adult equivalent.

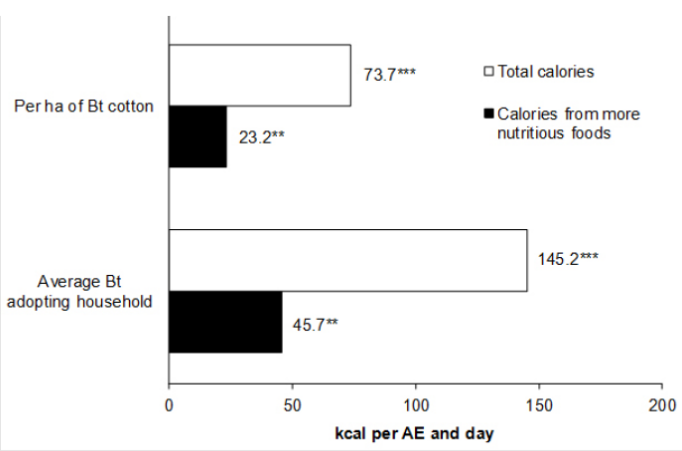


Figure 2. Net effects of Bt cotton adoption on household calorie consumption.
**Significant at the 5% level. ***Significant at the 1% level.

Matin Qaim and Shahzad Kouser (2013) ISB News Report September.
Jonas Kathage and Matin Qaim (2012) PNAS 109 (29), 11652–11656.

Some considerations….

Allocation of more %age of GDPs for Agriculture, Health and Education.

Increased Access to food and education for the rural masses.

Linkage of all development programmes with inclusive growth of the society.

To bridge the increasing gap between poor and rich.

Making agriculture more remunerative

Acknowledgements

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Brazilian Academy of Sciences

Thank you