Grey side of the Green Revolution

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Green, White, Yellow and Blue Revolutions

Between 1951 and 2013

- Foodgrain production 51 to 265 mt, 5.5x
- Horticultural production 268 mt, 7x
- Milk production 17 to 140 mt, >8x (World No. 1)
- Fish production 0.75 to 10 mt, 12x
- Poverty and hunger percentages more than halved
- From Ship-to-mouth and Chronic Energy Deficits to Food Bill – Right to food

Foodgrains Production in Punjab and Haryana

YEAR	Production (Million Tonnes)
1965-66	5.37
1975-76	13.86
1985-86	25.46
1995-96	32.00

- **In 1995-96 contributed 21% of India's total foodgrain production**
- **Contributed 50% of rice and 85% of wheat total procurement**

Grey Effects of Green Revolution

- Rice productivity growth rate in Punjab during 1965-74 was 9%, but dropped to 1.13% during 1995-96.
- Area under pulses sharply declined Summer rice cultivation excessively increased water and energy demands
- Incidences of diseases, pests and weeds (*Phalaris minor*) increased, biodiversity decreased, aerosols concentration in urban areas increased;

Grey Effects of Green Revolution

- Soil organic carbon declined from 0.5% in 60s to 0.2% in the 90s. Soil with low Phosphorus increased to 73% in 1996 from only 3.5% in 1975 in Haryana; the $N:P_2O_5$ ratio came down from 3.3:1 to 4.2:1;
- Harvested more nutrients than being applied, particularly P & K, reducing profitability
- Over exploitation of groundwater led to higher costs of pumping water, thus decreasing profitability and also adding to salinity problems.

Ground Water Status in Punjab

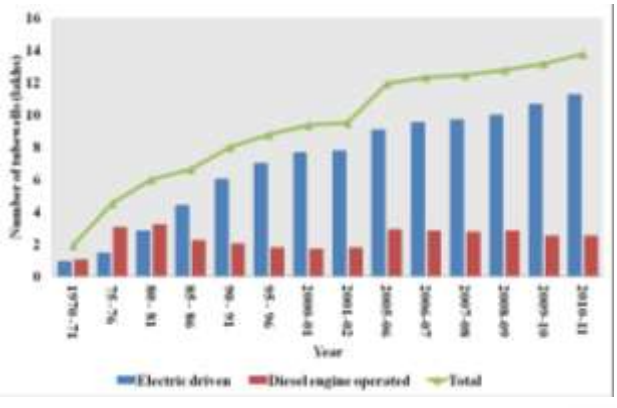
TRENDS OF DECREASING WATER TABLE IN PUNJAB OVER THE YEARS

Year	Affected Area	Depth of water level (in feet)
1973-1974	3%	30
2005-2006	30%	70
2023	Whole Punjab	160

Number of tubewells in Haryana and Punjab

	Haryana		Punjab	
	1966-67	1994-95	1966-67	1994-95
Tubewells	12570	547216	16932	740000

