Transitioning from an Unsustainable Irrigated Agriculture to an Environmentally Safe and Food Secure India: Challenges and opportunities in Irrigation Sector

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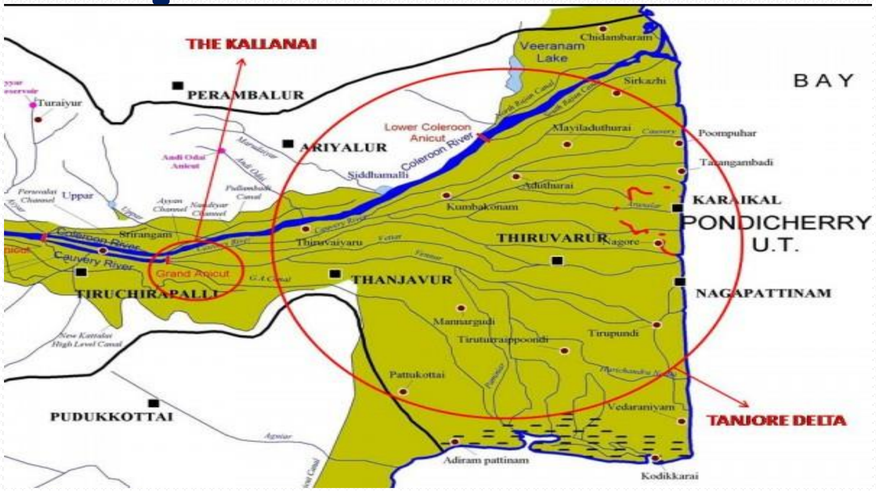
This Presentation Covers

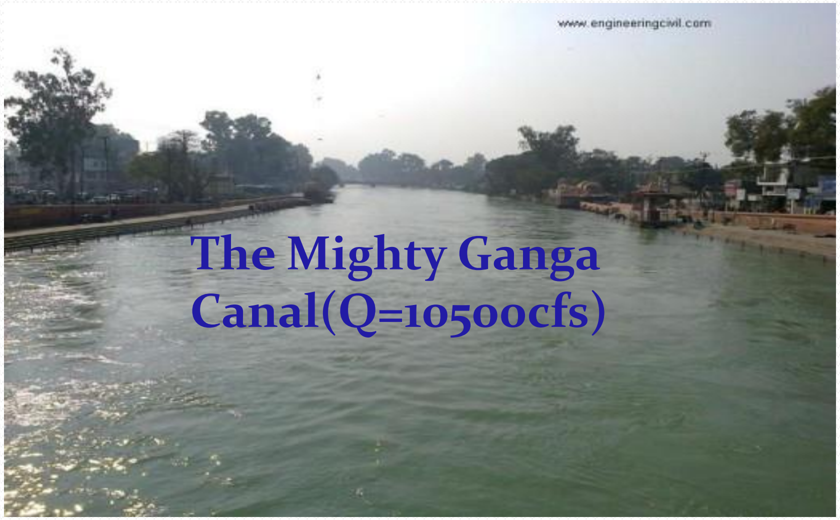
- Introduction to Indian irrigation system
- Productivity and heath of irrigated agriculture
- Agricultural water management institutions & initiatives
- Technology breakthroughs
- Policies &institutions
- Policy shifts & way forward

Grand Anicut First Constructed in 2^{nd} AD by Chola King

The ancient Indian hydraulic civilization knew the technology of river water diversion for irrigation



Upper Ganga Canal Designed and Constructed by P. T. Cautley (1843-54)



These systems were designed to provide extensive ,protective irrigation to avoid crop failures, and followed Warabandi delivery schedule

Indian irrigated agriculture depends on all kinds of irrigation technologies

The application efficiency varies from 40-85 %











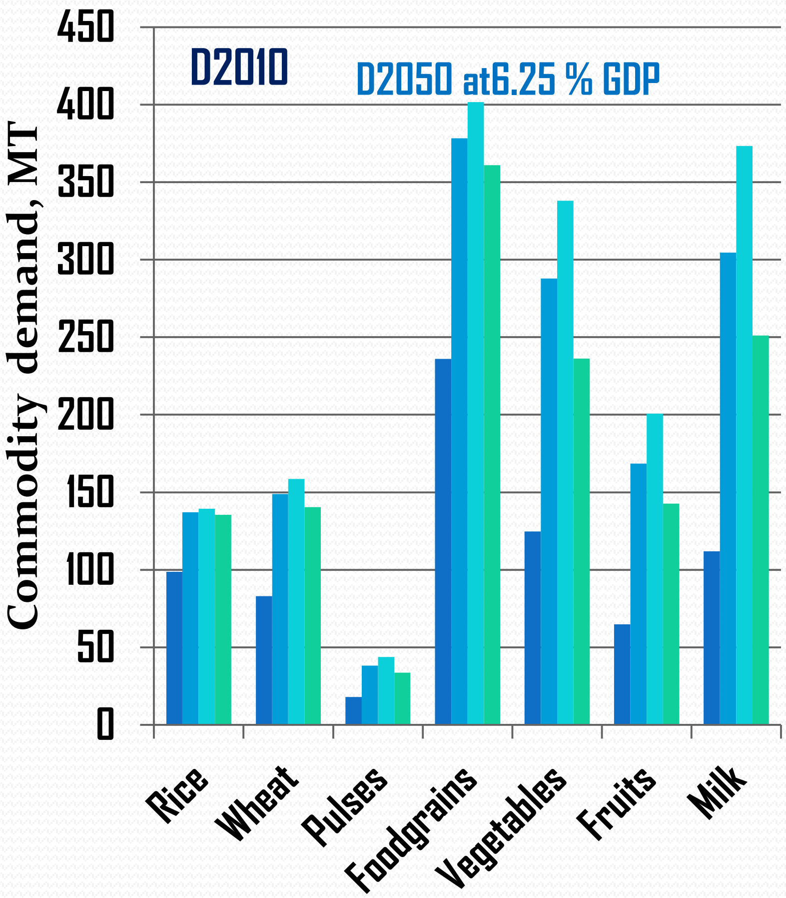
India's land &water resources and irrigation statistics

