Nicholas Institute for Environmental Policy Solutions
Duke University

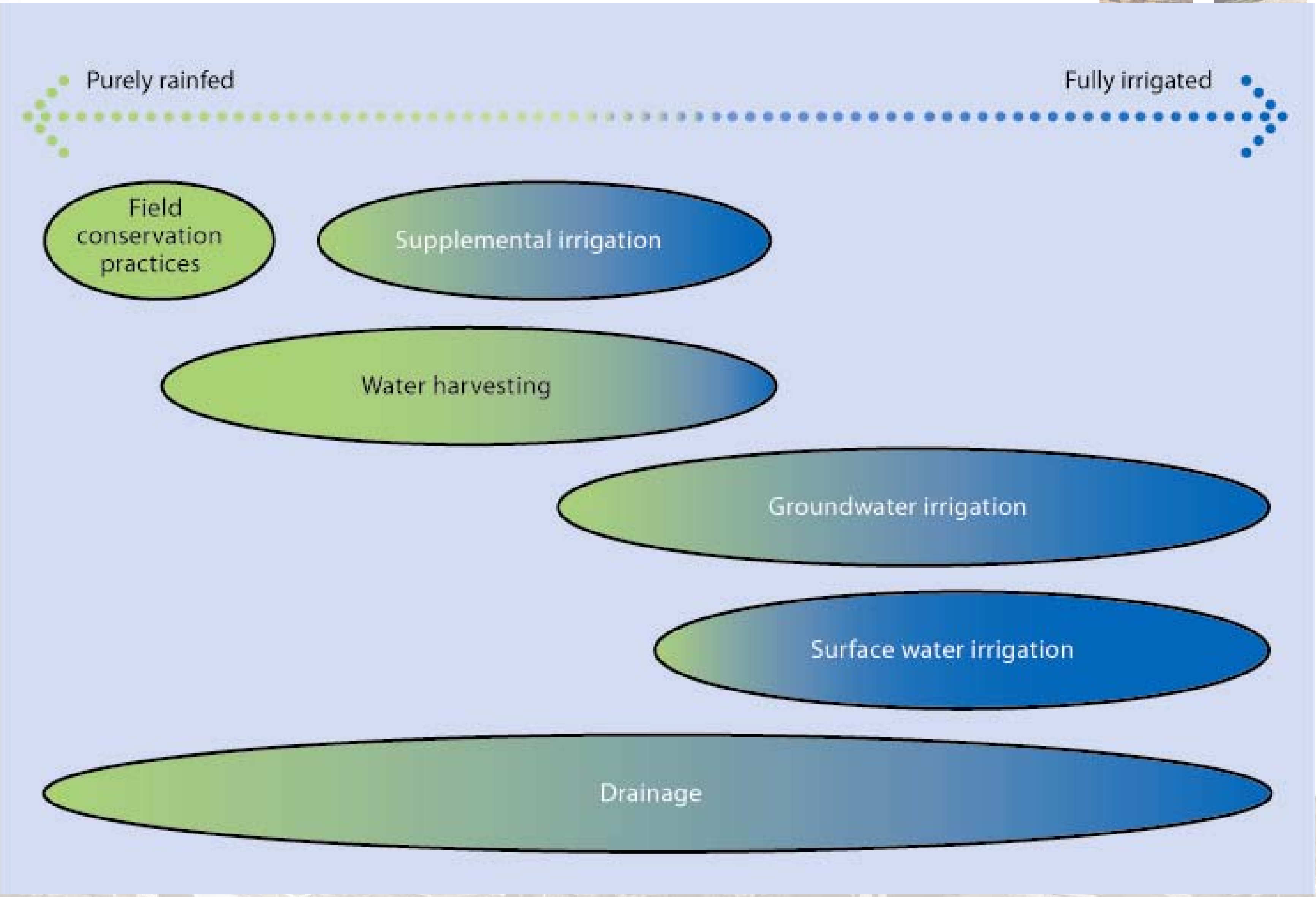
Water, Agricultural Productivity and Environmental Services

Peter G. McCornick
Director for Water
P.McCornick@duke.edu

Measuring Food Insecurity and Assessing the Sustainability of Global Food Systems
February 16-17, 2011
Keck Center of the National Academies
Washington, DC

