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Geosmart Water – Integrated Water Resources Management

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IWRM is interaction between "spatial fit" and "interplay"

Fig 1

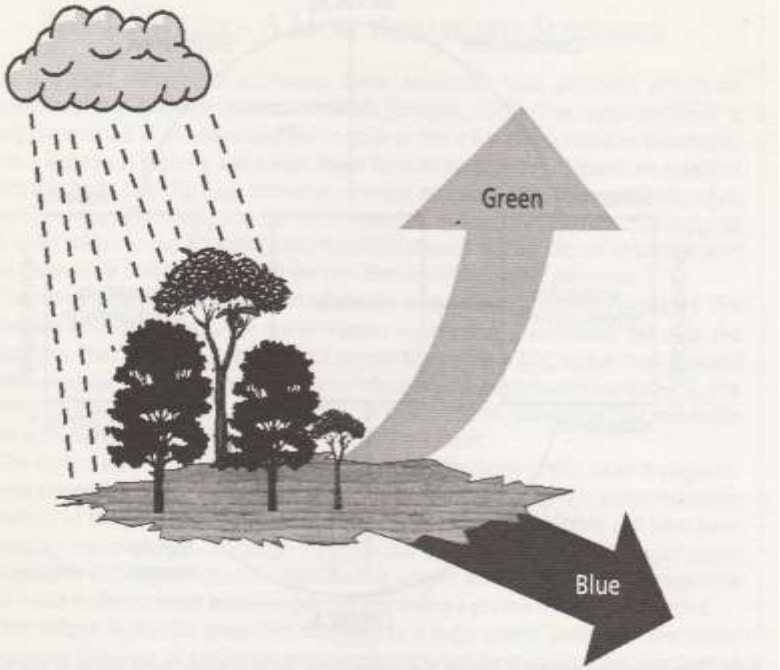


Figure 3 *Rainfall partitioning – the vertical green water branch of water vapour and the semi-horizontal blue water branch of liquid water*

Fig 2

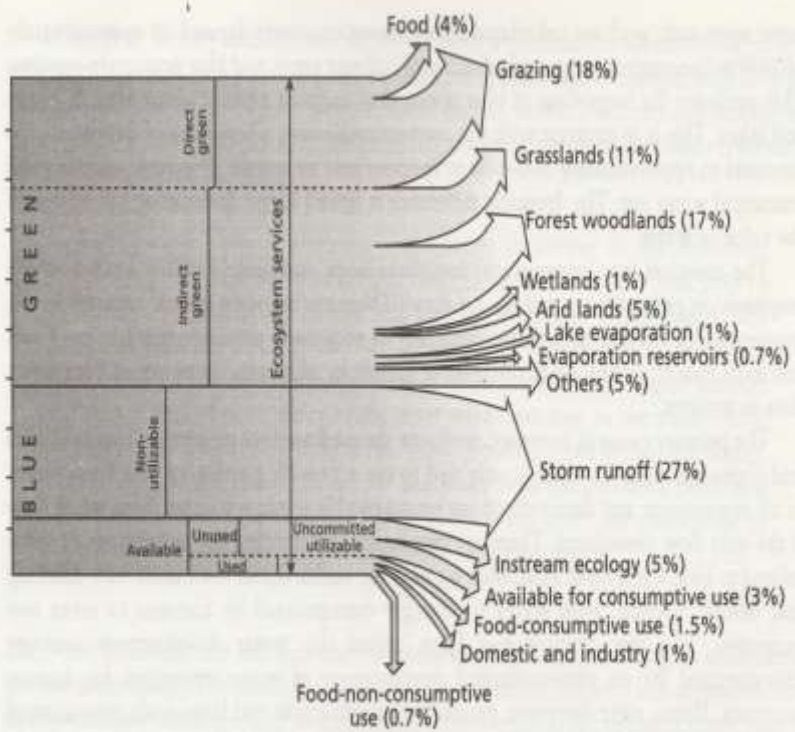


Figure 7 *The relative partitioning of global terrestrial rainfall into green and blue water flow components*