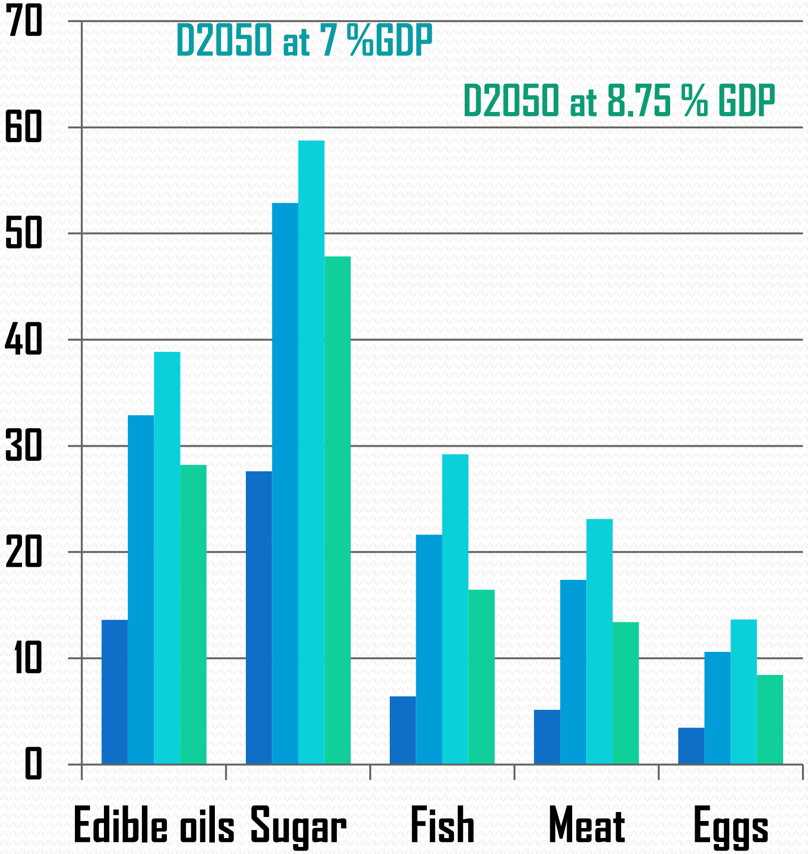
RESOURCES		IRRIGATION STATISTIC ,(Mha)	
LAND(Mha)		Gross irrigated	92.57
Geographical area	329	Net irrigated	66.1
Cropped area	142	Surface water	23.8
Rainfed	76	Ground water	42.3
Cropping intensity (%)	140	Flow irrigation	58.3
WATER(Mha-m)/BCM		Sprinkler	4.4
Total renewable water	2081	Drip	3.4
-Utilizable surface water	690		
-Storage capacity	220		
-Utilizable groundwater	381		

Target 2030- At least 35 % pressurized irrigation

Source: GOI,2015,2016

Demand for various food commodities- 2010 and projections for 2050 (Source: P Kumar,2015)