OUTLINE

- Water Source
- Assessing Agricultural Water Management
- Water Productivity
- Scale
- Reliability and Risk
- Water Security
- Conclusions


Purely rainfed
Fully irrigated
Field conservation practices
Supplemental irrigation
Water harvesting
Groundwater irrigation
Surface water irrigation
Drainage

WATER SECURITY & STORAGE

- Soil-water management
- Rainwater harvesting and micro-storage
- Groundwater
- Wetlands and ponds
- Large, medium and small reservoirs
- Storage of virtual water

SELECTED AGRICULTURAL WATER MANAGEMENT INDICATORS

INDICATOR	Unit
Increased production per unit of water consumed (crops, livestock & fisheries)	$/m3, kg/m3, cal/m3
Increased agricultural production on lands under improved water management	ha
Area under improved irrigation and water management	ha
Area under improved rain-fed water management	ha
Increased water storage capacity	m3/ha
Increased agricultural water use efficiency	%
Reduced volume of wastewater (expansion of reuse)	m3/ha
Adoption of agricultural water management/water conservation technologies	# Farmers
Women with access to agricultural water management (AWM) technologies	# Women

INDICATOR	Unit
Water users associations, producer & trade groups, trade and business associations, and community-based organizations (CBOs) established/enhanced.	Number
Increased AWM capacity of extension services and NGOs	?
Training in improving water use,strategies, skills, and techniques	# People
Communication and outreach programs introduced	Number
AWM policy reforms/ regulations/ administrative procedures	Number
Level of investment by water users associations in infrastructure & equipment	$
Increased adaptive capacity to cope with impacts of hydrological variability and change	# People
Vulnerability assessments	
Increased household/community resilience	
Reduced water footprints	

WATER PRODUCTIVITY

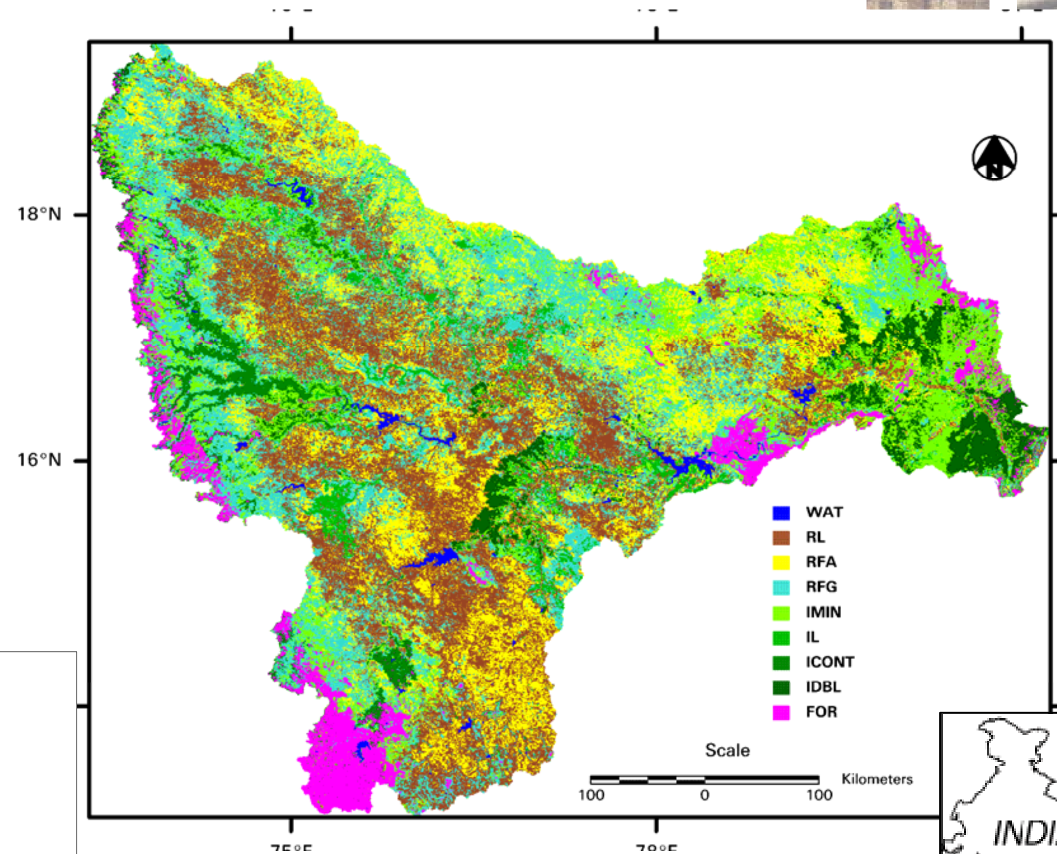
- Obtaining more value or benefit from each drop of water
  - eases water scarcity
  - conserves resources
  - more water for other uses and ecosystems.
- Ratio of output produced over the water used (consumed) in production
- Output depends on the sector and the scale:
  - value or quantity of crop, livestock, fisheries or forests
  - field, farm, landscape, basin, national scales
- Water consumed
  - National - economic value of produce/water consumed
  - Field - weight (kg) of crop/water consumed

