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• **Norwegian University of Life Sciences**

Oslo, 5 February 2013

Sustainable Food Security in an Era of Climate Change

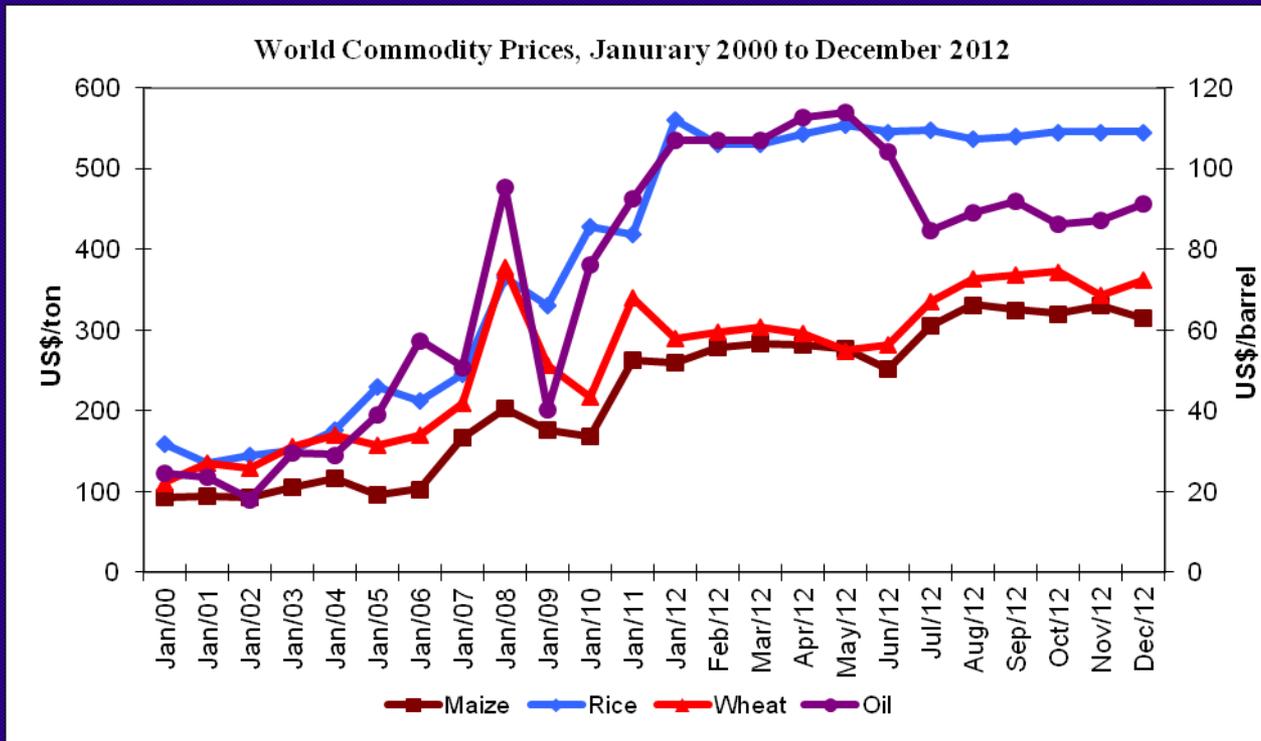
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M S Swaminathan Research Foundation, Chennai, India



Price Volatility and Hunger



The Future belongs to nations with grains and not guns

Source: FAO, US Energy Administration and www.indexmundi.org and <http://quotes.post1.org/historical-crude-oil-price-chart/> (data updated as on Dec 27, 2012)

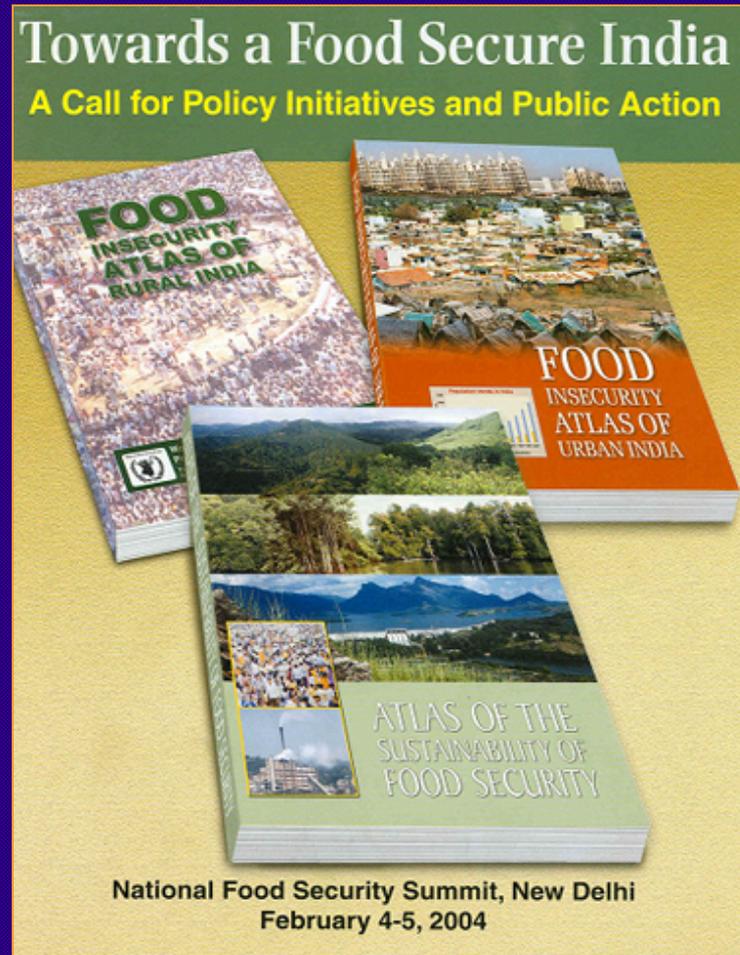


Demand-Supply gap; energy cost and climate variability



MSSRF / WFP : Food Insecurity Atlas

Hunger
Chronic
Hidden
Transient



Food
Security
Availability
Access
Absorption

Awareness – Analysis - Action



Famine : Triage classification of countries

Haiti	Can't- be-saved
Egypt	Can't-be-saved
The Gambia	Walking Wounded
Tunisia	Should Receive Food
Libya	Walking Wounded
India	Can't-be-saved
Pakistan	Should Receive Food