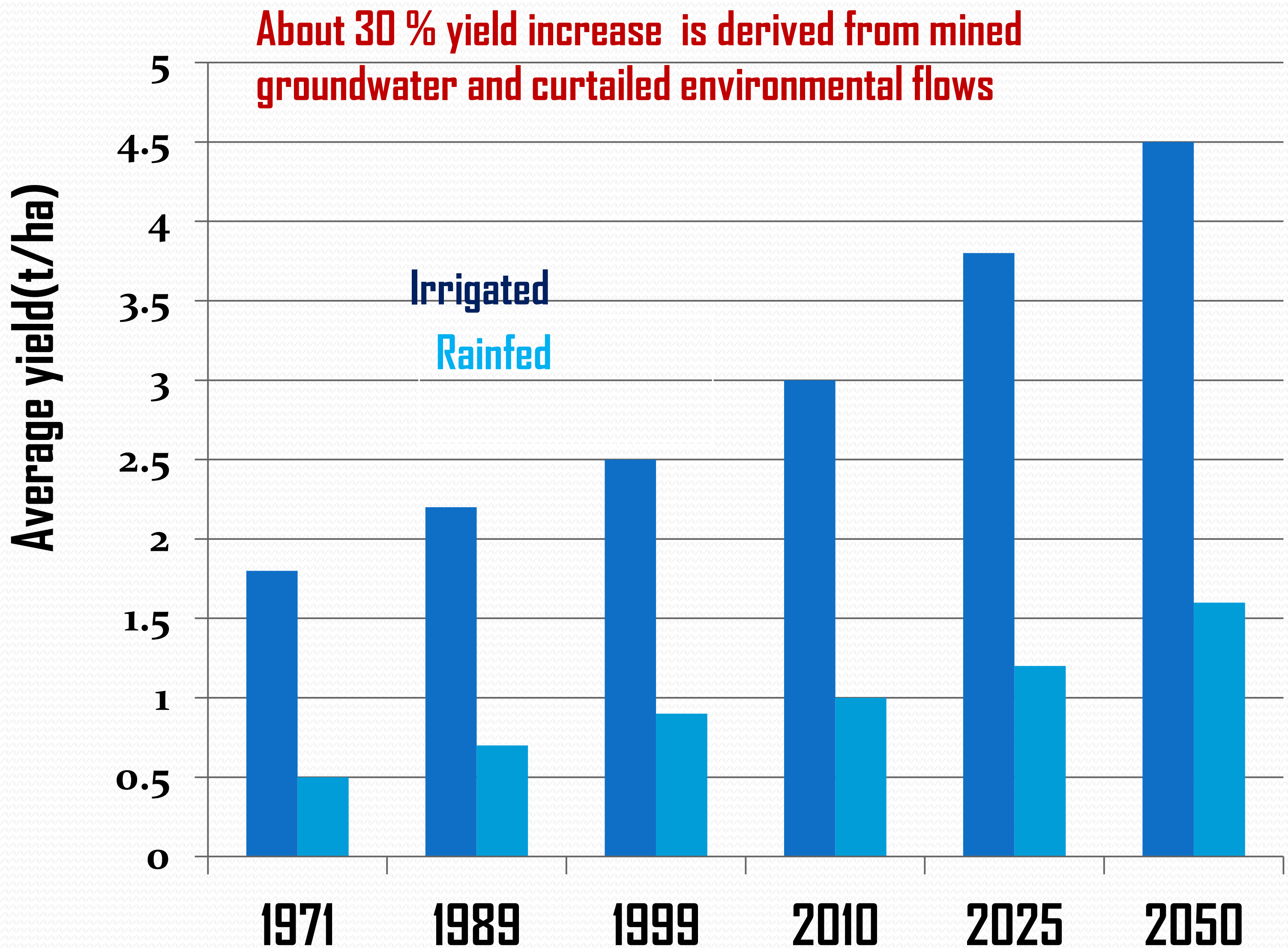


The five transitions impacting WEF Security in India

Transition Item	Value in 2010	Value in 2050
Urbanization transition	31 % ;Per capita income INR 53000	55%;Per capita income INR 430000
Nutrition transition	2200 KCl; 8 %from animal products	3000 KCl, 16-20 % from animal product
Climate transition	Shifting of production zones- Yield have stated declining TFP declining	2 ∘C rise, rise in water demand by 15-20 %!
Energy transition	Per cap consumption 725 kWh(74 FS: 26 RS)	Per cap consumption 3000 kWh (50FS:50RS)
Agricultural transition	85 % farms ≤2ha, Per HH Income- INR 40,772(2011-12); Subsistence farming	Increased farm size due to urbanization , Commercialization

***Data taken from different GOI reports; KCl-Kilo calories, FS-Fossil sources, RS-Renewable source**

Growth in food grain yield in India (1971-2050)



Water Productivity of Grains Across States Covering IGB Parts of India

State	Total (Irrigated + Rainfed)		
	Yield	CWU	WP
Unit	Ton/ha	mm	Kg/m³
India	1.66	344	0.48
Uttar Pradesh	2.13	351	0.61
Madhya Pradesh	0.99	278	0.36
West Bengal	2.31	447	0.52
Bihar	1.71	373	0.46
Rajasthan	1.00	220	0.46
Punjab	4.07	404	1.01
Haryana	3.13	363	0.86

Source : Sharma et al, 2008

Health of Production System

- Most river basins have high criticality ratio(CR) exceeding 0.50,In Indus basin CR= 0.90. There is physical scarcity in Indus, Krishna, Cauvery Rivers Basins.
- Groundwater has been overexploited. The GWAR has reached 172 % in Punjab, 133 % in Haryana, and 137 in Rajasthan
- Water logging & salinity in major irrigated areas- 10 mha
- Water quality declining in both , rivers and aquifers(As, F)
- Low carbon and micro-nutrient deficiency in soils