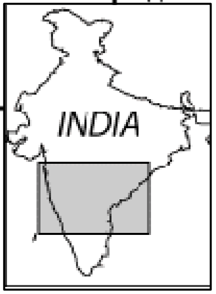
Table 1
Range of water productivities in biological, economical and nutritional terms for selected commodities (Molden et al., 2007a,b).

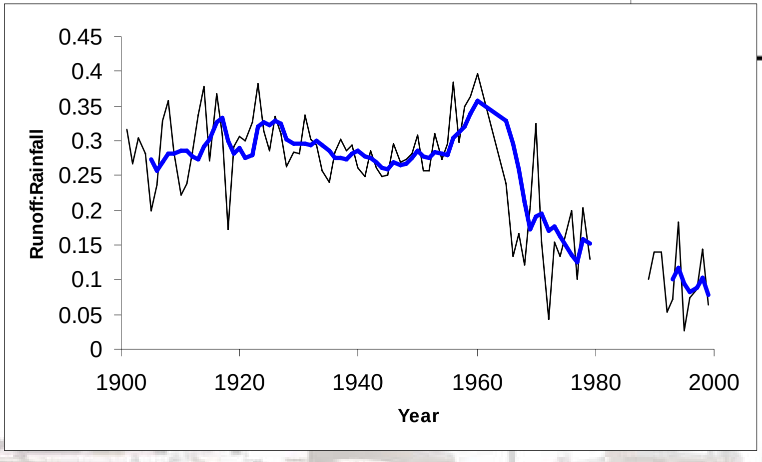
Product	Water productivity			
	Kilograms per cubic meter	Dollars per cubic meter	Protein grams per cubic meter	Calories per cubic meter
Cereal				
Wheat ($0.2 per kilogram)	0.2–1.2	0.04–0.30	50–150	660–4000
Rice ($0.31 per kilogram)	0.15–1.6	0.05–0.18	12–50	500–2000
Maize ($0.11 per kilogram)	0.30–2.00	0.03–0.22	30–200	1000–7000
Legumes				
Lentils ($0.3 per kilogram)	0.3–1.0	0.09–0.30	90–150	1060–3500
Fava beans ($0.3 per kilogram)	0.3–0.8	0.09–0.24	100–150	1260–3360
Groundnut ($0.8 per kilogram)	0.1–0.4	0.08–0.32	30–120	800–3200
Vegetables				
Potato ($0.1 per kilogram)	3–7	0.3–0.7	50–120	3000–7000
Tomato ($0.15 per kilogram)	5–20	0.75–3.0	50–200	1000–4000
Onion ($0.1 per kilogram)	3–10	0.3–1.0	20–67	1200–4000
Fruits				
Apples ($0.8 per kilogram)	1.0–5.0	0.8–4.0	Negligible	520–2600
Olives ($1.0 per kilogram)	1.0–3.0	1.0–3.0	10–30	1150–3450
Dates ($2.0 per kilogram)	0.4–0.8	0.8–1.6	8–16	1120–2240
Others				
Beef ($3.0 per kilogram)	0.03–0.1	0.09–0.3	10–30	60–210
Fish (aquaculture[a])	0.05–1.0	0.07–1.35	17–340	85–1750