GROWTH OF TUBEWELLS IS LINKED WITH DECLINE OF TABLE IN PUNJAB

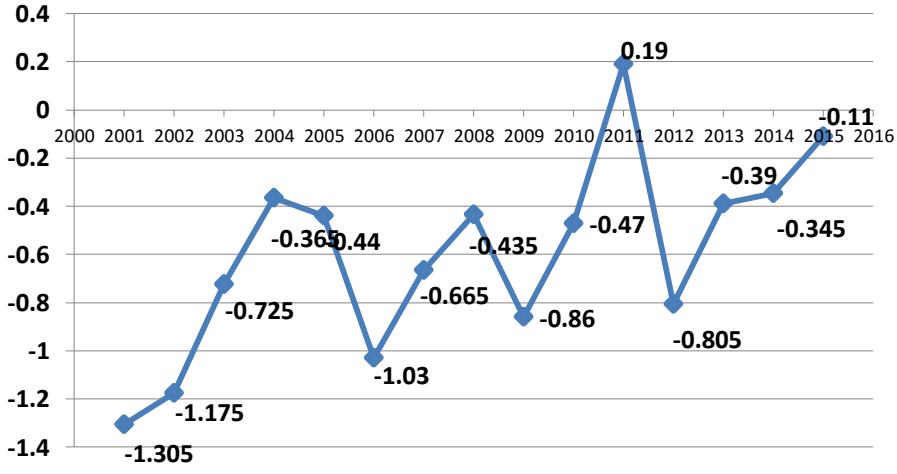


Safe Semi Critical Critical Overexploited

Irrigated Area (thousand hectors) in Haryana and Punjab

State	Net irrigated area		Gross irrigated area	
	1965-66	1994-95	1965-66	1994-95
Punjab	2263	3944	3136	7315
Haryana	1293	2663	1736	4515

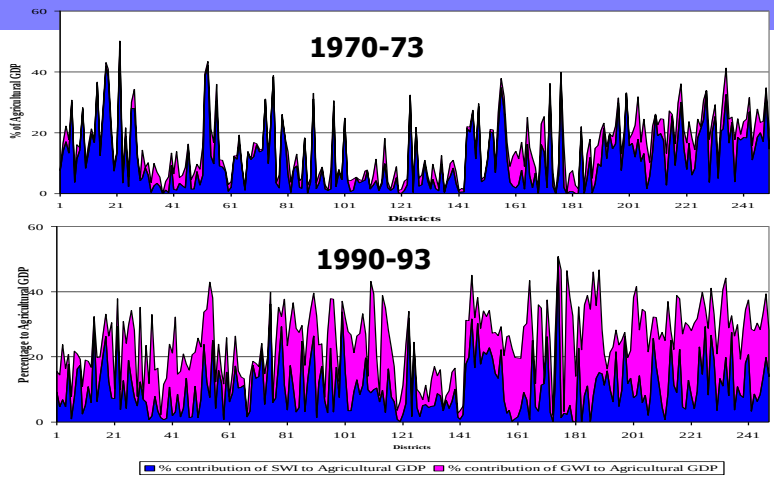
Ground Water Status in Haryana



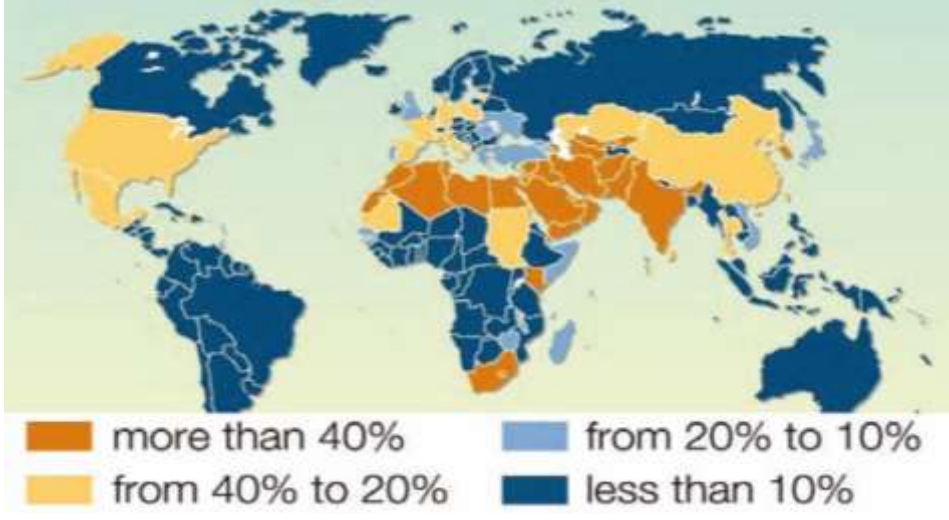
Rate of decrease of water tabe in Haryana

- From 1974 to 2015 depth of water table in Haryana decreased by 8.56m , from an average of 9.19 m in June 1974 it went down to 17.75 m in June 2015
- Hisar is the only district where the water table has risen with more than 7 m per in the last 40 years as the water quality is not good.