- Paul and William Paddock, 1967



Ehrlich 1968

- Some time between 1970 and 1985 the world will undergo vast famines — hundreds of millions of people are going to starve to death. That is, they will starve to death unless plague, thermonuclear war, or some other agent kills them first.
- The United States should announce that it will no longer ship food to countries such as India **where dispassionate analysis indicates that the unbalance between food and population is hopeless.**



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From Teosinte to Maize

Beginning of the Green Revolution



Impact of Selection and
breeding

Tian F. et.al. PNAS;2009;106:9979-9986



Rachel Carson 1962 : Silent Spring



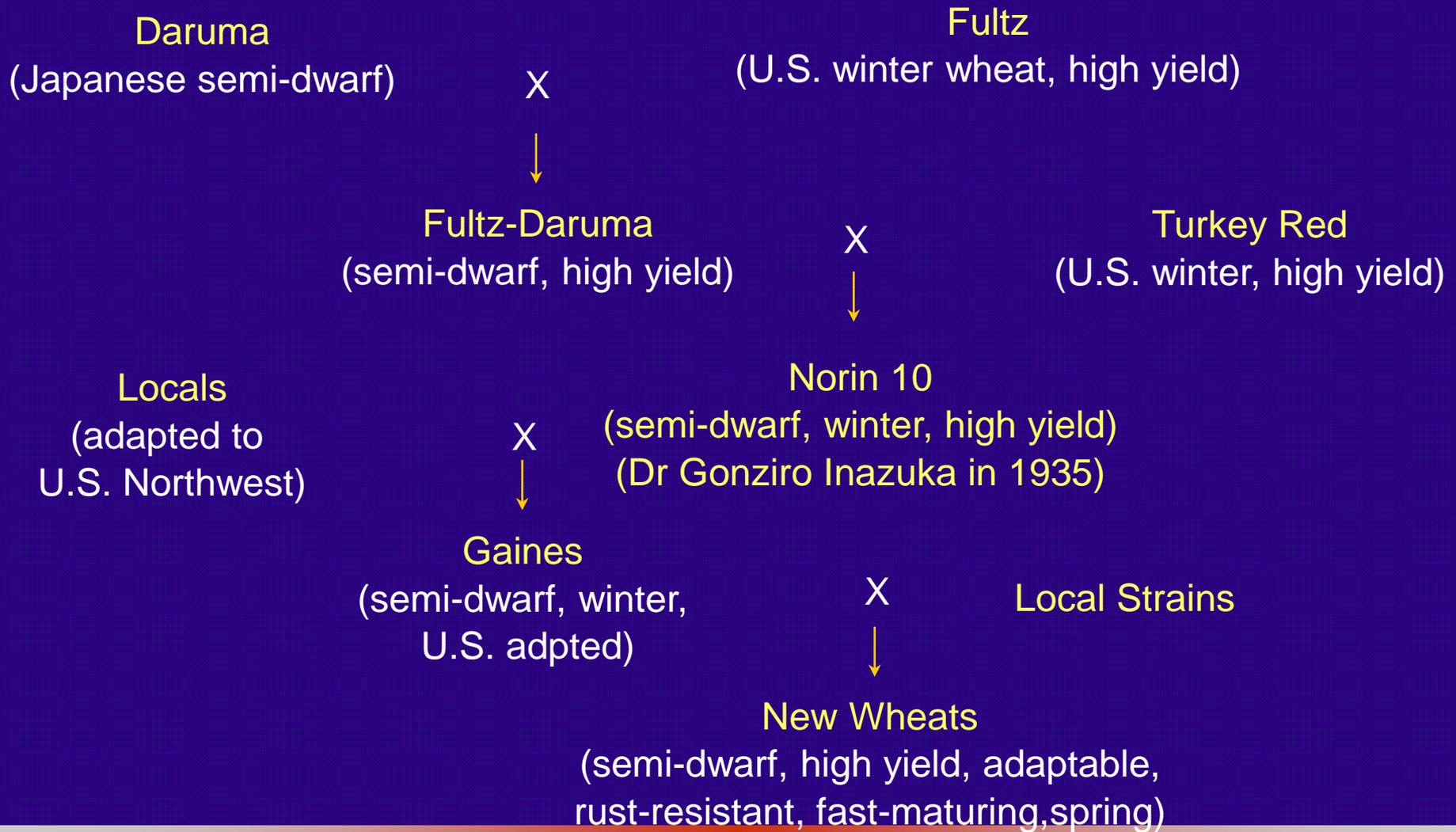
“Man has lost the capacity to foresee and to forestall. He will end by destroying the earth”