SCALE

KRISHNA BASIN





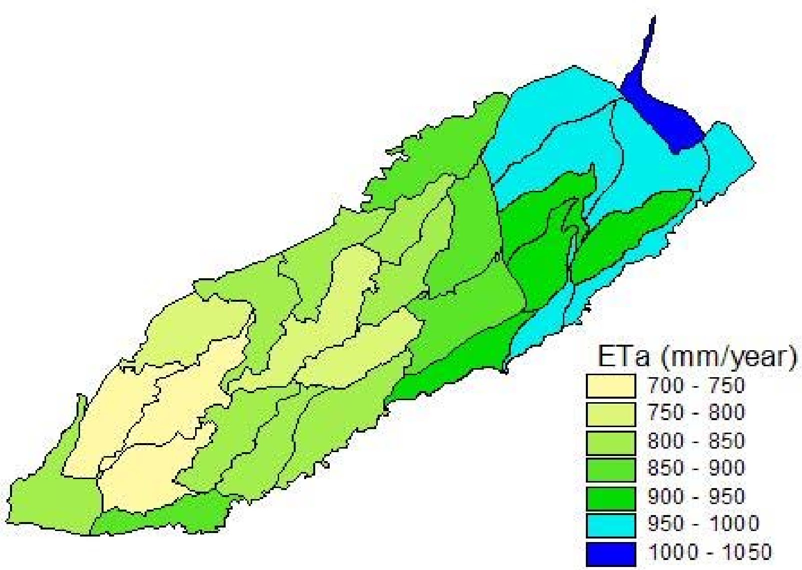


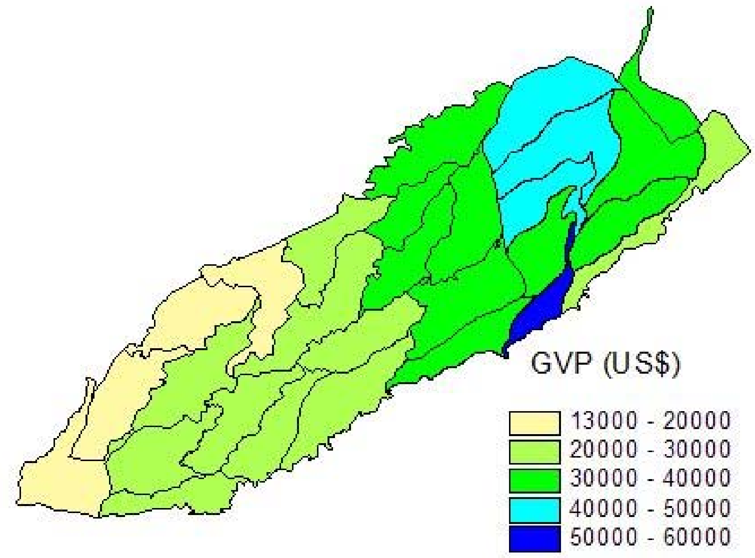
FIELD LEVEL CONSERVATION IN THE INDUS BASIN

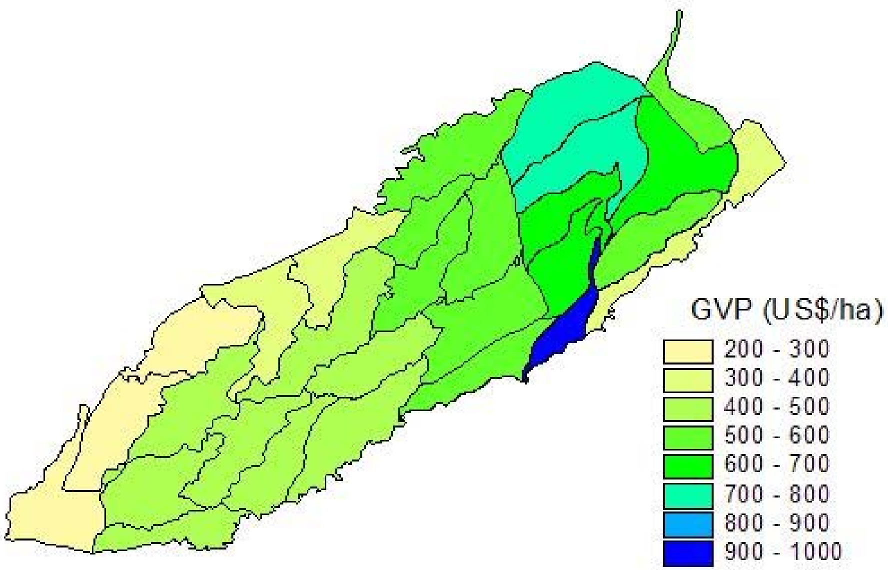
- Potential for further productivity growth in water scarce portions of the rice-wheat cropping system of Indo-Gangetic plains (IGP) is limited.
- Introduce Resource Conservation Technologies (RCTs) developed and promoted.
  - Zero tillage for wheat, direct seeding, bed planting, laser land leveling & crop residue management.
- Objective was to save resources, especially water.
- Field water savings of 30% primarily due to adoption of zero tillage in rice-wheat systems.
- Resulted in localized water spreading
- Downstream water availability declined