Until 1970, canals dominated irrigated agriculture… Since then, tube-wells have emerged as "Engines of Agricultural Growth"…



Water availability : 30% of crop production at risk by 2025



Source: World Economic Forum, 2010

Role of groundwater (GW) in Food Security

Net irrigated area : 58.5 M ha
GW irrigated area : 35.0 M ha

Increase in irrigated area (1951- 2007)

Major and medium irrigation projects : 3.5 times
Tank irrigation : 1.9 times
Ground water : 6.3 times

During past 25 years : 75 % increase in GW irrigated area

Ultimate GW potential|: 64 M ha with sustainable GW management

Status of groundwater development in North Western Indian states (2008)

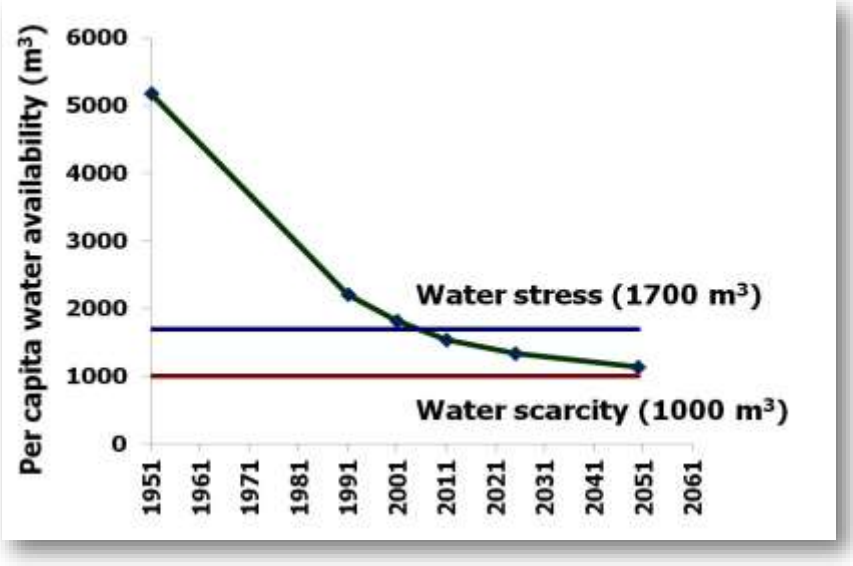
State	Total blocks	No. of overexploited groundwater blocks
Haryana	113	55
Punjab	137	103
Uttar Pradesh	803	37
Gujarat	223	31
4 States	1276	226 (**27 %**)
India	**5723**	**839 (15 %)**

Groundwater Utilization (BCM) in Eastern Region

States	Annual Repleni-shable GW	Net annual GW availability	Annual GW draft	Stage of GW deve-lopment (%)	GW avai-lability for future irrigation
Assam	28.52	25.79	3.49	14	22.14
Bihar	29.34	26.86	11.95	44	14.10
Chhattisgarh	12.42	11.63	4.05	35	7.44
Eastern UP	27.29	25.47	17.68	69	7.58
Jharkhand	6.31	5.76	1.86	32	3.69
Odisha	17.78	16.69	4.73	28	11.64
West Bengal	29.25	26.58	10.69	40	15.38
Eastern Region	**150.91**	**138.78**	**54.45**	**39**	**81.97**
India	432.72	398.16	245.10	62	154.71

Source: Dynamic Ground Water Resources of India (2014)

Per capita water availability in India



Country	Abstraction (km^2/year)
India	251
China	112
United States of America	112
Pakistan	64
Iran	60
Bangladesh	35
Mexico	29
Saudi Arabia	23
Indonesia	14
Italy	14

Groundwater-Abstracting Countries as of 2010

Groundwater Challenges

- **Uncontrolled Groundwater exploitation both in hard rocks and alluvial areas is the threatening sustainability of this resource, mostly in the states of Rajasthan, Gujarat, Tamil Nadu, Punjab, Delhi and Haryana**
- **Dependence on groundwater for irrigation will increase due to global warming. Quality issues will increase.**
- **Excessive withdrawal of ground water is worsened further due to free/subsidized power in some States. (Water-Energy nexus)**
- **Groundwater pollution due to excess application of fertilizers and pesticides, indiscriminate disposal of effluents from industries and urban sewerage.**
- **Arsenic, Fluoride and Iron in groundwater in excess of permissible limits in several states of India prohibits its use for drinking purposes.**
- **Seawater Ingress in Coastal Aquifers-** Groundwater in coastal aquifers exists in a fragile dynamic equilibrium with seawater. Indiscriminate exploitation of ground water from such aquifers leads to seawater intrusion into the fresh water aquifers.

