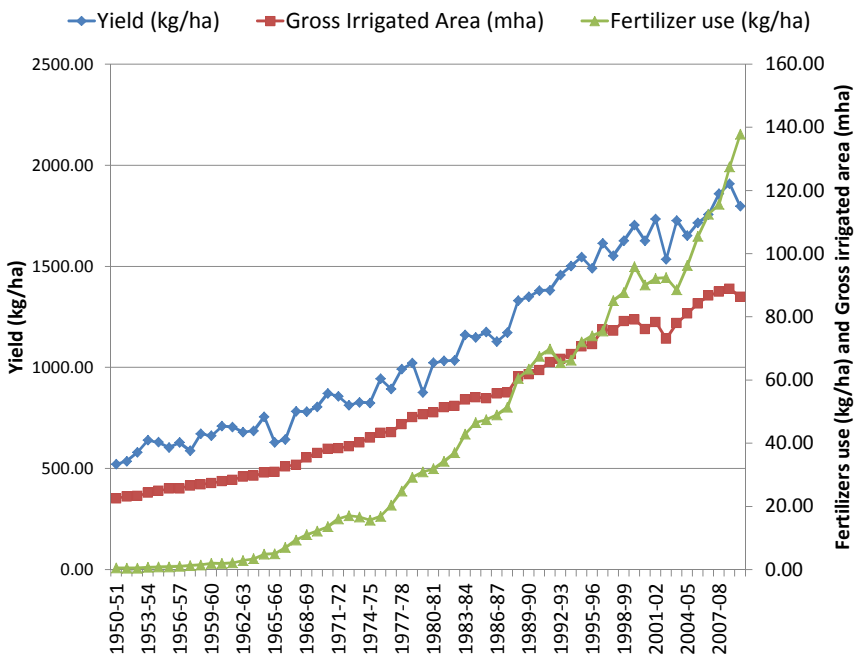
Managing Water and Fertilizer for Sustainable Agricultural Intensification

IFA-FAI National Seminar

Sustainable Fertiliser Management for Soil Health

16-17th March, 2015, Hotel The Grand, New Delhi, India

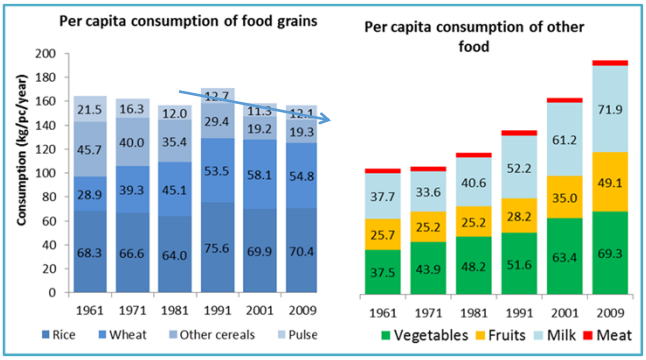
Indian Agriculture is on a rising trend- Yields, Irri. Area, Fertilizer Use



India's Future Food and Water Demand?

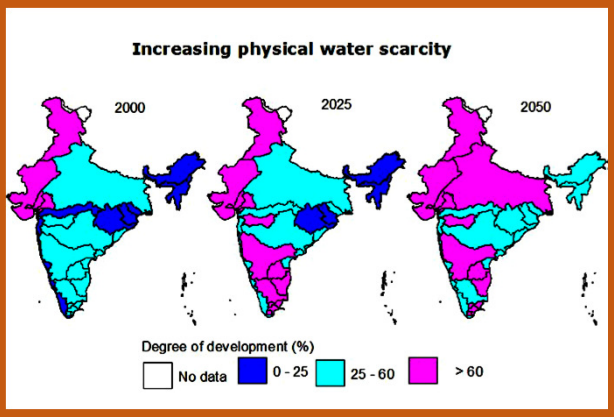
By 2050, even by conservative estimates:

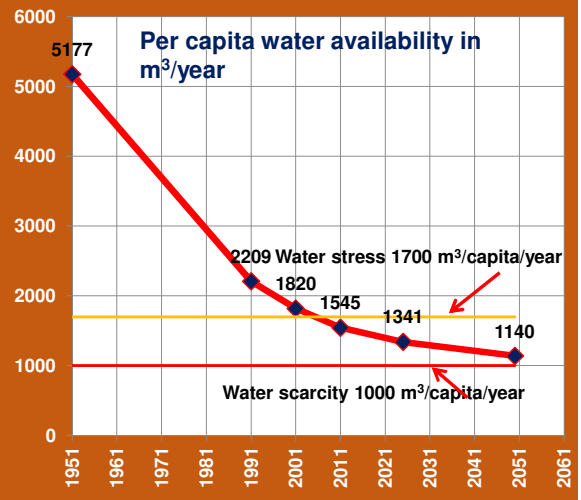
- Population will increase by 55% (1020 to 1580 million)
- Foodgrain demand will increase by 145% (200 to 490 MT)
- Irrigation demand will increase by 35% (600 to 800 Bm3)



- Food consumption patterns are changing
- Also changing are demographic patterns

But most of the Indian river basins are becoming water scarce

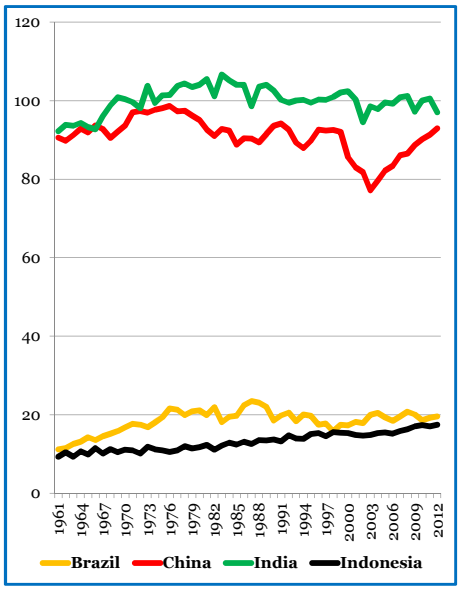




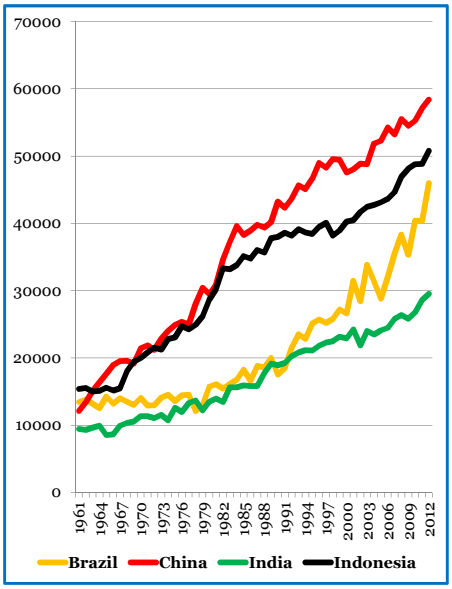
- 10 river basins will be physically water scarce by 2050
- 8 river basins will withdraw more than 75% of the available groundwater resources
- These basins account for 80% of India's GW withdrawals

And Production Levels are Low In India !!

Total Area Harvested for Cereals (million ha) (1961-2012) (Brazil, China, India and Indonesia)



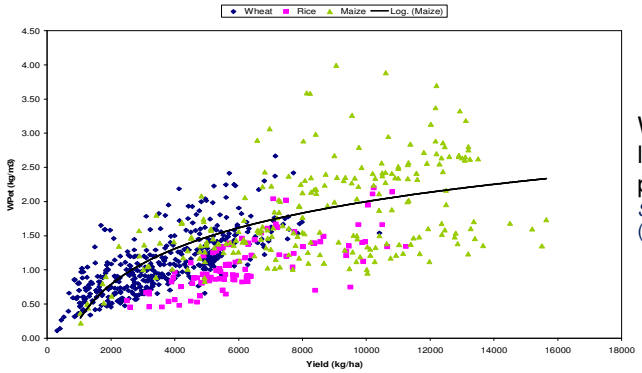
Total Cereals Yield (hg/ha) (1961-2012) (Brazil, China, India and Indonesia)



Source: Lele and Associates, based on FAOSTAT data

How has the agricultural intensification unfolded in India ?