- *Albert Schweitzer*

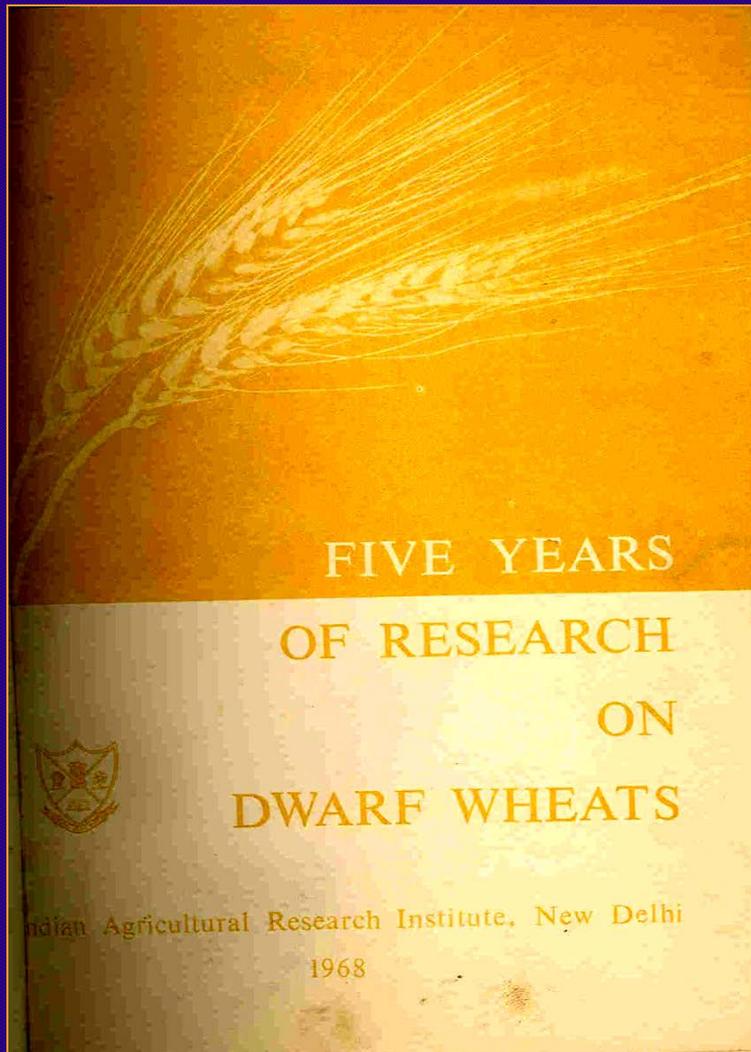
Sustainable Development : Early Warning



Genesis of Green Revolution (Transformational Technology)



Science and Shaping the Future



- 1962-63 : Identification of the new plant type (dwarf stature coupled with long panicles)
- 1963-64 : Receipt of seeds from Dr Norman Borlaug: extensive multi-location trials of *Semi Dwarf Wheat* selections
- 1964-65 : National Demonstrations in Farmers' Fields, standardisation of agronomic and irrigation practices
- 1965-66 : Selection of amber grain material, *Kalyan Sona and Sonalika*
- 1966-67 : Import and planting of 18,000 tonnes of seeds of *Lerma Rojo 64-A* and other strains
- 1967-68 : Quantum jump in production - onset of *Wheat Revolution*



The duty of scientists is not to predict the future, but to shape it



Green Revolution Symphony (1968)



Major Components

- Technology
- Services
- Public Policies
- Farmers' enthusiasm



Indian farmers achieved as much progress in wheat production in four years (1964–68), as during the preceding 4000 years.

Blend of Scientific skill, political will and farmers' toil



Wheat Revolution : 4000 years of Achievement in Production Condensed in Four Years

Earliest evidence of cultivation	: Mohanjo-daro excavations 2300 BC
Production in 1947-48	: 6 million tonnes
Production in 1963-64	: 10 million tonnes
Production in 1967-68	: 17 million tonnes
Production in 2012	: 92 million tonnes



Sustainable Food Production : Early Warning

“Intensive cultivation of land without conservation of soil fertility and soil structure would lead ultimately to the springing up of deserts. Irrigation without arrangements for drainage would result in soils getting alkaline or saline. Indiscriminate use of pesticides, fungicides and herbicides could cause adverse changes in biological balance as well as lead to an increase in the incidence of cancer and other diseases, through the toxic residues present in the grains or other edible parts. Unscientific tapping of underground water would lead to the rapid exhaustion of this wonderful capital resource left to us through ages of natural farming. The rapid replacement of numerous locally adapted varieties with one or two high yielding strains in large contiguous areas would result in the spread of serious diseases capable of wiping out entire crops, as happened prior to the Irish potato famine of 1845 and the Bengal rice famine of 1942. Therefore, the initiation of exploitative agriculture without a proper understanding of the various consequences of every one of the changes introduced into traditional agriculture and without first building up a proper scientific and training base to sustain it, may only lead us into an era of agricultural disaster in the long run, rather than to an era of agricultural prosperity.”

M.S. Swaminathan
Indian Science Congress, Varanasi, January 4, 1968



From Green to an Ever-green Revolution Pathways

Green Revolution : Commodity-centred increase in productivity



Change In plant architecture, and harvest index

Change in the physiological rhythm-insensitive to photoperiodism

Lodging resistance

Evergreen Revolution : increasing productivity in perpetuity without associated ecological harm



Organic agriculture : cultivation without any use of chemical inputs like mineral fertilizers and chemical pesticides

Green Agriculture : conservation farming with the help of integrated pest management, integrated nutrient supply and integrated natural resource management



- **From Bengal Famine to “Right to Food”**
- **National Food Security Bill of India, 2013**

Components

- Legal Entitlements (Life Cycle Approach) – 35 kg per family per month of wheat, rice or climate smart Nutri-cereals
- Enabling Provisions
 - Food availability
 - Food absorption
- Infrastructure : National grid of grain storages
- Governance : Reform of the Public Distribution System

Special Features : Adoption of a life cycle approach with special attention to the first 1000 days in a child’s life, enlarged food basket and considering women as Head of the Household with regard to food entitlements.



