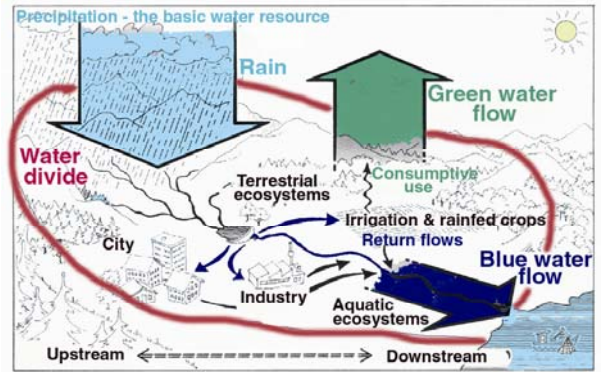


# Green Water Management to Sustain Agricultural Production in a Changing Climate

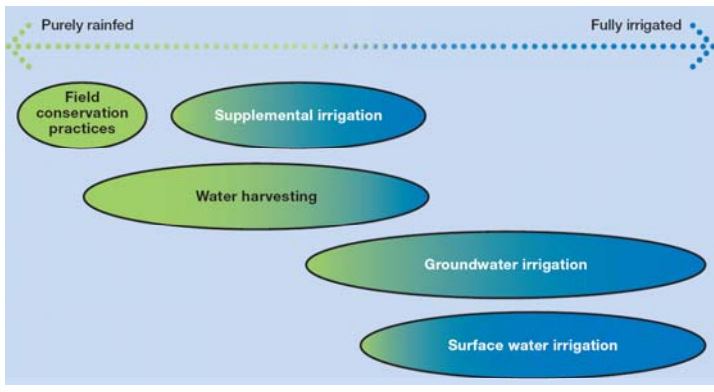
Johan Rockstrom  
Stockholm Environment Institute  
David Purkey  
Stockholm Environment Institute-US Center

Toward Sustainable Groundwater in Agriculture – An International Conference Linking Science and Policy  
June 16, 2010  
San Francisco, California

# Definition of Green and Blue Water



# Management on the Green-Blue Continuum



# Journal of Hydrology Green-Blue Water Initiative-Special Issue

Volume 384, Issues 3-4, Pages 175-306, 30 April 2010

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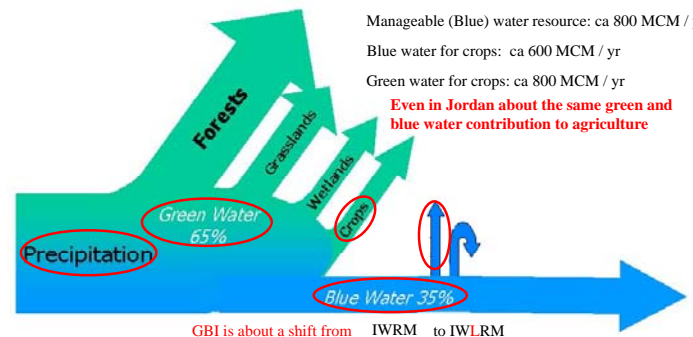
# The Key Conclusions

- Green water dominates food production and virtual water trade.
- Blue water resources are being critically over-exploited.
- There is significant potential for improving green and blue crop water productivity.
- A wide range of management options exist along the green to blue water continuum.
- A combined top-down and bottom-up approach will be required.

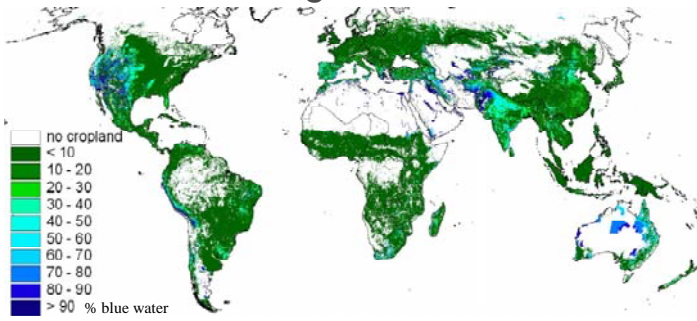
# Importance of Green Water

Extremely dry country: Jordan  
Precipitation: ca 8000 MCM / yr  
Manageable (Blue) water resource: ca 800 MCM / yr  
Blue water for crops: ca 600 MCM / yr  
Green water for crops: ca 800 MCM / yr