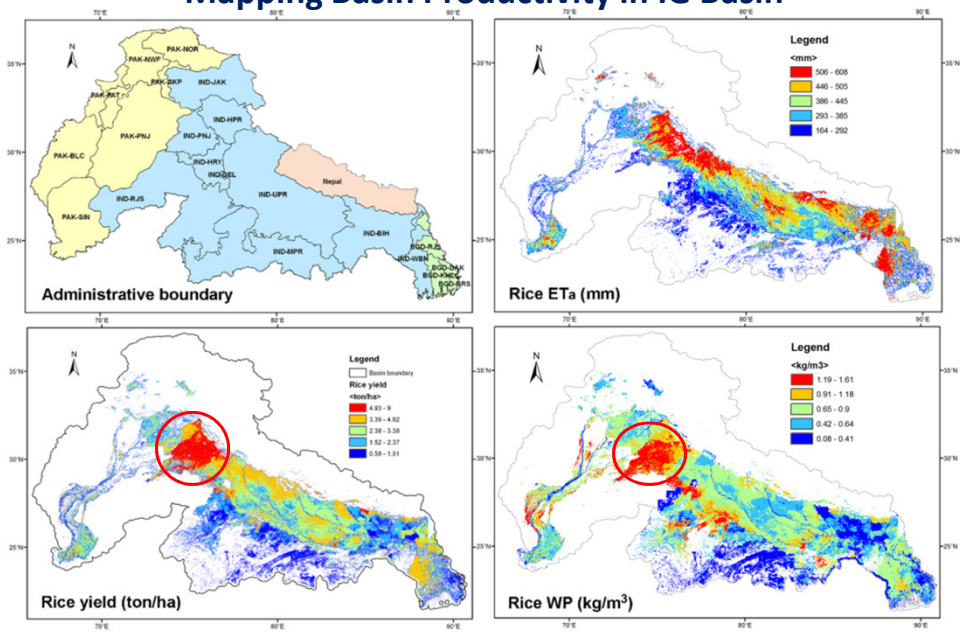
"The near linear relationship between transpiration and crop production has far-reaching consequences for water needs. Increase in food production in productive areas is achieved with near proportionate increase in transpired water."

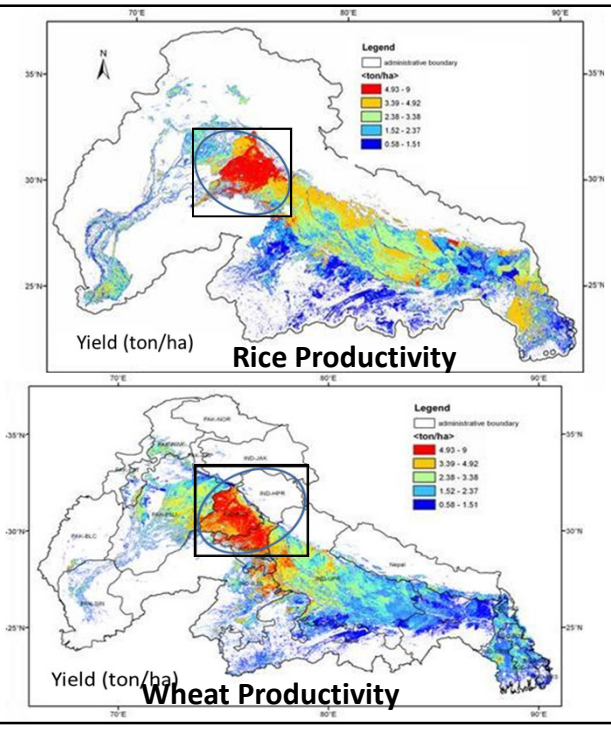


Water productivity gains are higher at lower yield levels and tend to be proportionate at higher yield levels.
Source: Adapted from Zwart and Bastiaanssen (2004).

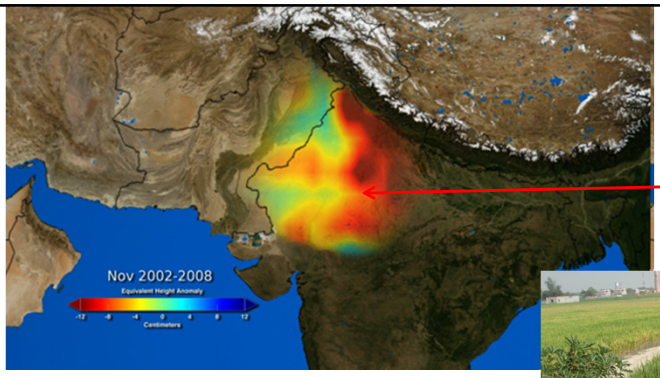
As a result, country has small areas of very high productivity and vast areas of low productivity- and not in synchrony with the water availability status of the country.