Chhattisgarh Food Security Bill, 2012

Food Entitlements

General Households	15 kg foodgrain at Rs.9.50/kg for rice and Rs.7.50/kg for wheat
Priority Households	35 kg foodgrain at Rs.2 / kg; 2 kg pulses at Rs.10/kg (in non-scheduled areas); 2 kg chana at Rs.5/kg (in scheduled areas); 2 kg iodized salt (free)
Antyodaya Households	35 kg foodgrain at Rs.1 per kg; 2 kg pulses at Rs.10/kg(in non-schedules areas); 2 kg chana at Rs.5/kg(in scheduled areas); 2 kg iodised salt (free)

Addresses the problems of calorie deprivation, protein hunger and micronutrient malnutrition



National Grid of Grain Storages



Establish 50 modern Grain Storages in different parts of the country each with a capacity for storing 1 million tonne of food grains in a healthy condition





NATIONAL POLICY FOR FARMERS

2007



Department of Agriculture & Cooperation
Ministry of Agriculture
Government of India

Goals

- To improve the economic viability of farming by substantially increasing the net income of farmers and to ensure that agricultural progress is measured by advances made in their income
- To provide opportunities in adequate measure for non-farm employment for the farm households
- To introduce measures which can help to attract and retain youth in farming

23 November 2007

Response to Current and Emerging Challenges



Gene Banks for a Warming Planet

Community Gene & Seed Banks



National Gene Bank

Svalbard –
Global Seed Vault



A similar Seed Vault
has been
established by
DRDO at Chang La
in the Himalayas

Conservation Continuum



Swaminathan, M.S. 2009. Gene banks for a warming planet.
Science, 325:517.



Towards an era of Biohappiness

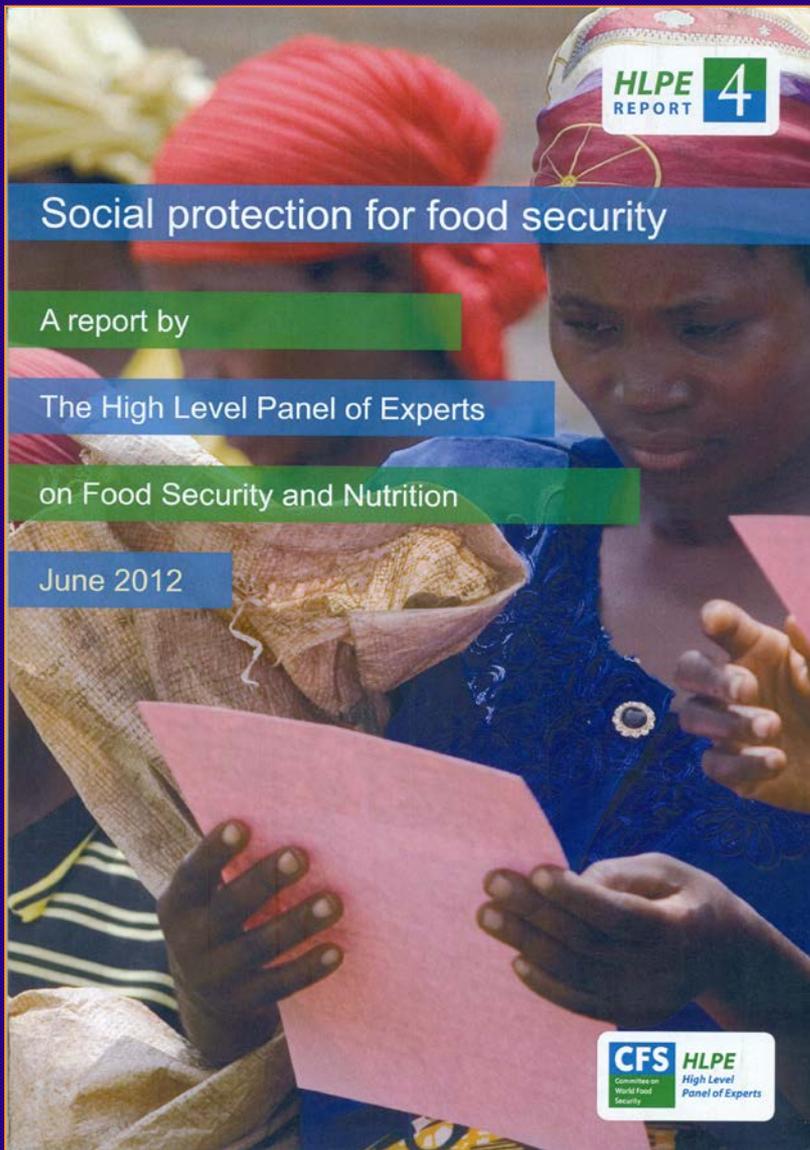


Biohappiness results from the conservation, sustainable and equitable use of biodiversity and the blending of traditional knowledge with frontier technology



Convert Biodiversity Hot Spots into Happy Spots





A comprehensive report on
overcoming hunger based on
“**A Food Security Floor**”
approach



Water Security : WAR for Water (Winning, Augmentation and Renovation)

Components

- Rain Water Harvesting
- Recycling of wastewater
- Conjunctive use of water
- Technologies for desalination
- Providing safe drinking water for rural and remote areas

Department of Science and Technology



Water Security :

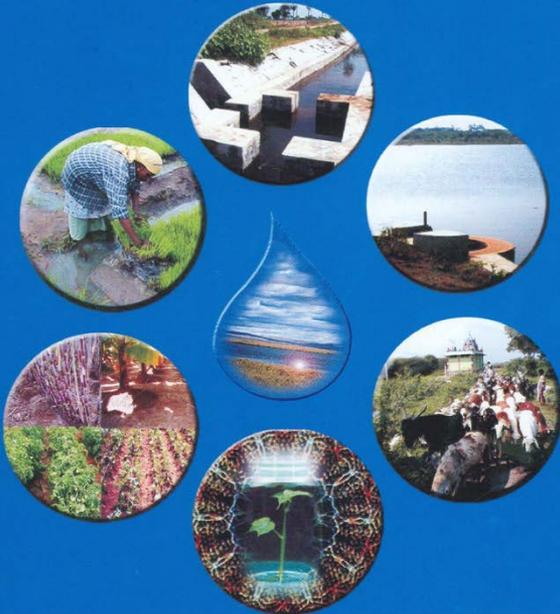
Small Water Harvesting Structures (Jal Kund)