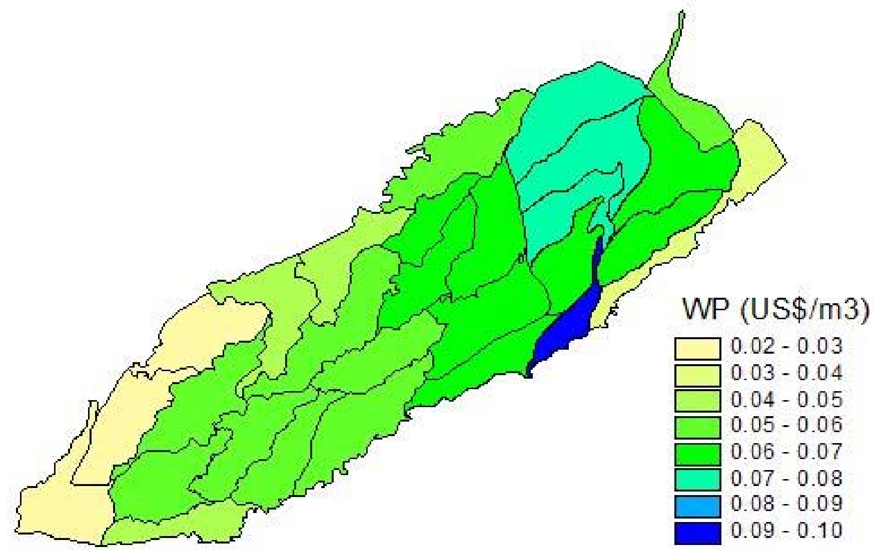
(Mobin-ud-Din, et al. 2006)