Water stress across India

54%

of India

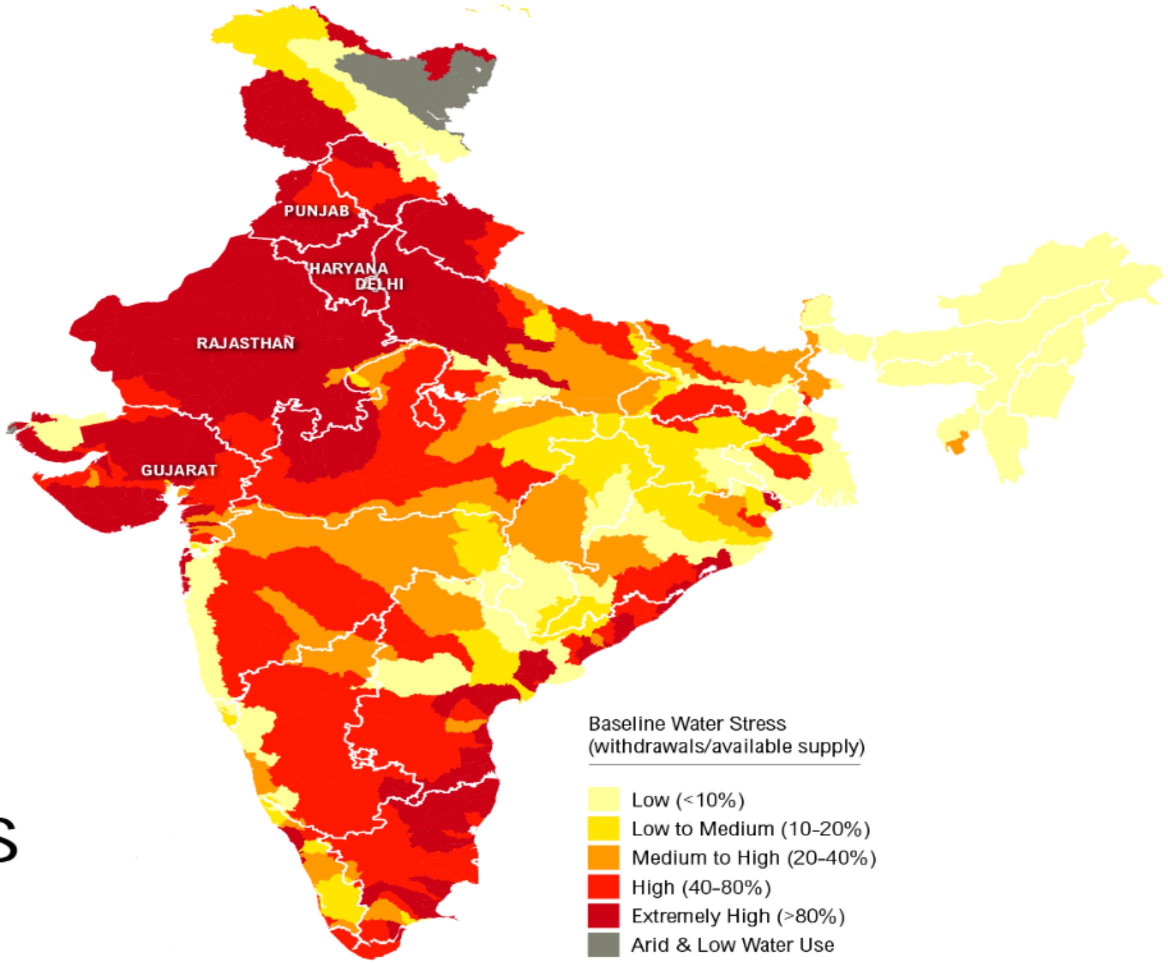
Faces

High to

Extremely

High

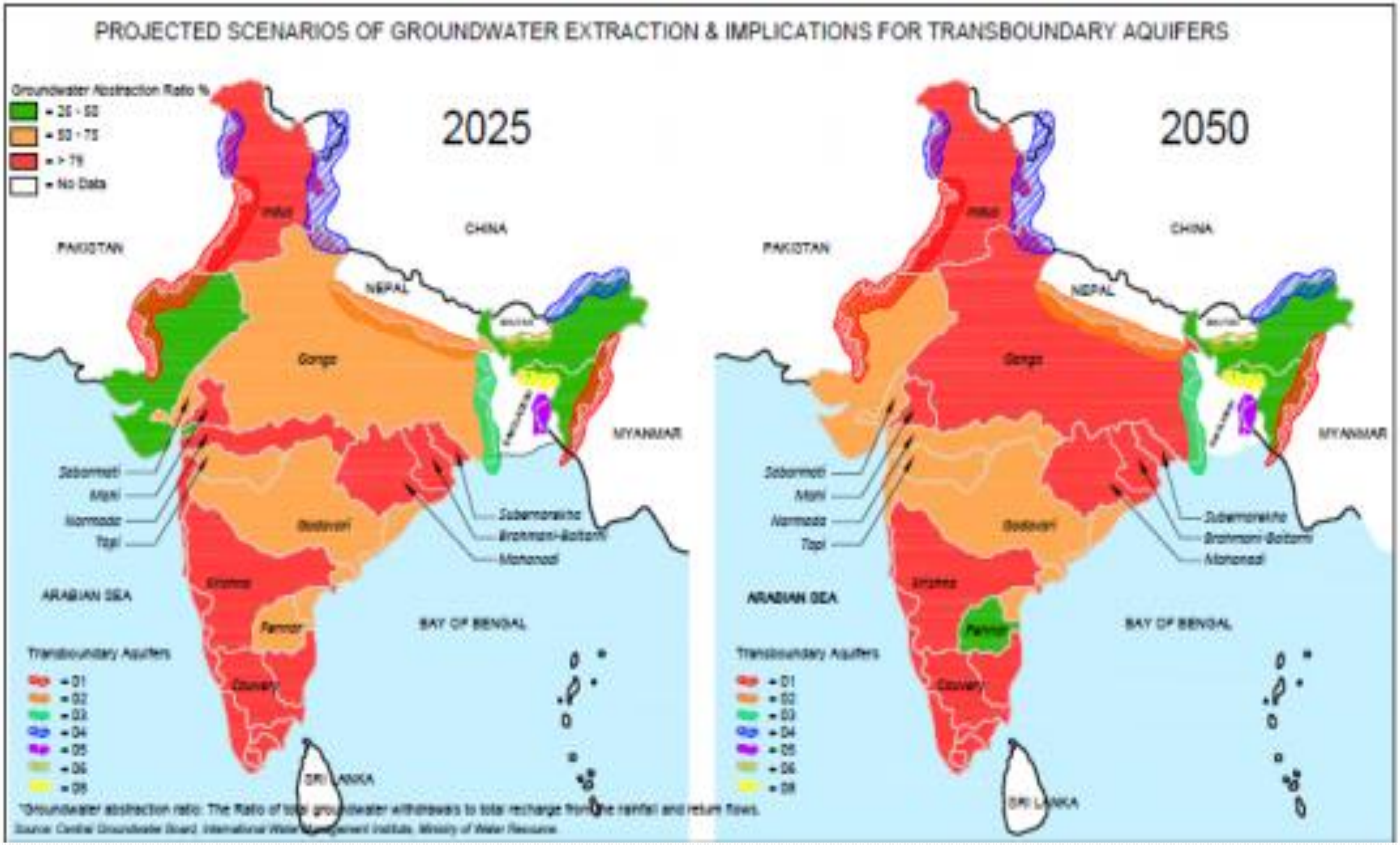
Water Stress



www.indiawatertool.in

WORLD RESOURCES INSTITUTE

Projected Scenarios of Ground Water Extraction(FEW Report)



Water logging in Sarda Sahayak Canal Command


Some irrigated areas in Haryana turned into white desert

The Two Emerging Situations

- The demands for WEF are rapidly growing due to increase in population, urbanization, rising income, change in life style
- The the safe planetary boundaries of the resources, particularly of land, water, biodiversity and climate ,have been violated . As a consequence of these violations , the WEF security is under threat
- What can we do to harmonize the two situations ?
- Whether the WEF nexus approach, (successor of IWRM), would succeed?

Agricultural water management research & development system in India

- ICAR -NRM Institites-13, AICRPs-42 locations all over India
- State Agricultural Universities-50
- Ministry of Water Resources-NIH, National Water Academy
- State Government- WALMI's in most states
- Technical universities/IITs

Technology breakthroughs for meeting transition challenges

Guiding principles

- High land productivity- genetic improvement & agronomy
- High nutrition value- genetic improvement -biotechnology
- Low water foot prints- water technology main instrument
- Low energy & carbon footprint- efficient mechanization, agronomy
- Higher economic returns- technology, pricing, markets

Genetic enhancement for high nutrient value with low carbon footprints

- Seed route is the cheapest option to enhance productivity and it has been very useful in the past. But productivity enhancement alone will not remain the best criterion in future.

- Probably the targets will be the calories or protein (other nutrient in which a population is deficient) per unit of water/energy/carbon .

- Effectiveness of current technologies will go down with increased warming.To beat the heat arising due to climate change, genetic improvement for heat tolerance will be major candidate for future research –heat , drought , salt tolerance & disease resistance

India has strong crop improvement programme