Even in Jordan about the same green and blue water contribution to agriculture

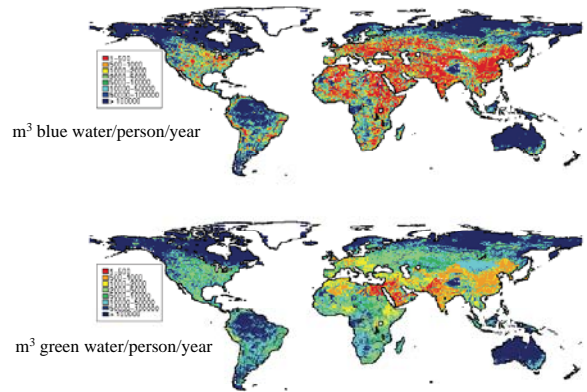


## Global Green Water Importance in Agriculture

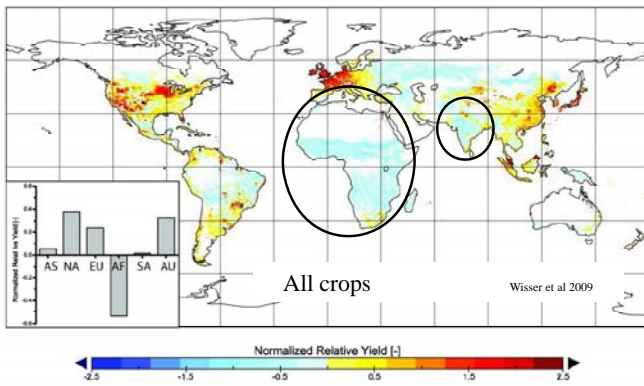


Siebert et al 2009

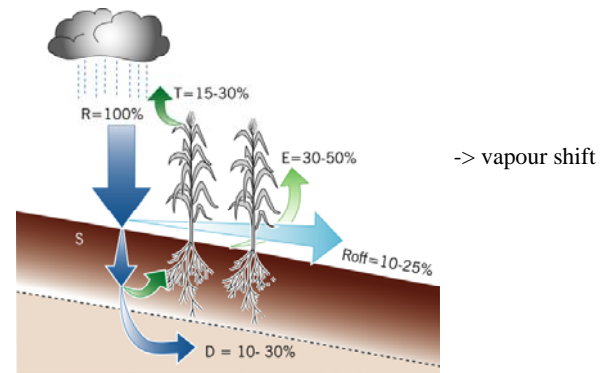
## Blue Water Resources Stressed



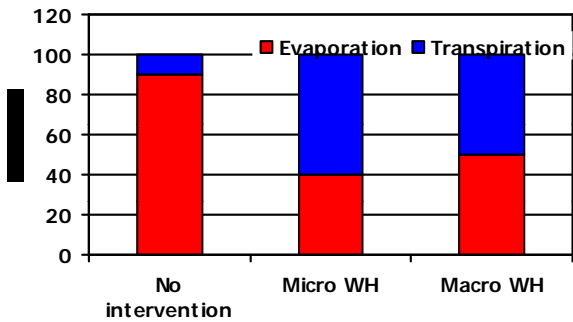
## Opportunities to Improve Productivity