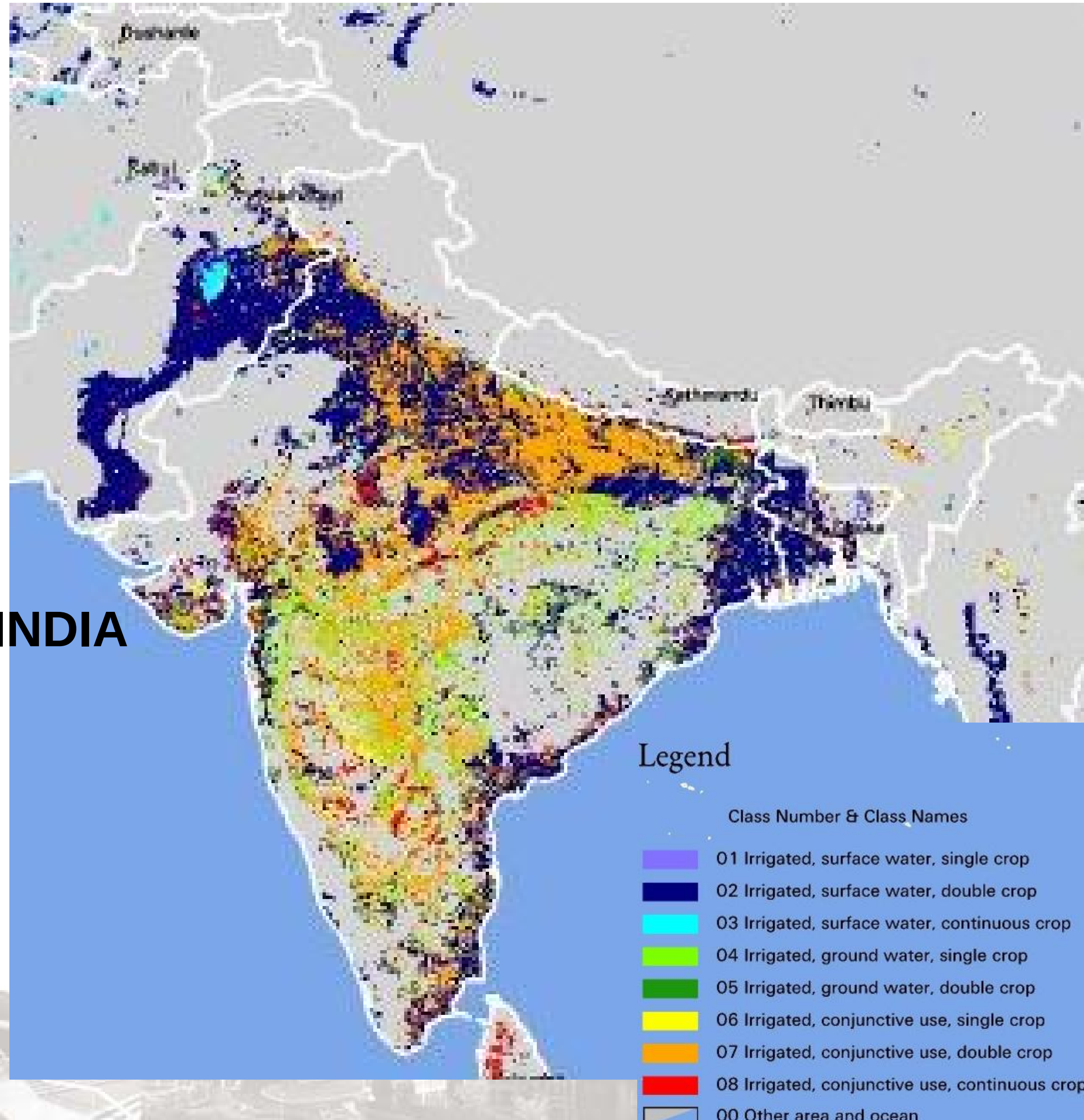

ETa (mm/year)
700 - 750
750 - 800
800 - 850
850 - 900
900 - 950
950 - 1000
1000 - 1050


GVP (US$)
13000 - 20000
20000 - 30000
30000 - 40000
40000 - 50000
50000 - 60000


GVP (US$/ha)
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1000


WP (US$/m3)
0.02 - 0.03
0.03 - 0.04
0.04 - 0.05
0.05 - 0.06
0.06 - 0.07
0.07 - 0.08
0.08 - 0.09
0.09 - 0.10

INDIA


Dushanbe
Kathmandu
Thimbu
Legend
Class Number & Class Names
01 Irrigated, surface water, single crop
02 Irrigated, surface water, double crop
03 Irrigated, surface water, continuous crop
04 Irrigated, ground water, single crop
05 Irrigated, ground water, double crop
06 Irrigated, conjunctive use, single crop
07 Irrigated, conjunctive use, double crop
08 Irrigated, conjunctive use, continuous crop
00 Other area and ocean