Intensive research for bio-fortification of food grains crops is underway

Crop	Nutrient
Maize	Provit. A
Rice	Zinc (Iron), Provit. A, Iron
Wheat	Zinc (Iron),Beta carotene
Cowpea	Iron, Zinc
Lentil	Iron, Zinc
Pearl millet	Iron (Zinc)
Sorghum	Zinc, Iron

Research and development initiatives in irrigation sector

- Water distribution & delivery system improvements
- Water application system improvements
- Drainage for reclaiming water logged & saline lands
- Tillage practices &conservation agriculture
- Precision agriculture
- Crop genetic improvement
- Agriculture & water sector policy changes

Some Measures Taken for Canal System Efficiency Improvements

- Provision of auxiliary storage at watercourse outlets(Mishra & Tyagi,1988,ASCE)
- Rationalization of unit command area

(Tyagi et al, 1993, WRD)

- Modification in water delivery schedules(Bhirud et al,1990)
- Optimum lining of water courses (Khepar et al, 1979)
- Water users associations

Success with different technologies

- *Group A-Considerable information on impact*
- Altering irrigation and drainage practices, crop varieties and methods to respond to root zone environments
- Practicing conservation farming (tillage, residue management, land shaping) to harvest and conserve water.
- *Group B-Have been tried, but little information on quantitative impact*
- Diversification and reallocation of water and land resources and trade off between income and environmental benefits on large scale
- Weather advisories ; and insurance of climate risks through risk transfer mechanisms
- *Group C - Often advocated, but little work*
- Transparent water markets with tradable water rights
- Policies to incentivise optimal mix of options with considerations of WEF nexus
- Payment for eco services

Estimates of productivity increase & ,energy, fertilizer irrigation cost reductions under micro-irrigation(IAI & FICCI,2015)

State	Penetration (%)	Productivity increase (%)	Energy saving (%)	Fertilizer saving, (%)	Irrigation cost saving (%)
A P	10.4	19(F)-34(V)	22	29	21
Gujarat	8.1	73(F)-69(V)	40	43	49
Haryana	16.3	38 (F)-22(V)	49	38	49
Karnataka	8.5	28(F)-29(V)	27	28	25
Maharast.	7.3	49(F)-29(V)	33	23	31
Rajasthan	9.3	70(F)-39(V)	42	44	45
Tamil Nadu	6.4	17(F)-26(V)	15	27	25