Food self-sufficiency supported by irrigation is far from realistic

Fig 3

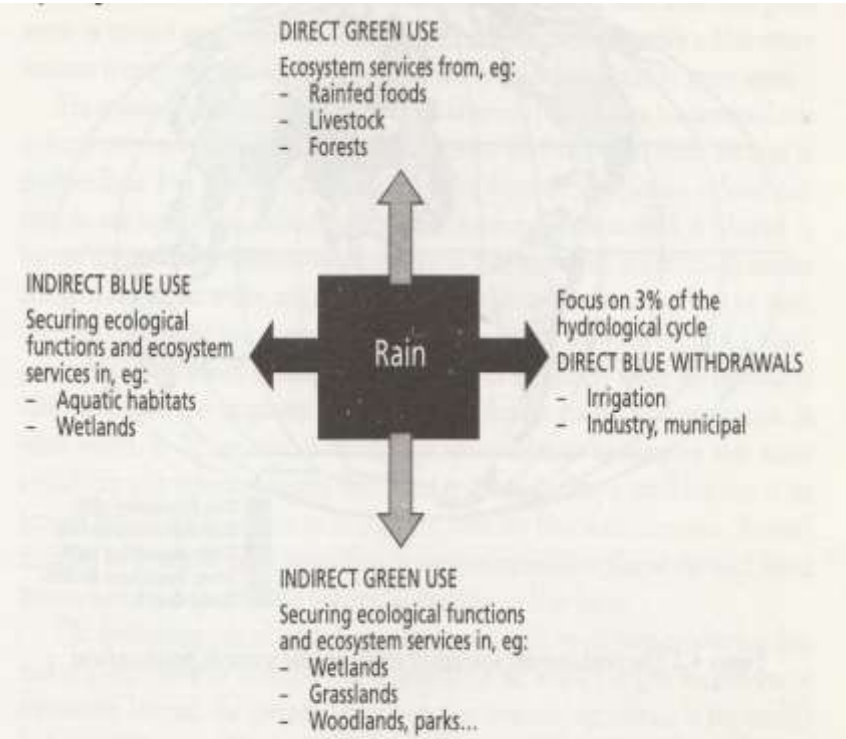


Figure 6 *Rainwater is partitioned into green and blue water flows, which sustain freshwater functions in four ecohydrological domains*

- Sustaining irrigated agriculture from blue water withdrawals forms a very small component of the global water use to sustain humans and nature (only 2 percent of rainfall and 3 percent of total water use).

- **Figure 2** places the blue water resource in the perspective of global-scale water flows to sustain direct and indirect green and blue water dependent activities, and ecosystem goods and services

Narmada Basin Studies of Green and blue water use and productivity

- The area in all 8 agro-climatic regions irrigated area reduces in drought years.
- Rates of water use in crop production – rates of WU increases in drought years. Depending on rainfall's magnitude and areal extent soil moisture varies changing ET requirements
- Water productivity variations across crops- Satpura Plateau -In rain fed crops no changes in productivity (Rs/meter cube) & in irrigated crops masoor (as compared to wheat , sugarcane , grain) has highest blue water productivity (Rs2.13 / meter cube)
- Temporal and spatial variability in water productivity – the opportunity cost of using rainwater is not as high as water pumped from aquifers, or water from surface reservoirs, or rivers.

The second green revolution through role of ICT technologies ,IoT and Cloud Computing in bringing automation to ensure dynamic management of natural resources like irrigation water, water vapour , vegetation water, surface water and ground water

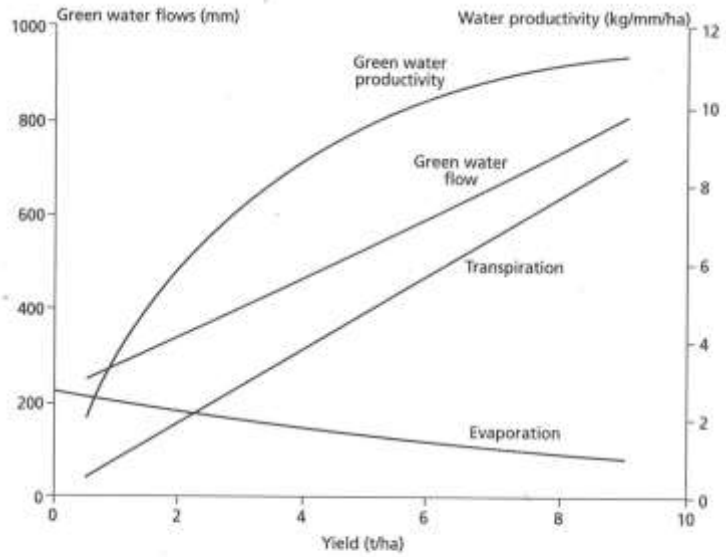
- **A. Geospatial technologies map agro-climate-eco-systems online for increasing crop water productivity**
- **B. Drone technologies (soil carbon sensing) along with satellite remote sensing can bring in information on degraded lands of small landholders also so that cropping systems productivity can be studied for knowing trade-offs in blue-green water productivity increase.**