Mapping Basin Productivity in IG Basin





Rice and wheat productivity, central to continent's food security, is high only in about 9% of the north-western part of the basin.



Groundwater storage varied in northwestern India between 2002 and 2008, relative to the mean for the period. These deviations from the mean are expressed as the height of an equivalent layer of water, ranging from -12 cm (deep red) to 12 cm (dark blue). Credit: NASA/Trent Schindler and Matt Rodell

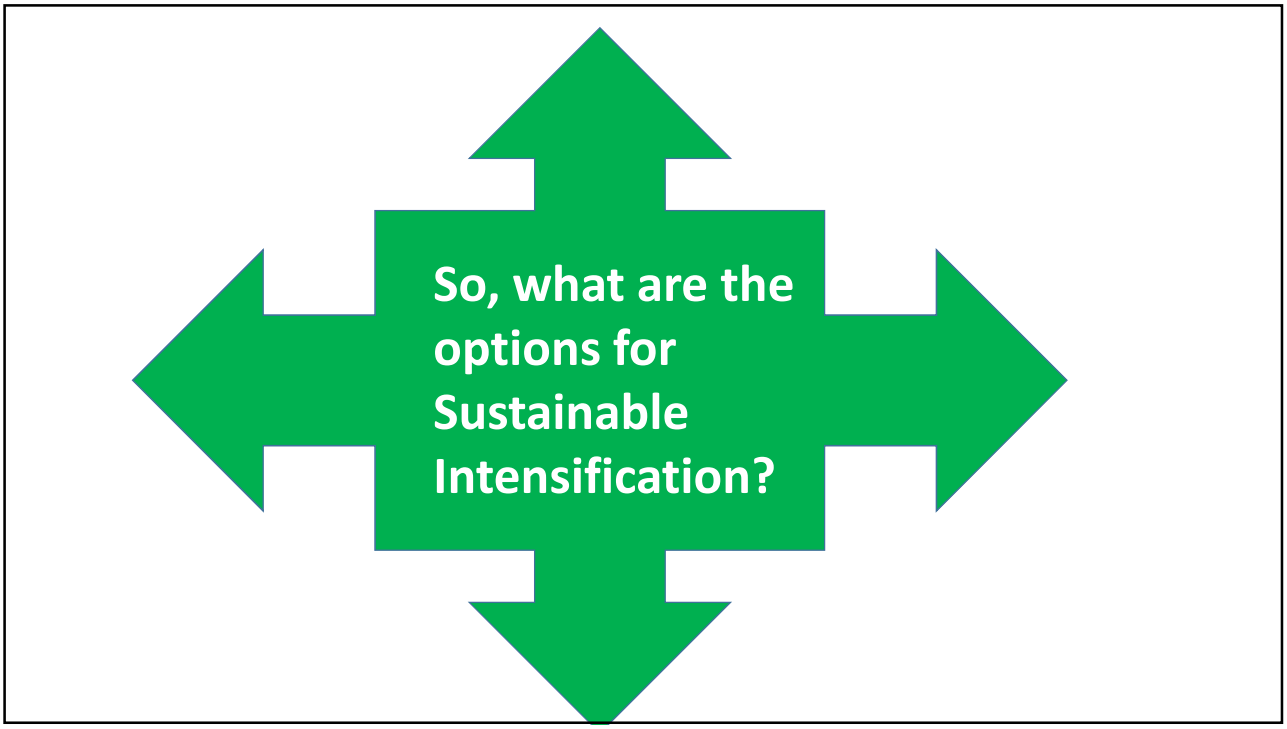
This intensification is Hydrologically unsustainable in the medium to long run!!