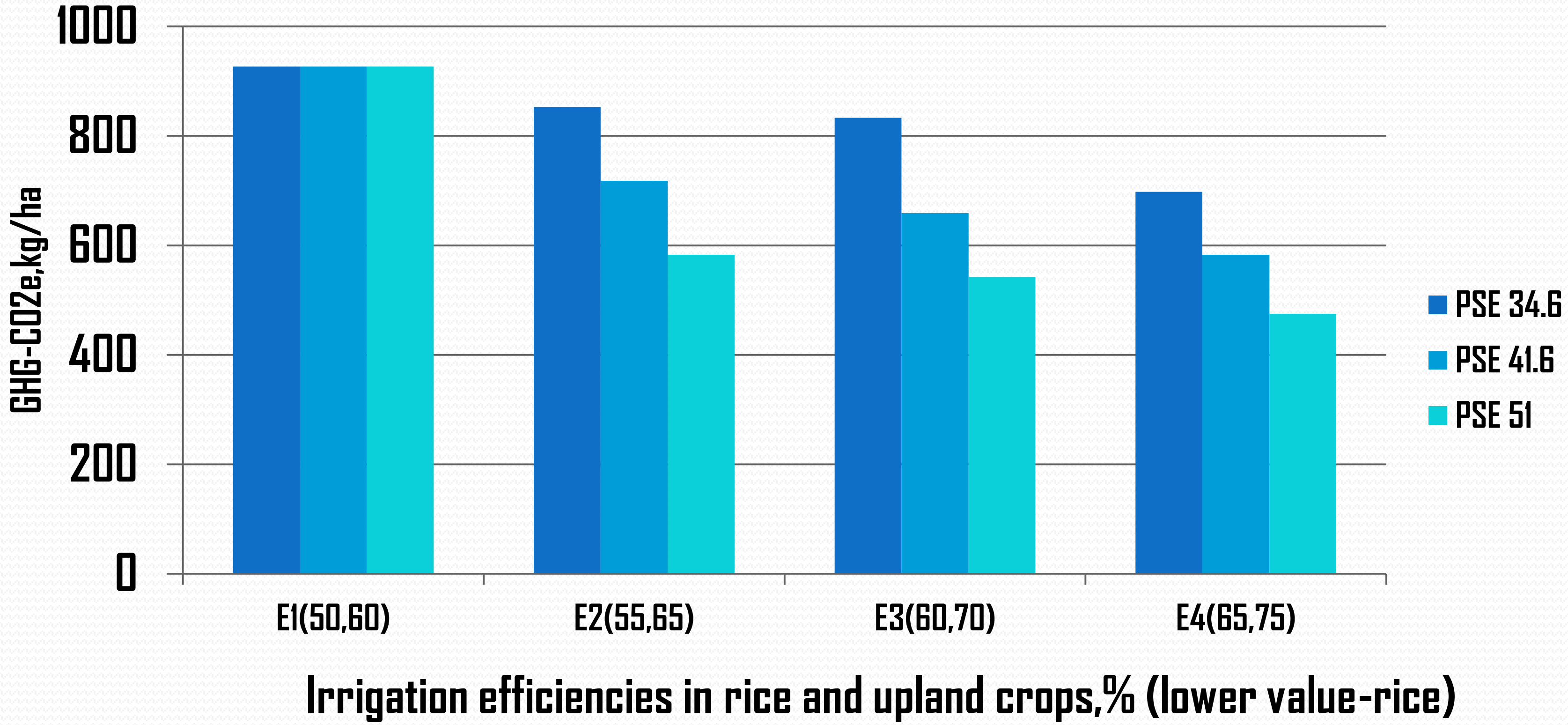
Expansion of micro-irrigation has been one of the major initiative during last 15 years

Triple benefits of micro-irrigation (Tyagi and Joshi,2017)

Micro-irrigation saves about 1000 MCM water annually, leading to I AE

Item	20%	30%
Water saving, M ha m		
- Current area (7 m ha)	0.89	1.33
- Potential area (42 m ha)	6.51	19.9
Food production, m t		
- Current area (7m ha)	4.56	6.84
- Potential area (42 m ha)	25.2	37.8
Food availability,(kg/cap$^{/year}$)		
- Current area (7m ha)	3.76	5.64
- Potential area (42 m ha)	22.57	34.12
Reduction in GHG emission($MtCO_2e$)		
- Current area (7m ha)	6.69	10.04
- Potential area (42 m ha)	40.20	60.3

Impact of pumping system efficiencies(PSE-%) and crop irrigation efficiencies on GHG emission (Data: Patle et al,2016)



Low pumping efficiencies of 8 million irrigation tube wells has been a big concern in India- These pumps will now be replaced

Conservation agriculture and other improved farming practices

Laser levelling &Conservation agriculture, particularly zero /minimum tillage , are a big draw among the farmers

Energy indicators and economics of tillage after six cycles of maize based cropping(Yadav et al,2016)

Tillage practice	Gross output Energy (10^3xMj/ha)	Energy efficiency	Energy intensity (MJ/ha)	Net return (INR/ha)	B C Ratio
Permanent Beds	199.2	15.7	8.06	41744	1.69
Zero tillage flat	210.1	16.4	8.50	45681	1.85
Conventional tillage	185.3	11.7	7.03	35363	1.34
SEm+_	2.55	0.20	0.103	1275.5	0.05

Effect of tillage practices on yield(t/ha) of different crops under maize based cropping system (Parihar et al,2016)