C. **Smart water grids (SWG) having features of demand response and demand side management (both power and water side) through the integration of smart meters, smart appliances and stakeholder / consumer loads (both 24/7 or irrigation) micro-generation (heterogenous)/ availability and water storage , water use and prices .(participatory management). SWG accommodates and facilitates all heterogeneous sources (like tanks, reservoirs, aquifers, soil moisture , water vapour , transpiration, vegetation moisture, evaporation) in EACH GRID / Watersheds , Even operations of smart grids by AI and ML and many more using systems engineering principles.**

Improving Green Water Productivity

Table 14 *Management strategies to improve green water productivity*

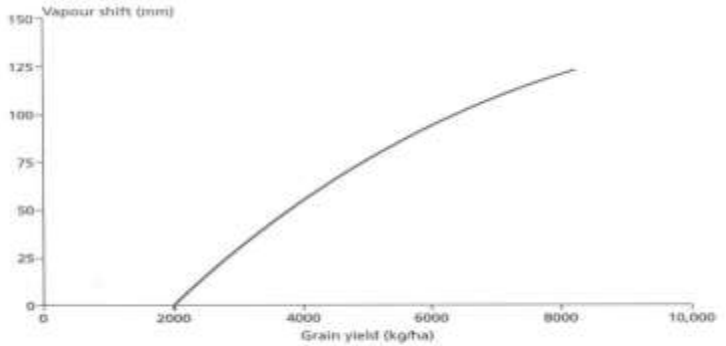
Water productivity strategy	*Process (refers to Figure 7.9)*	*Management options*	*Effect*
Vapour shift	[I] Reduce early season evaporation	Dry planting Mulching Zero tillage	Quick crop establishment Reduced evaporation flow Less soil exposure to atmosphere
		Intercropping	Maximize canopy cover
	[II] Reduce evaporation flux with increased canopy	Intercropping Mulching Windbreaks	Reduced energy inflow through advection
		Agro forestry	Reduced energy inflow through advection
Improve T/ET ratio	[III] Increase plant water uptake Maximize productive green water flow	Improved crop varieties	
		Water harvesting Soil and water conservation Soil fertility management Conservation tillage	Dry spell mitigation Maximize infiltration and WHC Maximize plant water uptake Maximize infiltration, WHC and rooting depth
		Intercropping	Maximize transpiration



Note: This chart clearly shows the dynamic relationship between green water flow, green water productivity and yield.

Fig4

Figure 12 *The dynamic reality of green water productivity*



Note: The reduction in evaporation is given in relation to the evaporation from a crop producing 2 t/ha (seasonal E = 167 mm).

Source: adapted from Novak, 1982, and Rockström and Falkenmark, 2000

Fig 5

Figure 11 *Vapour shift as a result of increased shading from a denser canopy cover*

Eco-legal Order

- Existing Legal Order - Mechanical jurisprudence in which legal system is seen as a machine applying hierarchy of norms to the concrete facts of a situation in a predictable and constant manner with out injection of creativity by an interpreter [– weak governments and strong corporations – separation of capital from labour- private property and exclusion-]
- From Capital to Commons-- Commons as capital- commoning the Law –Naples , Paris etc for water , solar farms, wind farms, community land trusts,] (generative ownership v extractice ownership) – For Ex : GW scenario as a commons and in eco-legal order becomes regenerative ownership)

CONCLUSIONS

** **Ignite**:

--Ecology of Law + Public Digital Databases [India WRIS + Bhuvan + MOSDAC+ NDEM + VEDAS + NRDMS + State GISs] DPRs for different disciplines

** **Innovate**:

Rainfed farming +Vapour shift + Cropping Systems + soil carbon + Water productivty (SWAP – WOFOST model) + Intermediate Environmental economics (Charles D Kolstad) Degradation/ pollution aspects + Cloud Computing Patterns + IoT

** **Integrate**:

IWRM + Policy analysis + Processes and mechanisms of water sector + AI/ML + ICT SCADA – Cyber physical systems in WDN (drinking , irrigation) irrigation management transfer + River basin / watershed scale ecological / water foot prints

[GADMFS + Indian NADAMS] [IMD Forecast + SAC-ISRO MOSDAC Forecast spatial 2 km wise & Watersheds delineation from SRSAC and CGWB and AISLULC watersheds Integration ?] Most of the above need GEOSPATIAL SMART TECHNOLOGY /Workforce