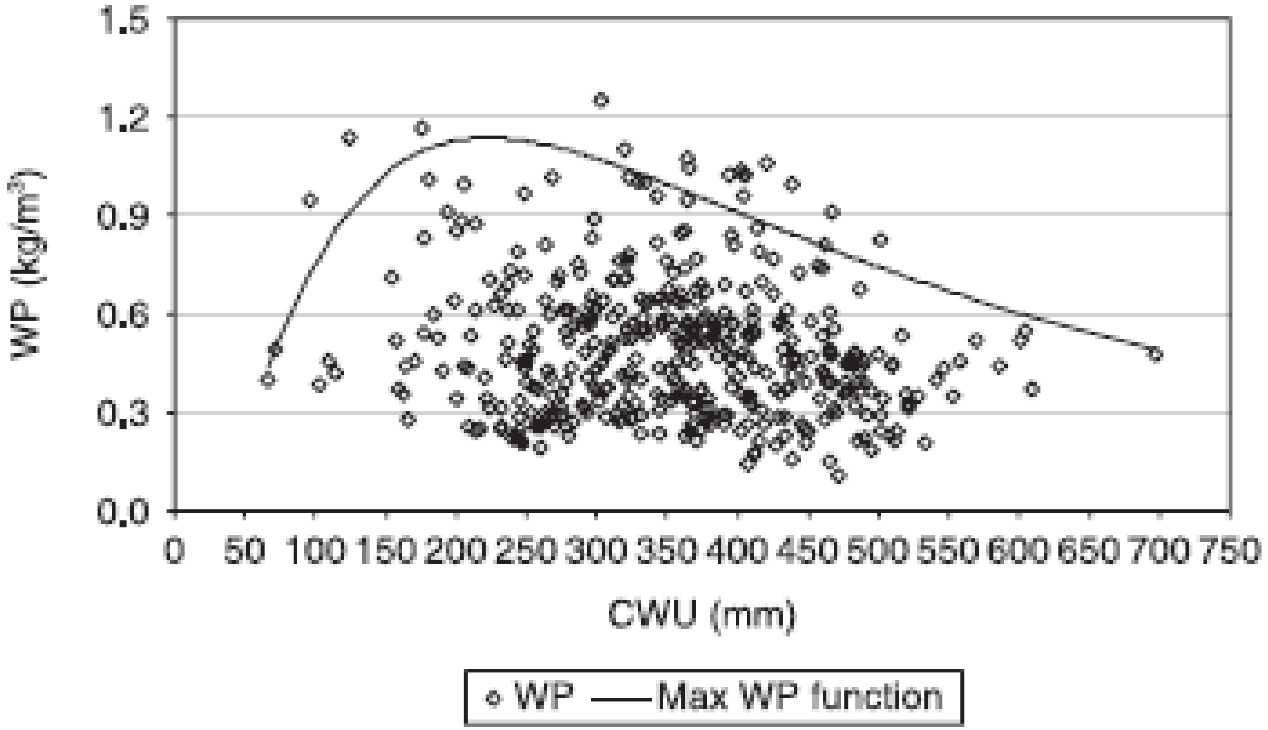
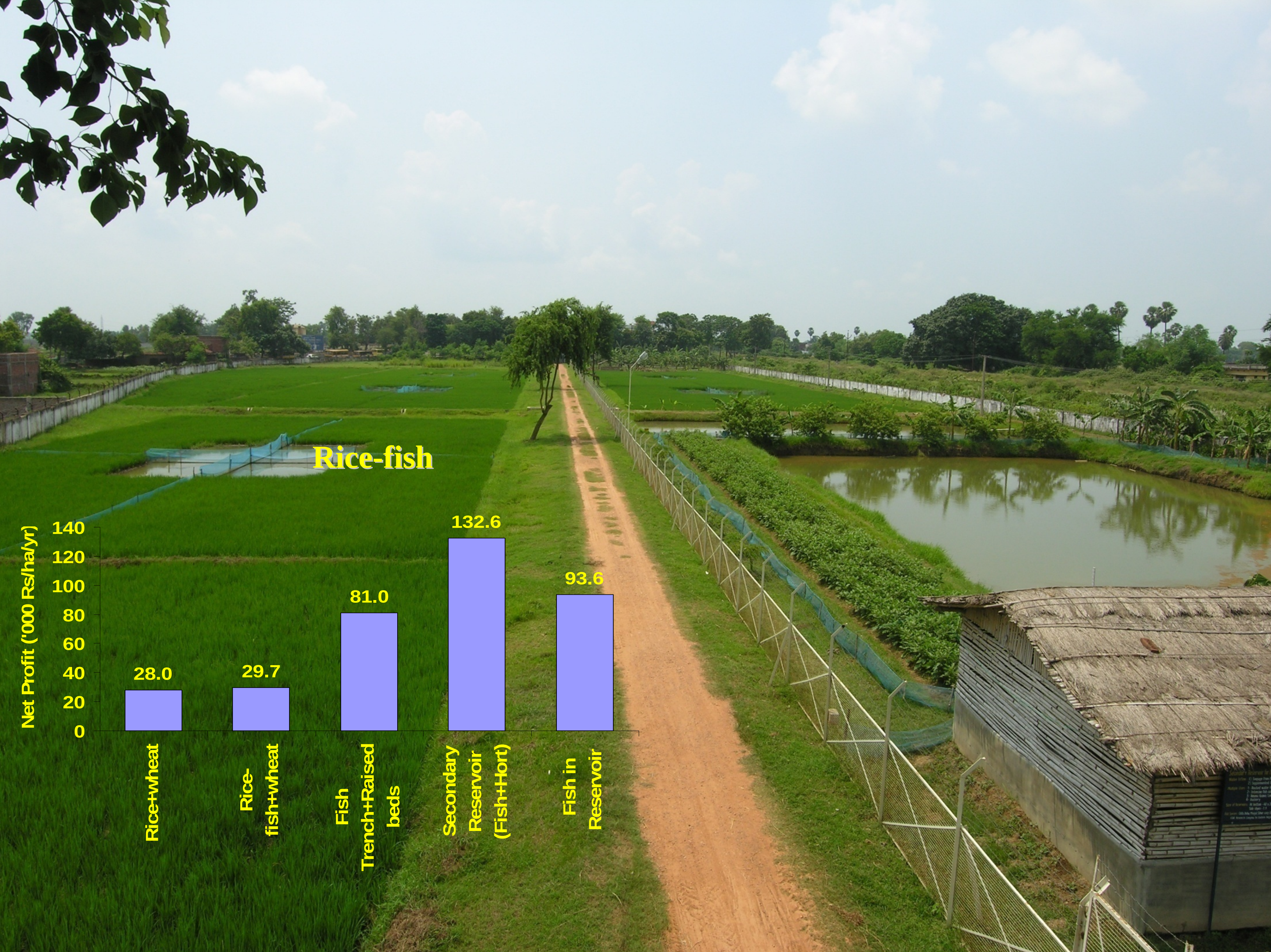