Global Hotspot in GW over-exploitation

Water Transfer in the Form of Food-grains and Per Capita Water Availability

STATES	W ATER AVAILABILITY (m^3 / capita/ year)	NET WATER TRANSFER IN THE FORM OF FOOD-GRAINS (billion m^3 / year)
Food Donors		
1. Punjab	3554	- 20.9
2. Haryana	2176	- 14.1
3. Uttar Pradesh	2922	- 20.8
	Mean 2884	**- 55.8**
Food Receivers		
1. Bihar	6898	15.3
2. Jharkhand	4580	9.3
3. Orissa	8710	4.8
	Mean 6729	

Scope for sustainable development of GW in Eastern region



Water and Fertilizer Use Efficiencies Improve when both Inputs are in Optimum Balance

Irrigation (mm)	WUE				N-use efficiency		
	N rate (kg ha^{-1})				N rate (kg ha^{-1})		
	0	40	80	120	40	80	120
No irrigation(rainfed)	2.8	4.4	6.3	3.6	5.3	4.8	0.9
50	**5.2**	**9.4**	**10.3**	**10.9**	**23.3**	**12.0**	**9.8**
120	5.7	8.4	10.3	9.0	23.0	17.6	8.8
300	5.1	7.0	8.6	8.8	19.5	20.0	14.8

Nitrogen and irrigation effects on WUE (kg grain ha^{-1} mm^{-1}) and N-use efficiency (kg grain kg^{-1} fertiliser N) in wheat at Ludhiana, India

(Adapted from Gajri et.al.,1993).

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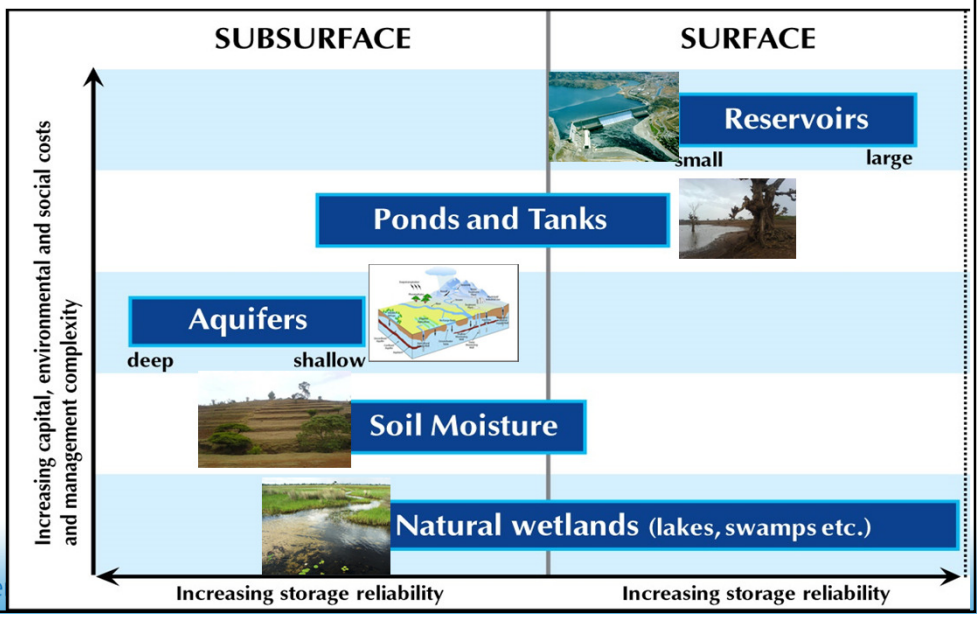
Apply Smart Water Solutions under Varying Agro-hydrological Situations

Water Storage Continuum

Source: McCartney & Smakhtin 2010



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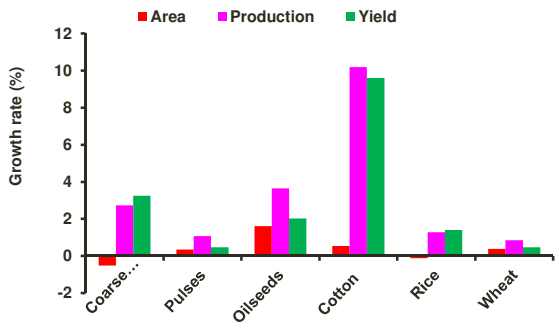
Rainfed Ecosystem: Untapped Potential