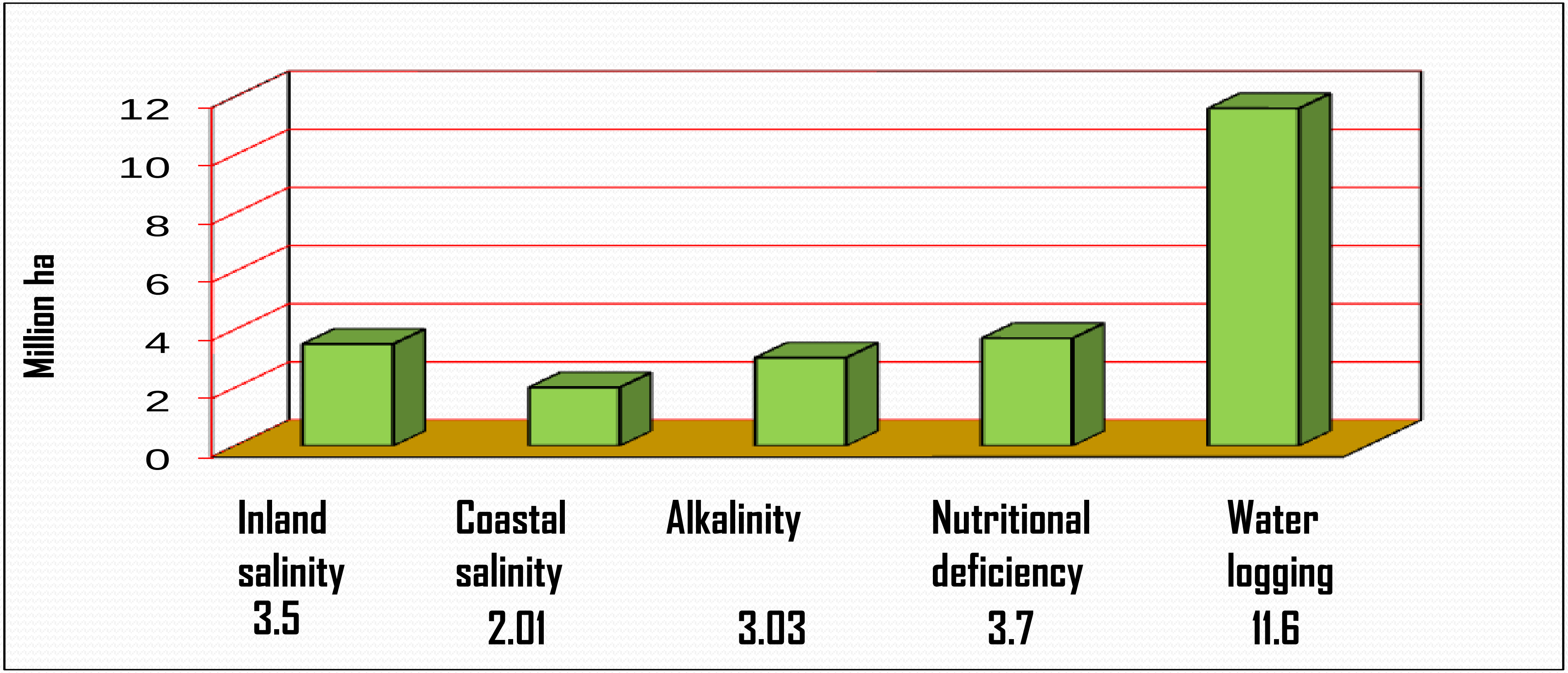
Tillage practice	Summer maize	Winter maize	Wheat	Mustard	Chick -pea	Mung-bean
Zero Till	4.54	5.78	3.90	2.05	1.71	0.71
Permanent Beds	4.37	5.55	4.44	1.90	1.54	0.65
Conventional	4.07	4.68	3.73	1.85	1.41	0.58

Impact of alternative agricultural technologies on global yields of important crops in 2050 (% change from baseline)(IFPRI,2013)

Technology	Maize	Rice	Wheat
No till	15.8(-8.2)	NA(-0.3)	16.4(-7.4)
Precision agriculture	3.7(-2.2)	8.5(-3.2)	9.7(-4.9)
Drip irrigation	0.1(-1.0)	NA(0)	0.7(0.4)
Sprinkler irrigation	0.1(-0.1)	NA(0)	0.4(-0.2)
Water harvesting	0.5(-0.3)	NA(0)	0.1 (-0.1)
Nitrogen use efficiency	11.3(-6.3)	20.2(-6.8)	6.2(-3.8)
Heat tolerance	16.2(-8.4)	3.0(-1.4)	9.3(-4.6)
Drought tolerance	1.1(-0.6)	0.2(-0.1)	1.4(-0.7)

Values within () are % change in harvested areas compared with base line

Salinity and water logging affect productivity of more than 10 million ha of agricultural land in India



Major research programme on reclamation of Salt affected & water logged lands was launched. 2 mha land has been reclaimed

Rehabilitation of waterlogged saline lands

Based on field experimentation, design specifications have been developed; and pilot projects were launched in Haryana

Triple benefit technology- subsurface drainage, water storage pond for irrigation , aqua culture (Sharda Sahayak Canal,U P)

