Climate Change

The International Journal

ISSN 2394-8558 EISSN 2394-8566

PRESENTATION

Technological Advances in Water Management in Relation to Changing Climate

Publication History

Received: 26 November 2016

Accepted: 31 December 2016

Published: January-March 2017

Citation

Patel NC. Technological Advances in Water Management in Relation to Changing Climate. *Climate Change*, 2017, 3(9), 372-427



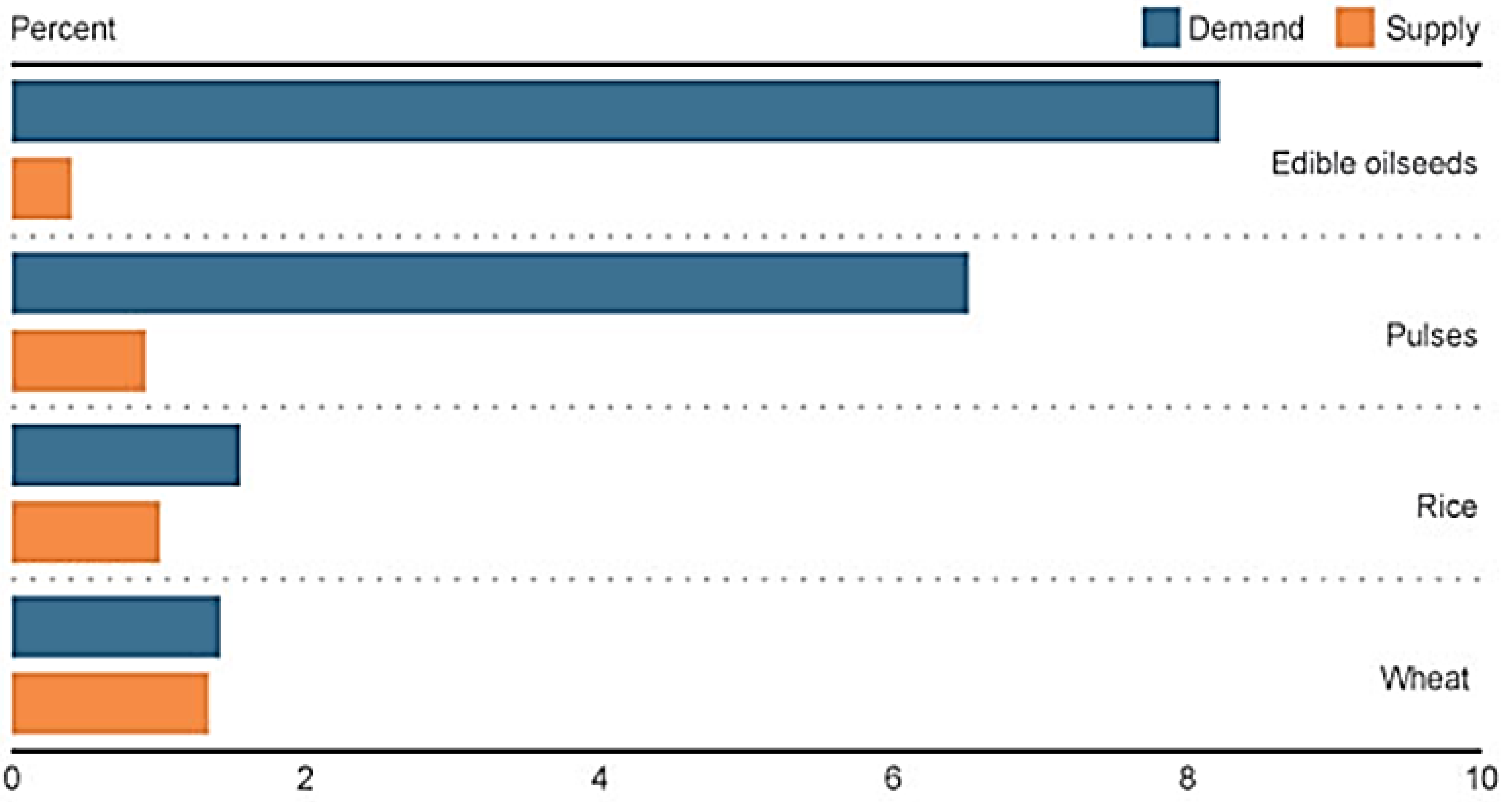

Technological Advances in Water Management in Relation to Changing Climate

Dr. N. C. Patel
Vice Chancellor, AAU, Anand.

कृणवन्तो राष्ट्र कृषि संपन्नम्

India’s projected food supply and demand

Annual growth rate of projected supply and demand of food items in India to 2026



Note: Demand calculation assumes GDP growth of 9 percent per year.

- Current yield gain for major cereals is 1.3% simple linear rate require a 1.3% compound annual rate of yield gain to meet demand from existing crop land.