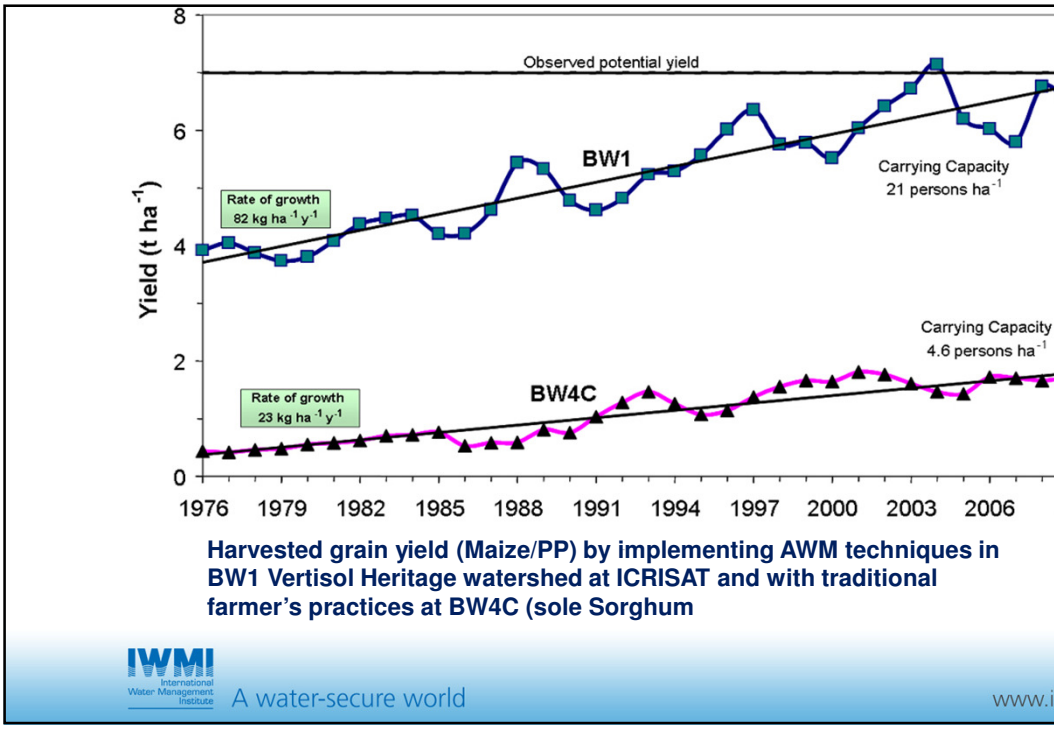
- Even with the cumulative policy neglect and low investments ($ 240-300 /ha against $ 4000-5000 /ha in canal irrigation), rain-fed agriculture contributes significantly to the national economy
- Rainfed crops have shown more impressive growth rates in recent years as compared to irrigated crops like rice and wheat
- Watershed management has been the major program with mixed response
- **Great opportunity to increase yield & WP in rainfed districts with RWH**

Regionally differentiated design tools for effective watershed planning in IWMP, MGNREGA, RKVY, etc.



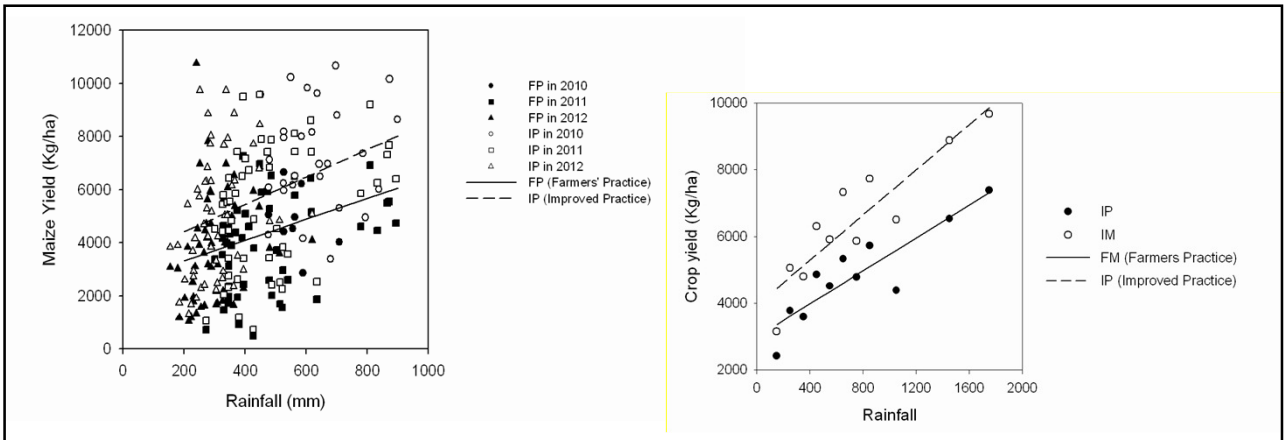
Growth rate in area, production and yield of major crops in India, 1998-99 to 2008-09