Institutions &Policy Compact

Institutions

Command Area Development Authorities- Limited success

Water & Land Management Institutes- Limited success

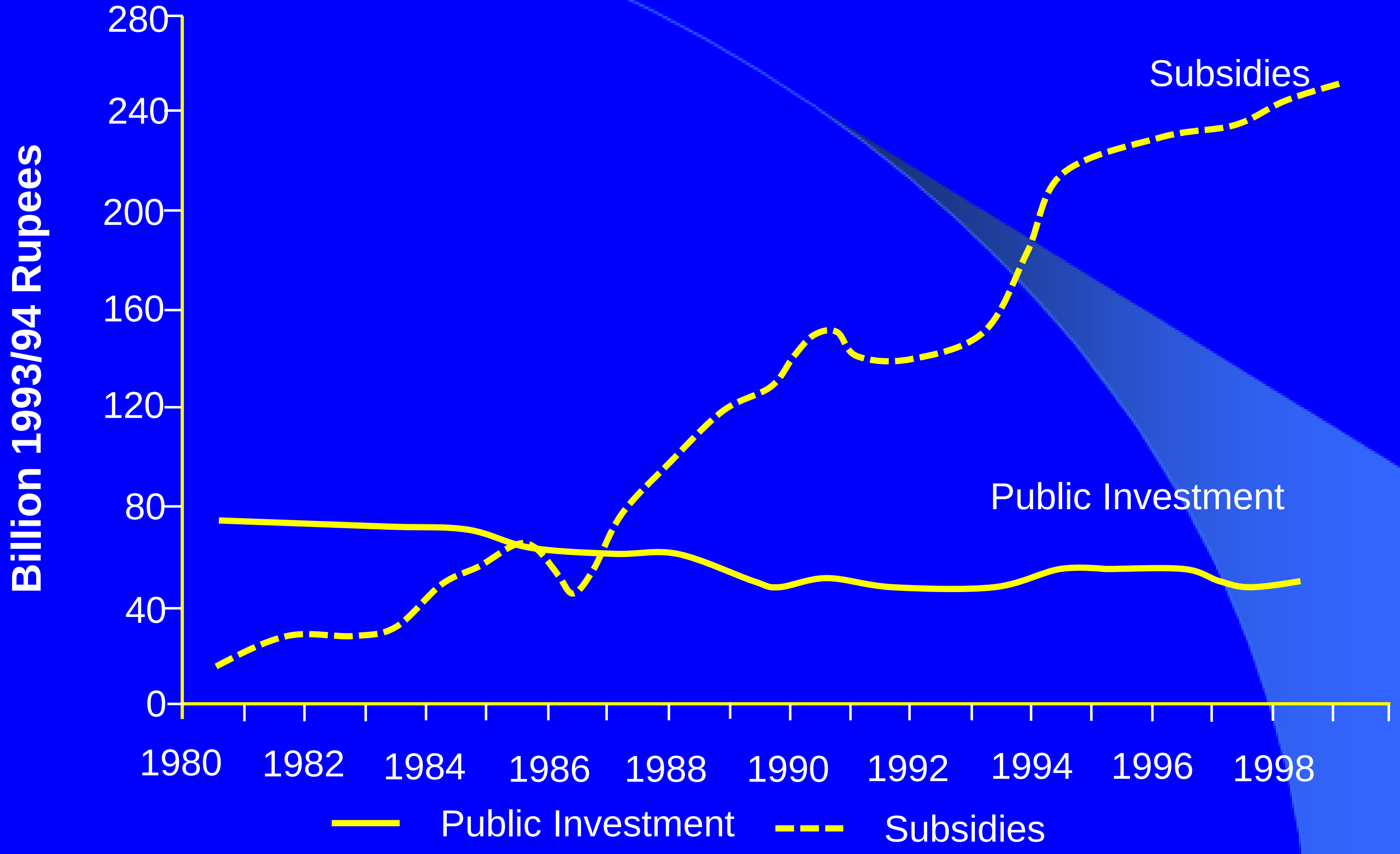
Water Management Research Centers- Making progress

Water users associations- Limited success

Policies

Subsidy on water, electricity , diesel- has been a mistake, but now it has become a political compulsion

Public Investments and Input Subsidies in Indian Agriculture



Source: Ashok Gulati and Sudha Narayanan, The Subsidy Syndrome in Indian Agriculture (New Delhi: Oxford University Press, 2003).

Societies in areas of water scarcity and / or high climatic variability have remained poor and in low equilibrium trap because it has not become possible for them to make comparatively large investment needed to achieve water security

Source : World Bank study

The policy shift

- Subsidy on efficient technology : Micro- irrigation, Laser levelling, Zero till machine, Irrigation pumps
- Mainstreaming of technology promotion in action programmes: PMKSY, NMIM,MNREGA, PMCIS
- Emphasis on : ICT, Space technology, Weather advisory services, Mechanization, PHT, Processing
- Change in land ownership rules : Promote contract farming, Land leasing to overcome small farm size constraint

A mega programme to improve irrigated agriculture

Prime Minister Krishi Sinchai Yojana(Irrigation Plan):

-Enhance on-farm water use efficiency through technology adoption

-Precision agriculture

-Aquifer recharge

Budget

₹ 10000 million(**£** 125 million) for 2015-16

₹ 50000 million(**£** 6250 million) for next five years

WAY FORWARD(I)

- **Remove adaptation deficit:** There is considerable adaptation deficit even for current level of climate change impacts, which could be met with increased adoption of currently available agro-hydro-technologies. Most of these are no regret adaptations .

- **Higher level agro-hydro-technologies to beat the heat** :Effectiveness of current technologies will go down with increased warming. Look at models like" My Climate "to set up technology generation research programmes
- **Commercial precision agriculture**: Increased use of GPS, Satellite-based remote monitoring and infield sensing, Cellular and wireless communication technologies + internet.

WAY FORWARD(II)

- Economic social and political barriers to technology adoption: Assess effectiveness of adaptation options under different operating policy regimes, geographical differentiations and risk transfer programmes.

- Focus on cross-sectoral impacts of policy decision to bring coherence in policy making(Water diversion vs downstream requirements)

- WRDM is highly political in nature: Generate strong empirical evidence to indicate resource use efficiency, adoption challenges and economics of adoption for end-users. Establish effective communication channels with policy makers

Forget the past. Remember every day dawns for us from the moment we wake up. Let us all, everyone, wake up now"

M. K. Gandhi,1947