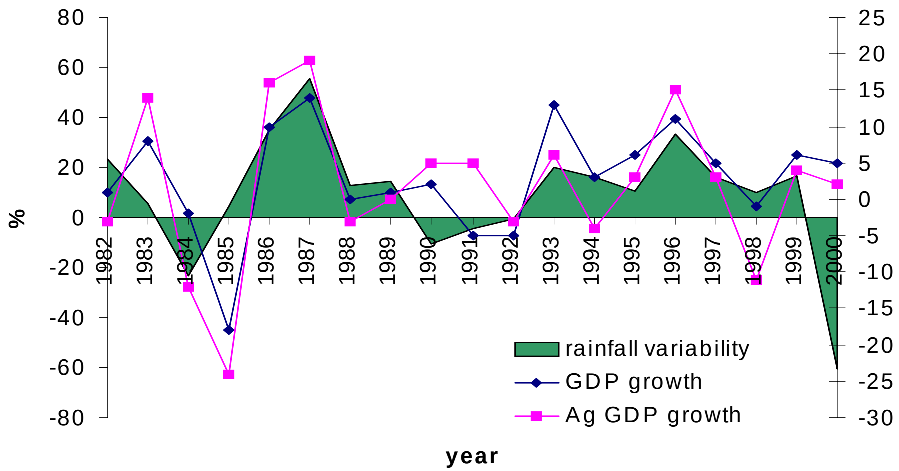
Figure 6. Variation of water productivity (WP) and consumptive water use of grain crops across districts.



Rice-fish
Net Profit ('000 Rs/ha/yr)
140
120
100
80
60
40
20
0
28.0
29.7
81.0
132.6
93.6
Rice+wheat
Rice-fish+wheat
Fish Trench+Raised beds
Secondary Reservoir (Fish+Hort)
Fish in Reservoir

RELIABILITY & RISK

Impact of rainfall variability on GDP and Agricultural GDP growth



Reduction in GDP Growth and increasing rural poverty are closely linked to climatic shocks in Ethiopia (World Bank, 2006)

WATER INSECURITY, PRODUCTIVITY & LIVELIHOODS

- The unpredictability of rainfall affects yields, food security and profits, and smaller farmers are least able to cope
- Negative correlation between variability of rainfall and GDP growth in many countries in SSA
- Climate variability impacts crop production direct supply (rainfall), availability of surface water runoff, shallow groundwater, and flooding of agricultural lands (negative & positive)
- Correlation between a country's capacity to manage water and GDP growth in SSA
- Contributes to availability of food and the volatility of prices,
- Creates a risk averse investment environment,
- Loss of opportunities especially vulnerable rural communities

CONCLUDING THOUGHTS

- Water Accounting – complex, especially in data scarce regions
  - Better able to determine water use
- Water productivity in the larger water resources picture, and tradeoffs
- Reliability
- Virtual water
- Water quality degradation and increasing wastewater