India: A Gene Rich Center

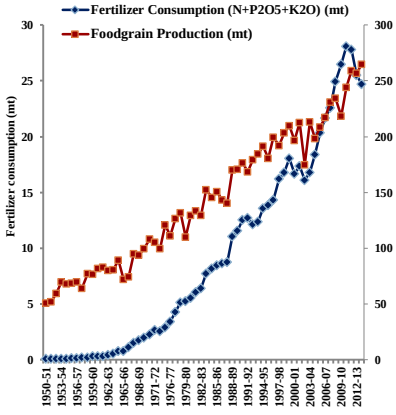
Science must ensure judicious harnessing of this Treasure, Know your treasure- Evaluation and Conservation through use

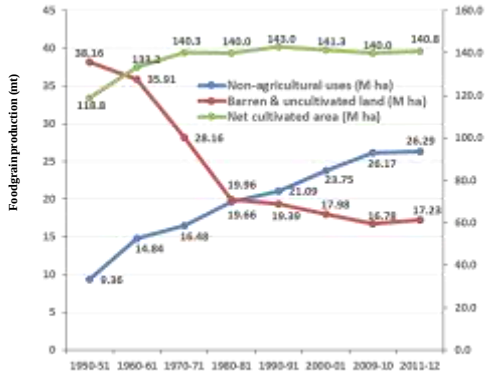
Second Generation Problems of Green Revolution

- Decline in quantity and quality of soil organic matter
- Multi-nutrient deficiencies in soils and crops
- Deterioration of soil physical health
- Nutrient withdrawals in excess of replenishment
- Factor productivity decline
- Stagnation/decline in production/productivity growth rates
- Increased incidence of diseases and pests
- Reduced farm profits

Soil Science and Agricultural Chemistry, IARI, New Delhi

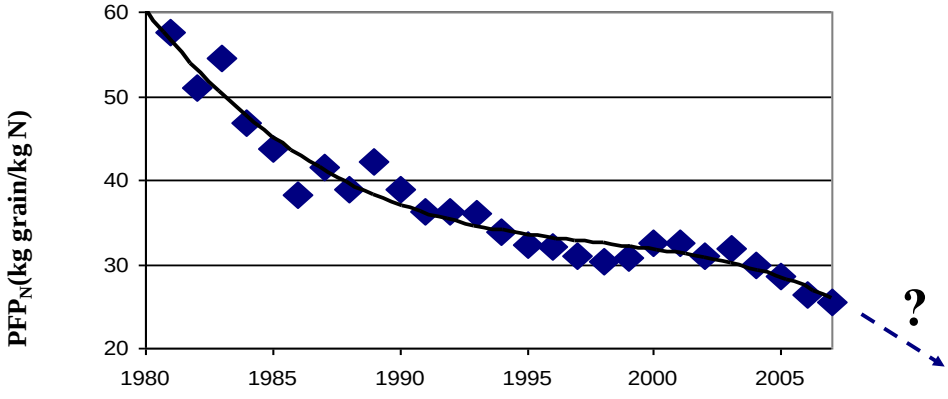
Temporal changes in fertilizer consumption, foodgrain production and land use