**Make on-farm and off-farm
water harvesting mandatory**



Report
of
Sub-Committee
on
MORE CROP AND INCOME PER DROP OF WATER



Advisory Council on Artificial Recharge of Ground Water
Ministry of Water Resources
Government of India
October 2006

Demand Management

Improving Water Use Efficiency

Aim : Mind set change from
quantity to the efficiency of use
Farmer Participatory Action
Research in over 2500 villages

More Crop per drop of water and diesel



Watershed Development - Mahatma Gandhi National Rural Employment Guarantee Programme



Gandhiji : Marry intellect with labour

Convert Every Watershed into a Bioindustrial Watershed



· · **Doha : Status quo or movement ahead?**

- It is clear that climate change requires tough action to reduce emissions
- The world is yet to find a convenient way to reduce emissions but also grow
- We know emissions in the industrialised countries have continued to increase. This is unacceptable
- We know that the world is increasingly at risk because of climate change. We know the poor are most vulnerable
- At Doha there has been minor movement ahead, because the world has recognised that its current actions are not good enough to keep the world below the danger threshold

Source : Dr Sunita Narain



The Future Roadmap

- The industrialised world has to cut emissions by 40% below 1990 levels by 2020.
- The US, which is not a Kyoto Party, must agree to take on comparable commitment
- The rest of the world, including India and China, are already doing what they can within their abilities. They can and should do more. But their targets to reduce must be based on a fair allocation of the global atmospheric space
- The Green Climate Fund must have adequate financing to pay for adaptation and mitigation costs
- Any agreement on using forests or agriculture in the developing world to cut emissions as for example, for biofuel production must recognise that these sectors involve livelihoods of poor communities. The burden of transition must not be shifted to them.



• Mitigation (Reducing Green Gas Emissions)

Carbon dioxide Reducing deforestation and forest degradation and promoting afforestation (REDD)

Methane Biogas Plants

Nitrous Oxide Neem Coated Urea

A Biogas Plant, a few Fertilizer Tress and a Farm Pond in every Farm



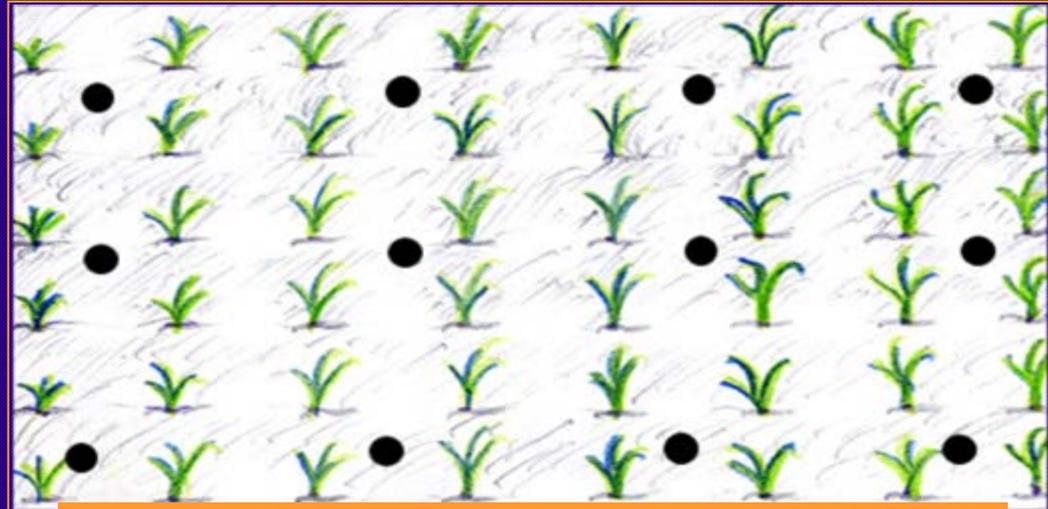
Urea Deep Point Placement (UDP)

Deep placement through which the fertilizer is located below the soil surface

(7 to 10 cm depth in reduced zone) - no volatilization and nitrification

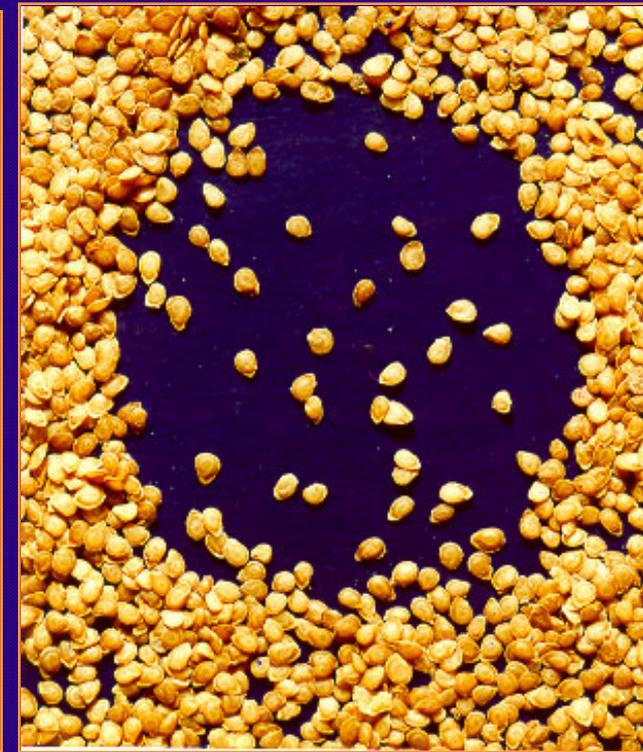
Point Placement results in high local concentration of ammoniacal N ($\text{NH}_4\text{-N} > 3,000$ ppm), resulting in inhibition of nitrification)