- If yield increases are slower than demand, expansion of crop area, will be needed to maintain food security

- Associated GHG emissions from such land use change will accelerate GHG emission rates, which could provide strong positive feedback to rate of climate change

Annual Greenhouse Gas Emissions by Sector

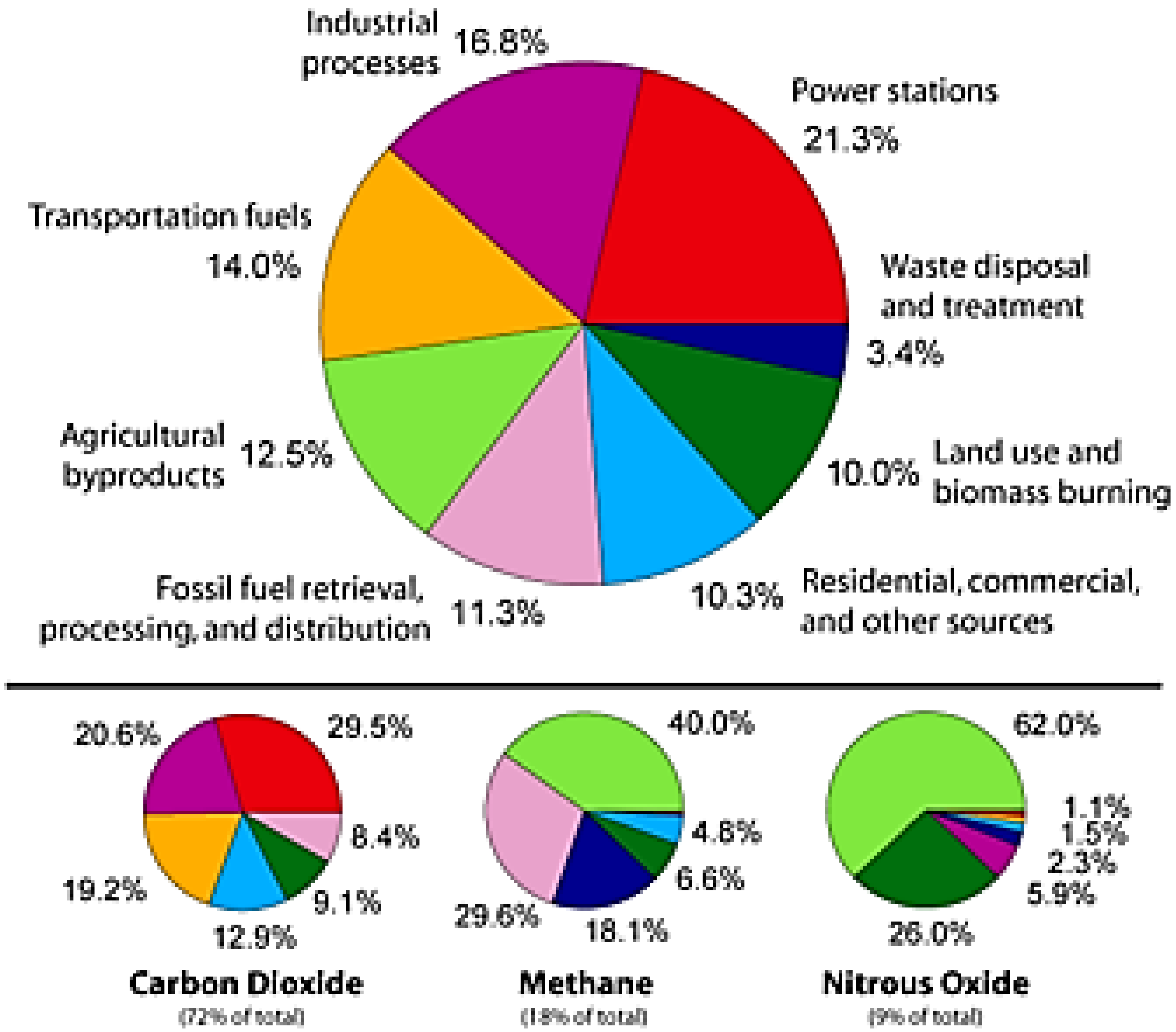
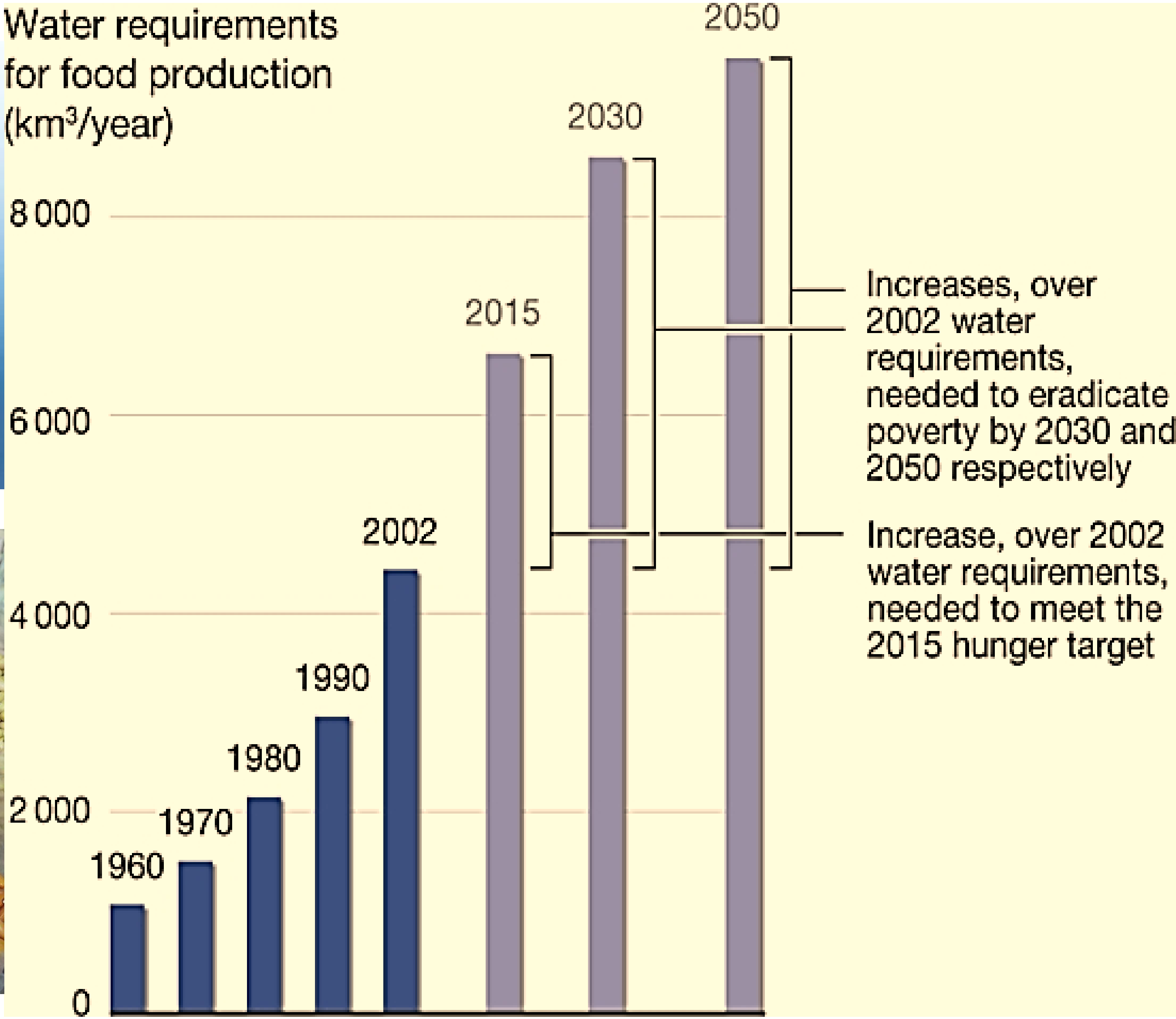