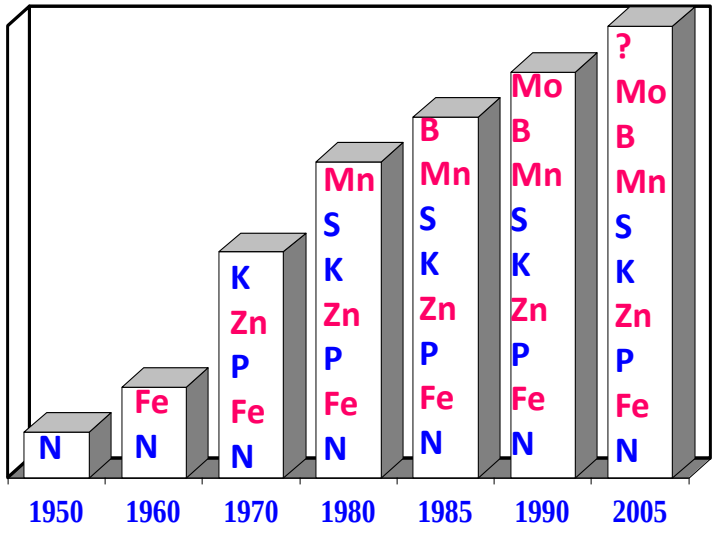
FAI, 2013

Fertilizer N Use Efficiency Trend for Cereals in India



Calculated using IFA and FAO data
under the assumption that two-thirds of fertilizer N is applied to cereals

Progressive expansion in the occurrence of nutrient deficiencies



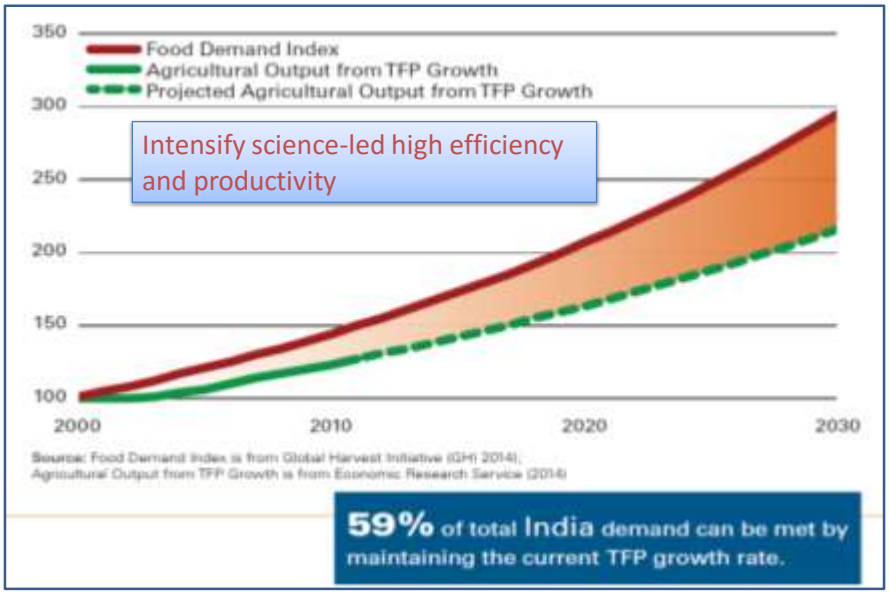
Causes of soil health deterioration

- Inadequate and unbalanced fertilizer use
- Incomplete fertilizer prescriptions
- Poor soil testing services
- Low use of organics
- Clean cultivation – residue removed/burnt
- Excessive tillage; poor land leveling
- Ignoring principles of crop rotation – monoculture
- Lack of awareness among farmers
- Fertilizer policies ???

Consequences of soil nutrient mining

- Depletion of native nutrient reserves
- More widespread and more acute nutrient deficiencies
- Low nutrient use efficiencies
- Lower returns from investment in fertilizers and other inputs
- Very high remedial cost of improving depleted soils
- Jeopardizing the sustainability of agriculture sector as a whole

Food Demand Compared to Agricultural Output from TFP Growth in India



The Indian Enigma

- Despite rapid economic growth trajectory of 7- 8%, 1/4th of World's hungry and poor, 200 m, have homes in India
- 40% of world's malnourished Children are our own; high epigenetic & economic costs
- 1/4th of world's smallholder farmers in India, they comprise 50% of rural poor and hungry, F:NF income 1:4
- A nation of youth, largest bulge of unemployed/poorly employed youth, a demographic disaster
- Agriculture 2-3 times more effective than other sectors in alleviating agrarian crisis, yet investment in Agr low