Source, IFDC



- **Consequences of temperature rise:**
- **Sustaining the Potato Revolution**

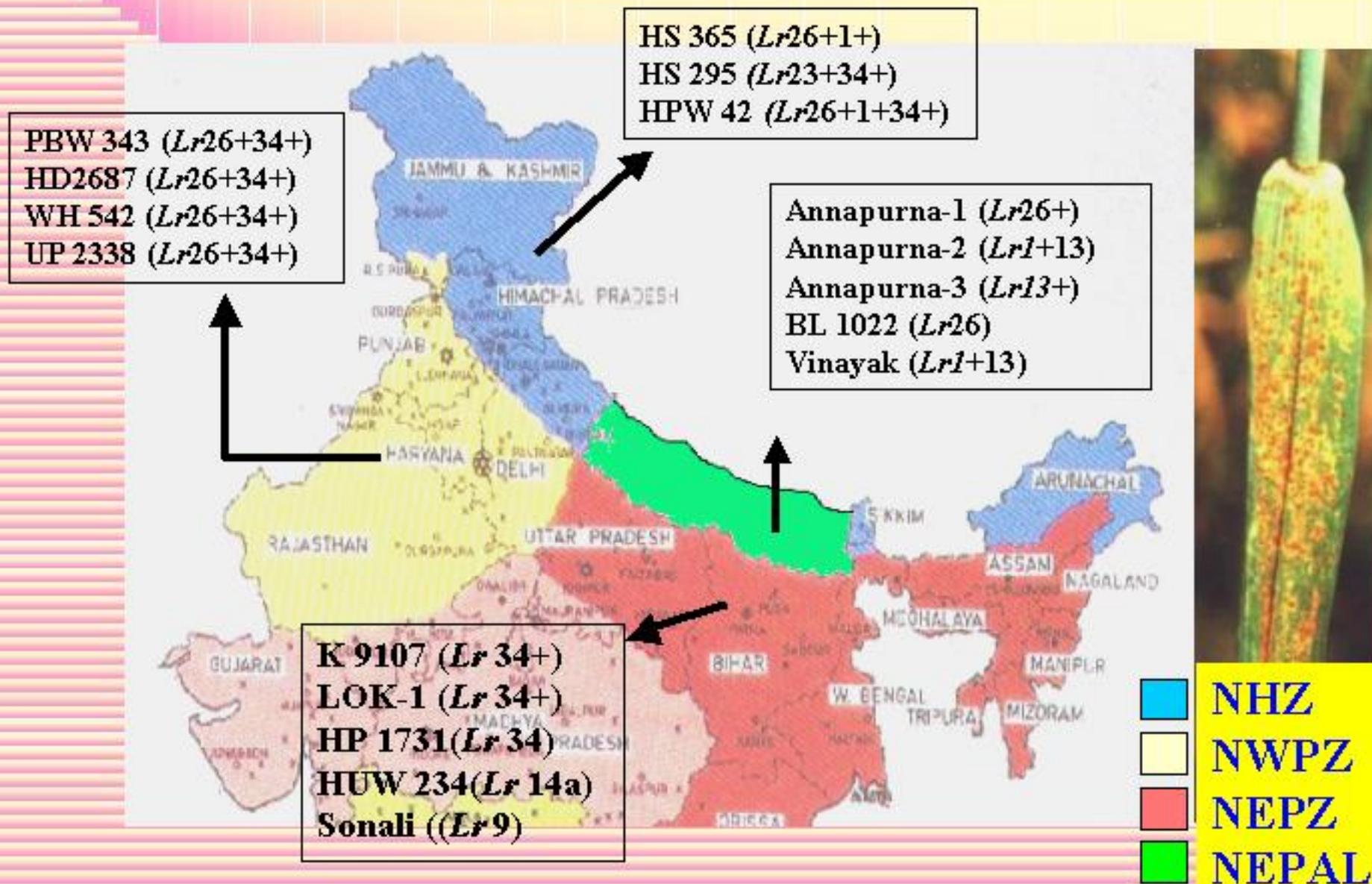
True Potato Seed



Answer to the challenge of producing disease free planting material as a result of rise in temperature



Deployment of leaf rust resistance genes over North India



Need for Genetic checkmating of new disease threats

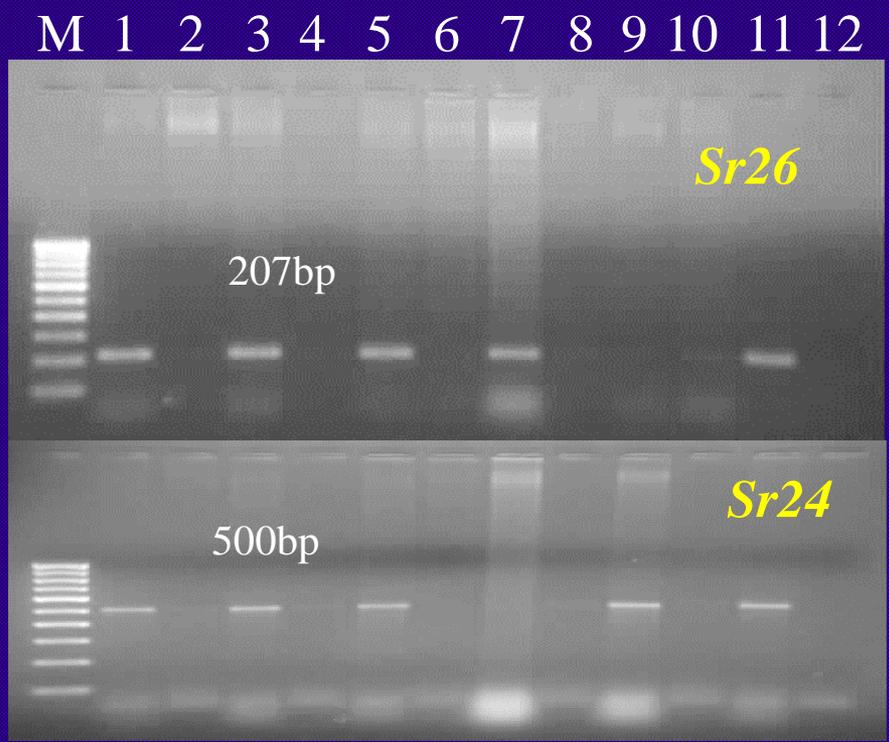
Combating Stem Rust (Ug99)