Watershed Based Technologies for Efficient Rain Water Harvesting and Soil Conservation

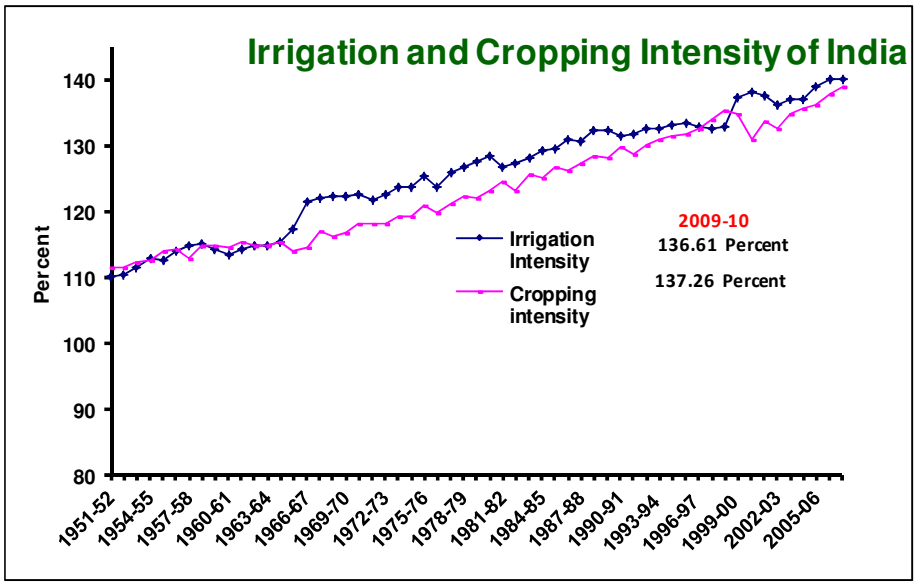


Harvested grain yield (Maize/PP) by implementing AWM techniques in BW1 Vertisol Heritage watershed at ICRISAT and with traditional farmer's practices at BW4C (sole Sorghum

Typically, in situations where yield is less than 40-50% of the potential, non-water factors such as soil fertility, limit yield and crop water productivity. The application of relatively small amounts of water and fertilisers for raising yields from 1 to 2 tons per hectare will lead to much higher gains in water productivity than doubling the yields from 4 to 8 tons per ha



Response of crop yield with rainfall and balanced fertilizer application in Maize productivity across the Karnataka between 2010 and 2012



1. Laser Leveler- Productivity Gains and Water Saving

Crop (Variety)	Grain yield (Kg/ ha)		Water saving over without laser leveled field (%)
	Laser leveled field	Without laser levelling	
Paddy	6792	6500	38
Wheat	4750	4550	20
Sugarcane	112000	98750	24
S.Moong	500	375	20
Potato	10000	9000	25
Onion	10000	9000	20
Sunflower	2250	2000	20

Agronomic efficiency (kg kg $^{-1}$) of N (AE-N), P (AE-P) and K (AE-K) under different land levelling systems in rice

Treatment	AE-N		AE-P		AE-K	
	2003	2004	2003	2004	2003	2004
LL+NPK	18.75	20.00	86.54	92.31	56.25	60.00
TL+NPK*	*7.67*	*9.17*	*35.38*	*42.31*	*23.00*	*27.50*

LL-Laser levelling, TL-Traditional levelling, *N @ 120 kg, P @ 26 kg and K @ 40 kg ha^{-1}

Source: Jat et al (2004)

Crops	Yield on beds (t/ha)	Yield on flat (t/ha)	Water savings (% over flat)	Yield increase (% over flat)
Maize	3.27	2.38	35.5	37.4
Urd bean	1.83	1.37	26.9	33.6
Mungbean	1.62	1.33	27.9	21.8
Wheat	5.12	4.81	26.3	6.4
Pigeon pea	2.2	1.5	30.0	46.7
Gram	1.85	1.58	27.3	17.1
Average	**-**	**-**	**30.04**	**28.57**