Big Picture

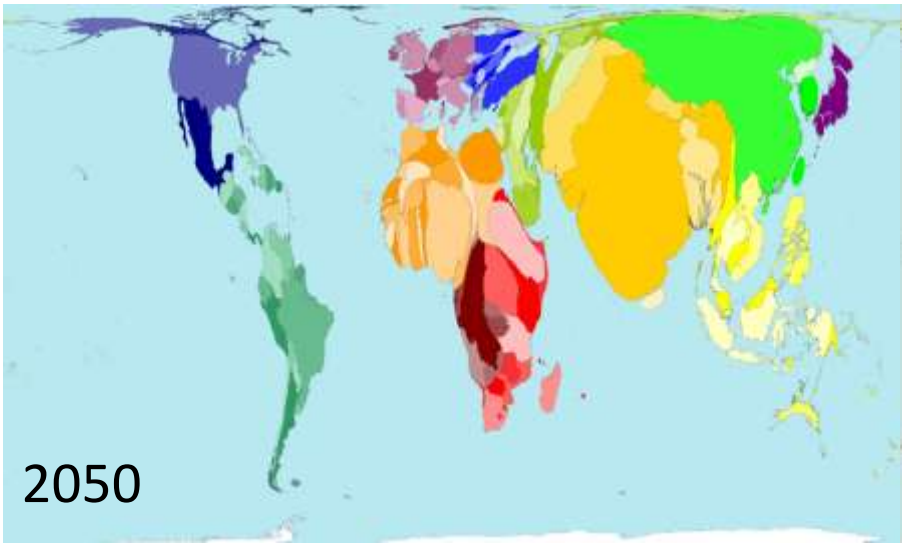
- No where in the world Food and Agriculture System (FAS) is as important as in India – 14% of national GDP, 50% of employment (650 m directly dependent on agriculture)
- Structural transformation during past 65 years failed to bridge farmer-non-farmer income gaps (1:4); small and declining farm size
- Agriculture is best bet for alleviating stubbornly high poverty, undernutrition, inequity, unemployment and livelihood insecurity.
- New Agriculture stipulates high efficiency, save and grow, competitive, resilient, sustainable, remunerative, modern, bio-based, healthy, safe and nutritious, vibrant and fast-growing FAS.

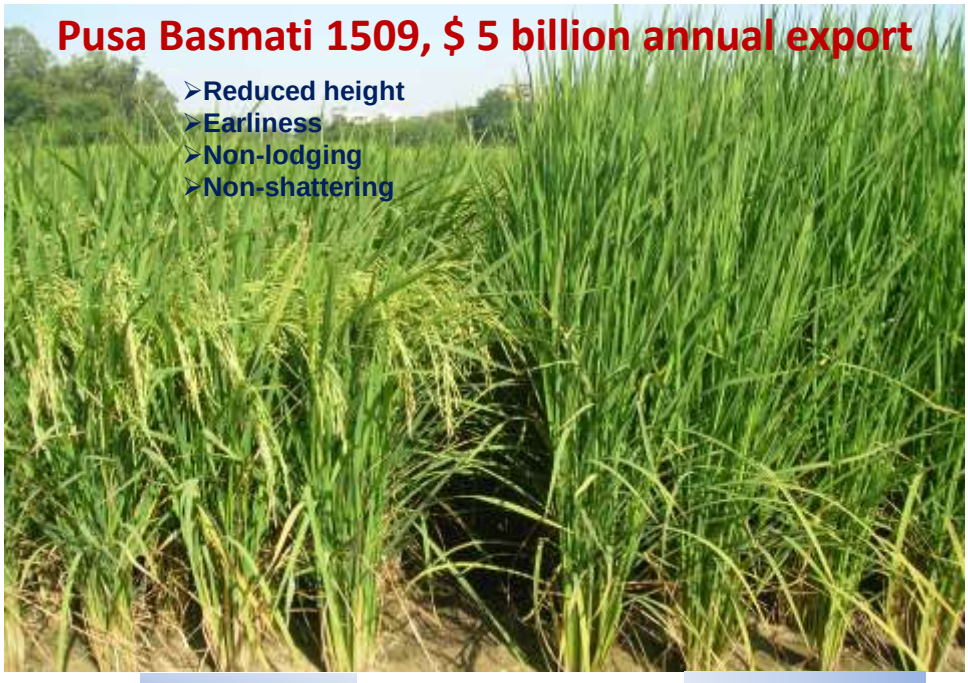
From MDGs to SDGs

In number terms, India will not meet the MDG1. Extra efforts needed to meet SDGs, especially the first 3 of the 17