Susceptible

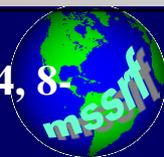


Resistant



Pedigree	Line	Response to Stem rust
Kalyansona*7//Darf*6/3Ag3/Kite	HW2021	20R- MR 80S
Kalyansona		
NI 5439*7//Darf*6/3Ag3/Kite	HW 2026	20R -MR 90S
NI 5439		
Sonalika*7//Darf*6/3Ag3/Kite	HW 2027	5R- MR 60S
Sonalika		
Darf*6/3Ag3/Kite	Darf NIL	10R -MR- 20R MR

M-Mol wt ladder, 1- Darf, 2-K'Sona, 3- HW 2021, 4-Sonalika, 5-HW2027, 6-Lok 1, 7-HW2094, 8-C 306, 9- HW 2023, 10-NI5439, 11-HW2026, 12-Water control





Agro-Forestry System involving Fertilizer Trees



Building Soil Carbon Banks



Mitigating Climate Change : Role of Terrestrial Carbon Banks

- Global net primary productivity (NPP) = 120 Gt/c/year
- Most of it is returned to the atmosphere through plant and soil respiration
- If 10% of NPP is retained in the terrestrial biosphere (i.e, soil, plants, wetlands, mangrove ecosystems), 12 Gt/c/year can become part of a terrestrial carbon bank
- Increasing soil C pool by 1 ton c/ha/year in the root zone can increase food production by 30 to 50 million tonnes

Source: Dr Rattan Lal



Impact of Sea Level Rise

1. Inundation of low lying coastal lands with sea water
 - o millions of ha of land would be affected
 - o small islands would be affected very severely
2. Increased incidence of storm surges
3. Seawater intrusion into freshwater and groundwater
4. Enhancement of tidal waters into rivers
5. Accelerated coastal erosion
6. **Climate Refugees** will look for new areas to settle