## Opportunities to Improve Productivity

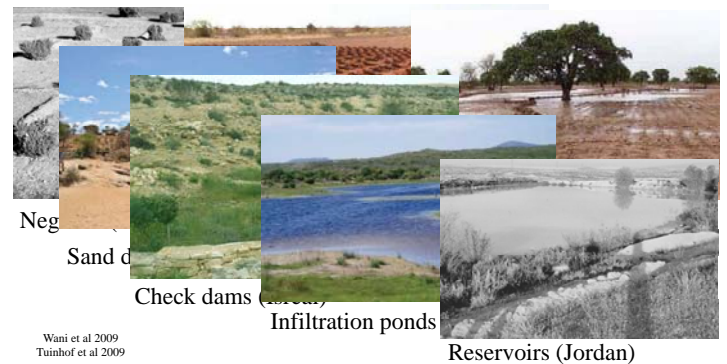


## Opportunities to Improve Productivity



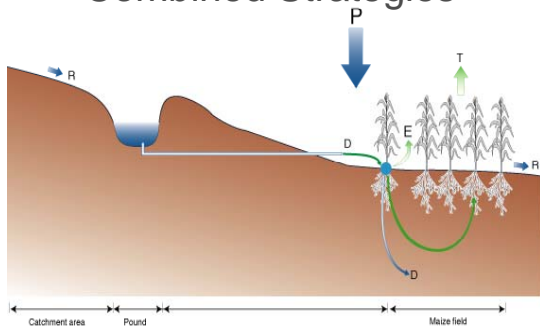
(CA 2007)

## Management Options Exist



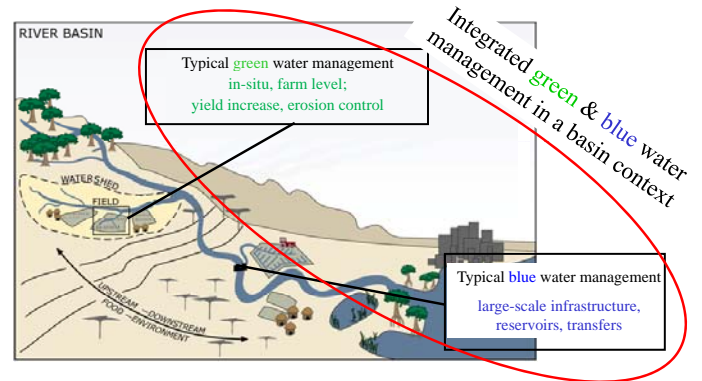
Wani et al 2009  
Tuinhof et al 2009

## Combined Strategies

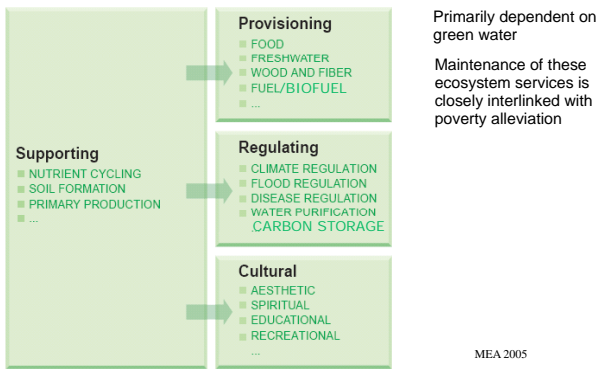


Integration of traditional and new techniques / approaches, here e.g. drip irrigation and nutrient management