- **"End poverty in all its forms everywhere**
- **End hunger, achieve food security and improved nutrition, and promote sustainable agriculture.**
- **Ensure healthy lives and promote well-being for all at all ages – a life cycle approach"**

The 9.6 Billion Person Question

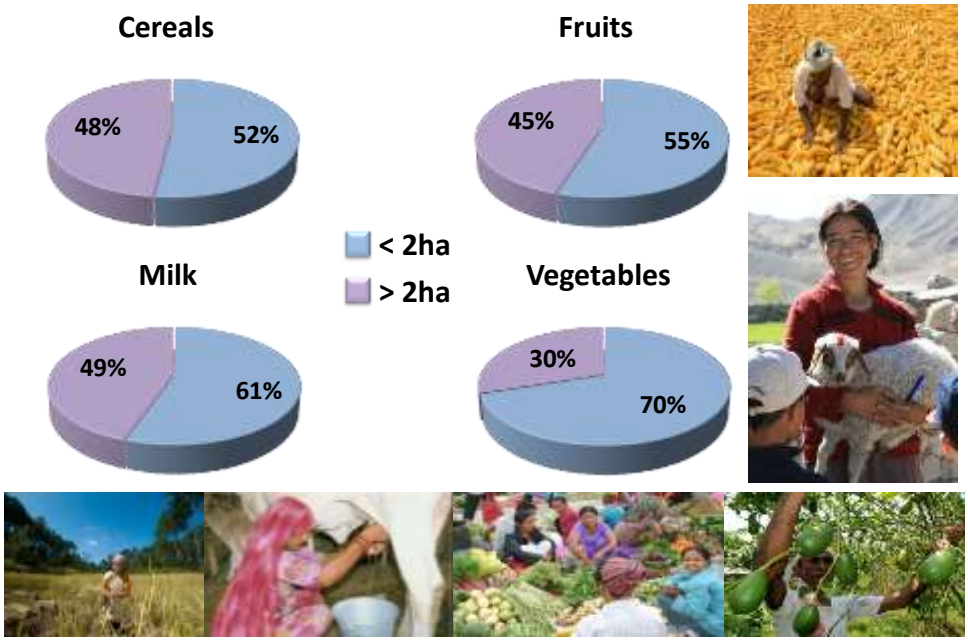




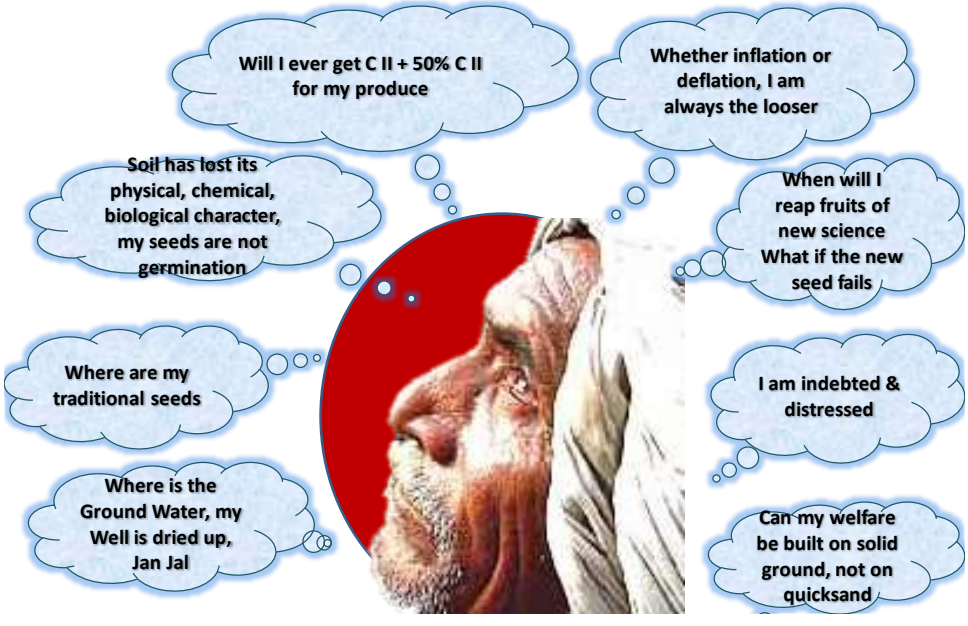
Pusa Basmati 1509 | Pusa Basmati 1121

Drip irrigation system

Small Farmers: Huge Contributions



Farmers' Challenges



NAAS

Can We Impose a BAN on Hunger?