Genetic Shield against Sea Level Rise



Mangrove Forests



Sea Water : A Social Resource

Dandi March(6 April 1930) of Mahatma Gandhi

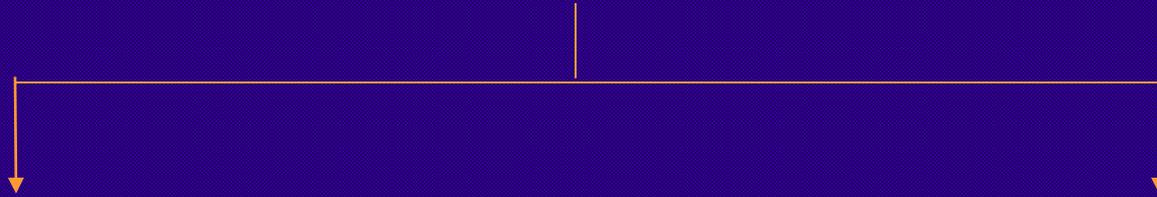


Sea Water constitutes nearly 97% of global water sources



Genetic Garden of HALOPHYTES at Vedaranyam

Converting Sea Water into Fresh Water through Halophytes



Obligatory halophytes

Tolerate high concentration of sodium salts

> 3 times of seawater salinity

Even demand high NaCl for survival and reproduction

1560 species

Facultative halophytes

Most of the species tolerate only moderate level of salinity

Reproduction requires low saline condition

Mangroves

60 species



Salt tolerant Rice Plants with Mangrove Genes

10 days

1



C

T

CTRL

Transgenic

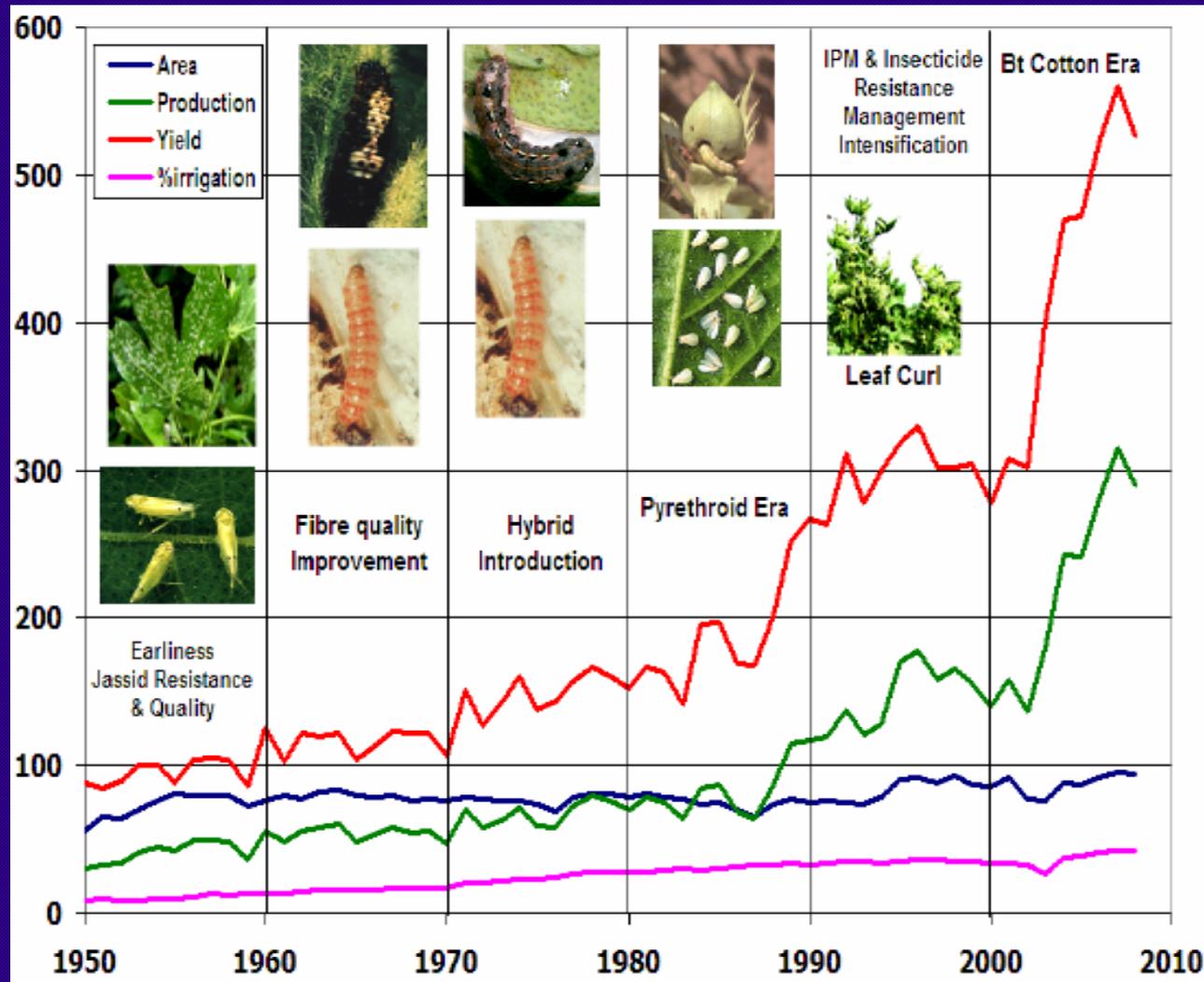


Rice plants with Mangrove Genes and Promoter

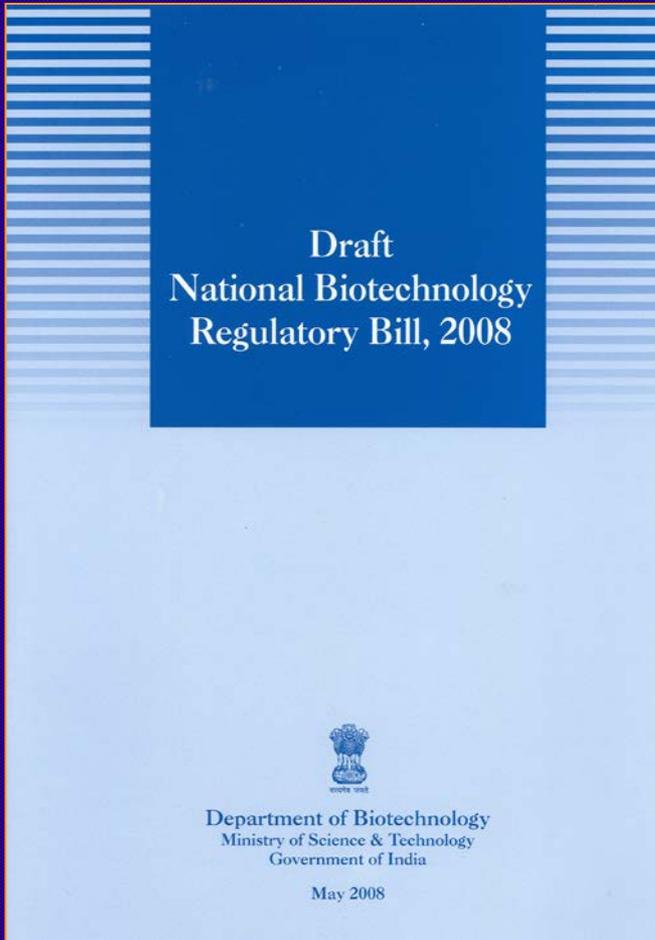
Performance Evaluation

Characters	Whiteponni with 150mM NaCl	Transgenic with 150mM NaCl
Plant height (cm)	95.10	104.95
No. of productive tillers	9.90	14.20
Panicle length (cm)	17.08	22.45
No. of grains per panicle	134.60	174.80
100 grain weight (g)	1.45	1.63
Yield per plant (g)	20.30	34.75

Impact of Technology on Cotton in India



National Biotechnology Regulatory Authority



The bottom line of our national agricultural biotechnology policy should be the economic well being of farm families, food security of the nation, health security of the consumer, biosecurity of agriculture and health, protection of the environment and the security of national and international trade in farm commodities”

(M S Swaminathan Panel 2004)



National Biosafety Authority

“To access risks and benefits from GMOs with reference to biodiversity, human and animal health and environment, a National Biosafety Authority is needed. Develop legislation using the Norwegian Model”

*Parliamentary Committee on Agriculture
chaired by Shri Basudeb Acharya (2012)*



• Norway – India Partnership in preparing for • Climate Change - ClimaAdapt Project

Funding by Norwegian Embassy in India

Project Goal: Improve the adaptive capacity of the agriculture and water sectors in the states of Andhra Pradesh and Tamil Nadu through development of appropriate adaptation measures.

Project Area: Three River Basins in South India viz., Krishna River Basin in Andhra Pradesh; Ponnaiyar and Kalingarayan River Basins in Tamil Nadu.

• *Partners:* Bioforsk, MSSRF, IWMI, TNAU, Water Resources Organization, Irrigation Management Training Institute (IMTI) and WALAMTARI