2. Furrow Irrigated Raised Beds (FIRBS)

3. Drip-fertigation and vegetable based farming system with created groundwater resources and in canal commands

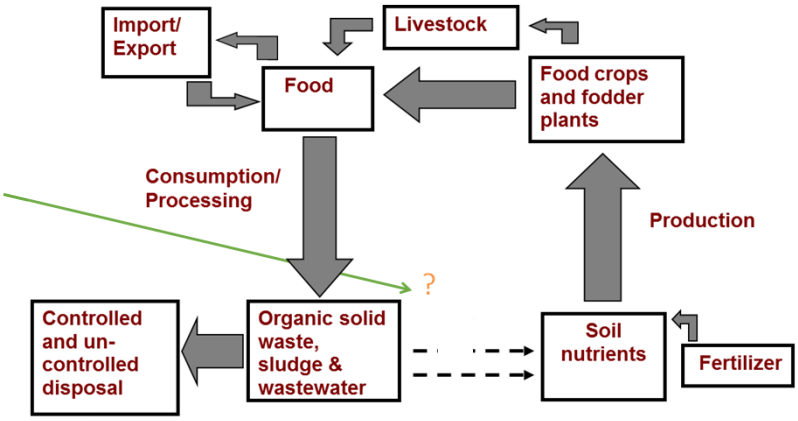
Crop	Saving in water (%)	Increase in yield (%)
Sunflower	52	-
Maize	53	12
Chilli	53	15
Cauliflower	63	27
Potato	39	38
Tomato	26	42
Cabbage	41	56
Bitter gourd	53	36.5
Brinjal	44	30
Banana	47	44

4. Waste – Resource for a Circular Economy

In most cities in sub-Saharan Africa, S. Asia and SE Asia, population growth has outpaced the development of sanitation infrastructure, making the management of urban waste, human excreta and wastewater ineffective. Investment in treatment will not catch up for decades.

Enhance Efficient Resource Use and Reuse

Challenge: closing the nutrient loop



Urban pollution and nutrient wasting

Peri-urban and rural nutrient mining

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Introducing business models to turn waste into an asset

- Solid waste and fecal sludge composting in Asia and Africa could save billions of US$ per year, assuming a market for only 25% of the urban organic waste.
- Not a new concept, but many pilots not viable or sustainable
- Business models for **resource recovery & reuse** (RRR) target private and public investors and business schools.

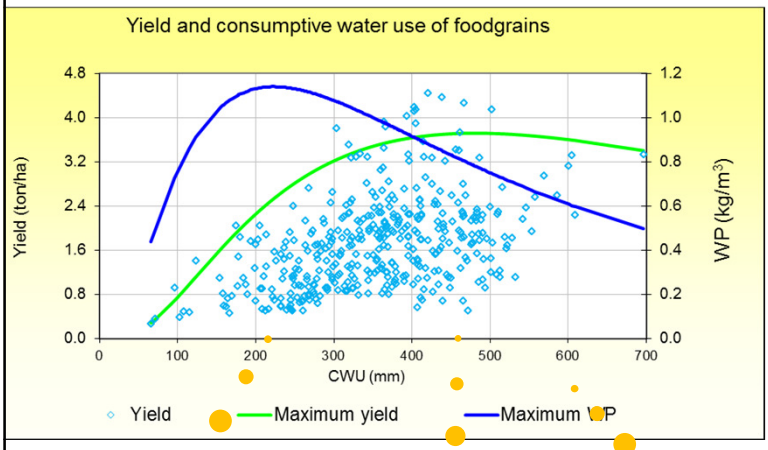
5. Context Specific Focus on Eastern Region

- Higher water availability but more water poverty due to limited access to small and marginal farmers.
- Lower water and nutrient productivity.
- Small and fragmented land holdings.
- Higher cost of pumping due to predominance of diesel sets.

Opportunity to contribute in tapping vast untapped potential

- Technological push for use of groundwater
- Evolving and promoting various institutional arrangements including groundwater markets, water franchisees, community/group tube wells.
- Enhance fertilizer use, micronutrients; ensure timely availability.
- Complement government's on-going program of Bringing Green Revolution in Eastern India.

Alternative options – Water and nutrient productivity improvements



Supplem entary irrigation

Reducing yield gap

Deficit irrigation

- Significant scope for yield and nutrient productivity increase.
- 1% increase of yield annually would meet all foodgrain requirements and require very little additional irrigation.

Thanks for the Opportunity!!

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