Yes We Can

100%	Zero	All	100%	Zero
access to adequate food all year round	stunted children less than 2 years	food systems are sustainable	increase in smallholder productivity and income	loss or waste of food

"Hunger can be eliminated in our life times" .

Ban Ki-moon, 2012

President Lula in Brazil did it in 10 years, 2003-2012

The Challenges for Agricultural Researchers and Educationists are to Develop Innovations that Offer:

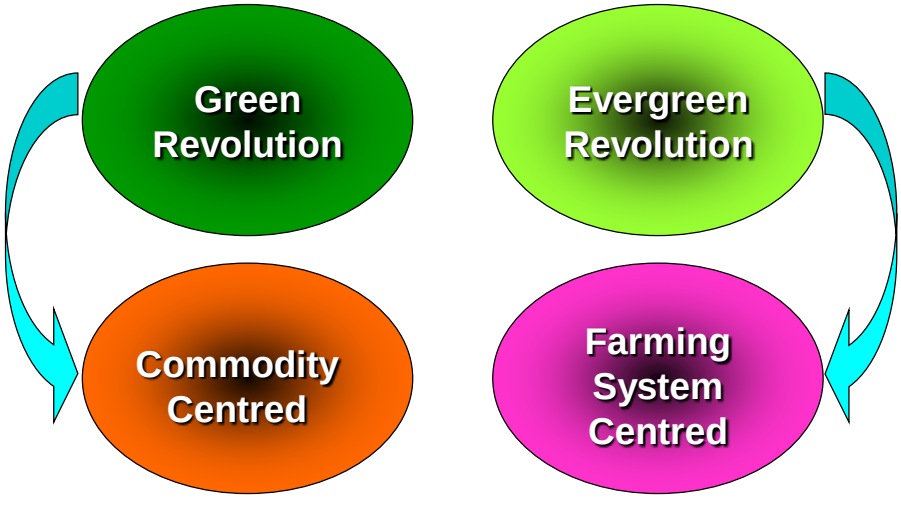
- **Sustainable Intensification** of production to meet global demand for food quantity and quality.
- **Profitability and Social Attractiveness** to agriculture as a profession.
- **Ecosystem Services** that improve water quality, soil health, carbon capture, biodiversity and wildlife habitat.
- **Predict differentiated** future demands and food and agriculture systems, and **match** them.

ASA Science Frontiers, 2015

STRATEGIES

- Diversification(Livestock, Horticulture, Aquaculture, Pulses, Oilseeds, MAC)
- Bridging Yield Gaps & Accelerated Productivity Growth
- Natural Resources Management – More from less for more, Efficiency
- Value Chain, Prevention of Post-harvest losses, Market Linkage
- Climate Smart Agriculture- the triple win
- Genetic Alchemy, Biotechnology Safe Food, Biosecurity
- Equity, Inclusiveness & Social Protection
- Right to Food - the Food Bill, implementation
- Agri Res, Education, Extension and demand-driven disruptive innovation
- Business Unusual, Monitoring, Evaluation and Impact Pathways

Paradigm Shift



Main Policy Options

- "New Normal"- Integrated outlook and action for food, nutrition, income, livelihood, education, sanitation hygiene and health securities
- Connect Jan Dhan, Digital India, Skill India, Swachh Bharat, Make –in- India, Start-up India, Innovate India, RKVY, MNREGA etc.
- Nutrition at centre stage of Government Development Plans and seen as a major development indicator; Implementation of the Food Bill
- Strong AREE4D for comprehensive livelihood security
- Big data, monitoring, evaluation, assessment and accountability, impact pathways, effective & transparent Social Protection Floors