## Top-Down, Bottom-Up Solutions

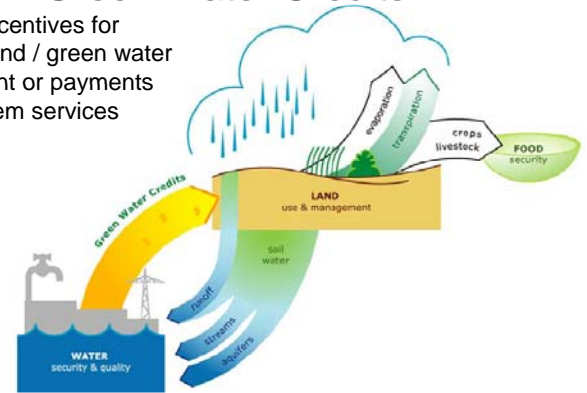


## Green Water Ecosystem Services

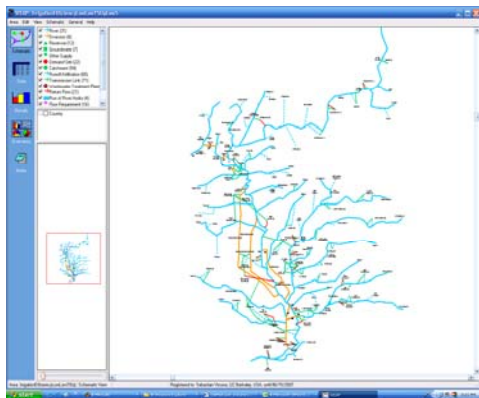


## Green Water Credits

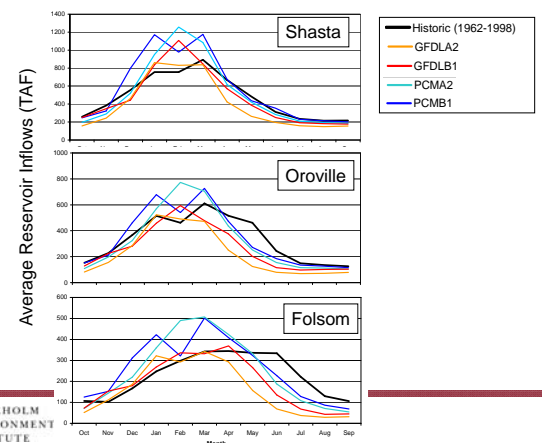
Financial incentives for improved land / green water management or payments for ecosystem services



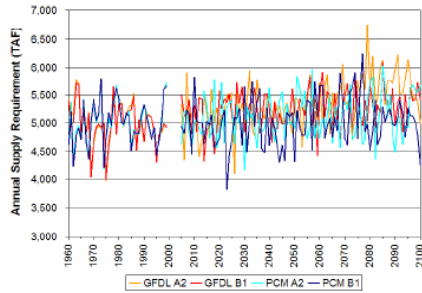
## A Tool for IWLRM



## Changes in Monthly Inflow (2070-2099)



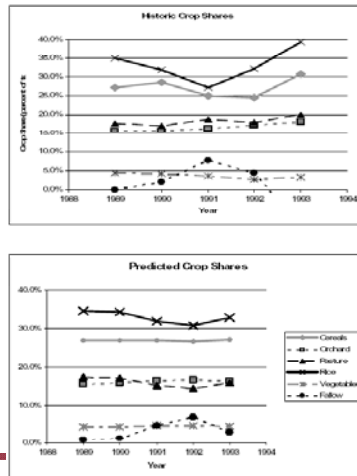
## Growth in Agricultural Demand



## Adaptations

- Assume a trend of improving irrigation efficiency for the first half of the 21<sup>st</sup> Century.
- Assume that on an annual basis that cropping decisions are made dynamically to favor higher valued, less water intensive crops in times of scarcity.

## An econometric cropping model



## Some Representative Results

	GFDL A2			GFDL B1			PCM A2			PCM B1		
	Without adaptation	With adaptation	Difference	Without adaptation	With adaptation	Difference	Without adaptation	With adaptation	Difference	Without adaptation	With adaptation	Difference
Average Annual Agricultural Water Requirement (TAF)	5,658	4,856	802 (-14%)	5,348	4,612	736 (-14%)	5,188	4,582	607 (-12%)	5,107	4,339	768 (-15%)
Average Annual Agricultural Deliveries (TAF)	3,493	3,226	267 (-8%)	3,216	2,957	259 (-8%)	3,024	2,757	267 (-9%)	2,833	2,574	259 (-9%)
Average Annual Groundwater Pumped to Agriculture (TAF)	1,831	1,650	181 (-10%)	1,545	1,328	217 (-14%)	1,473	1,262	211 (-14%)	1,477	1,230	247 (-17%)
Average Carryover Storage in Lake Reservoirs (TAF)	1,728	1,734	-6 (0%)	2,324	2,331	-7 (0%)	2,621	2,646	-25 (-1%)	2,305	2,363	-58 (-3%)
Average Carryover Storage in Lake Crochle (TAF)	1,641	1,647	-6 (0%)	2,032	2,044	-12 (-1%)	2,275	2,296	-21 (-1%)	2,475	2,503	-28 (-1%)
Maximum Groundwater Drawdown in Stone-Coral (ft)	307	235	72 (-24%)	36	39	-3 (1%)	368	300	68 (-19%)	132	134	-2 (-1%)
Average Annual Urban Deliveries (TAF)	381	499	-118 (31%)	393	507	-115 (29%)	391	506	-115 (29%)	389	506	-115 (29%)
Average Annual Delta Exports (TAF)	5,072	5,179	-107 (2%)	5,610	5,622	-13 (0%)	5,533	5,584	-51 (1%)	5,469	5,486	-17 (0%)

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