Table 2: Annual Current and expected requirement water in India (in BCM)					
Different uses of water	1990	2000	2010	2015	2050
Domestic	32	42	56	73	102
Irrigation	437	541	688	910	1072
Industry	-	8	12	23	63
Energy	-	2	5	15	130
Others	33	41	52	72	80
Total	**502**	**634**	**813**	**1093**	**1447**

BCM: billion cubic metres

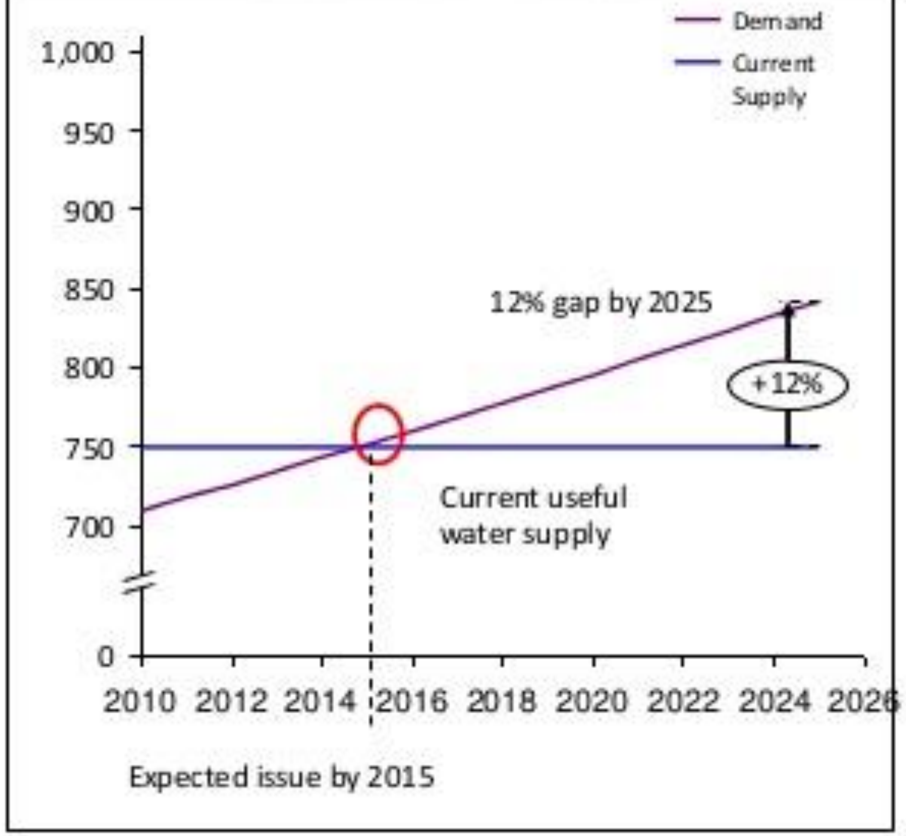
Source: UN Population Division: Medium variant



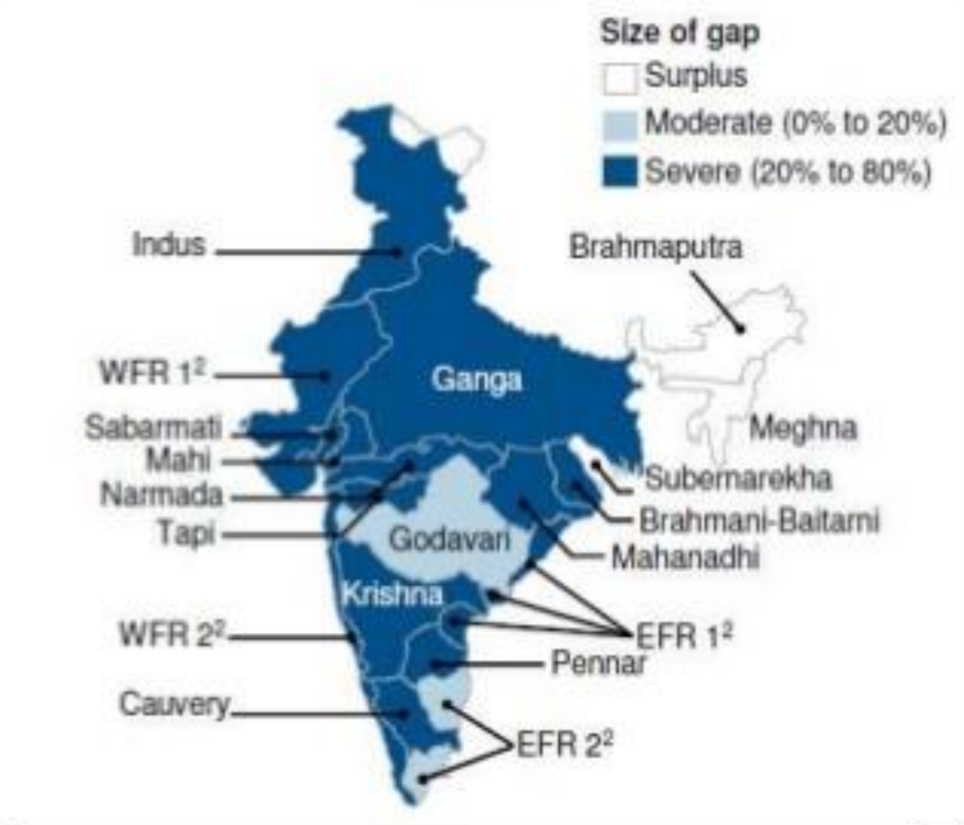
Water requirements
for food production
(km³/year)
8 000
6 000
4 000
2 000
0
1960
1970
1980
1990
2002
2015
2030
2050
Increases, over 2002 water requirements, needed to eradicate poverty by 2030 and 2050 respectively
Increase, over 2002 water requirements, needed to meet the 2015 hunger target

Resulting in a potentially significant demand supply gap in the near future

Water Supply and Demand in India; 2010 - 2050
Cubic KM or Trilion Liters



River Basins in India, with water shortage, 2030
Percentage



2: EFR – Eastern Flowing Rivers; WFR – Western Flowing Rivers (non major rivers)

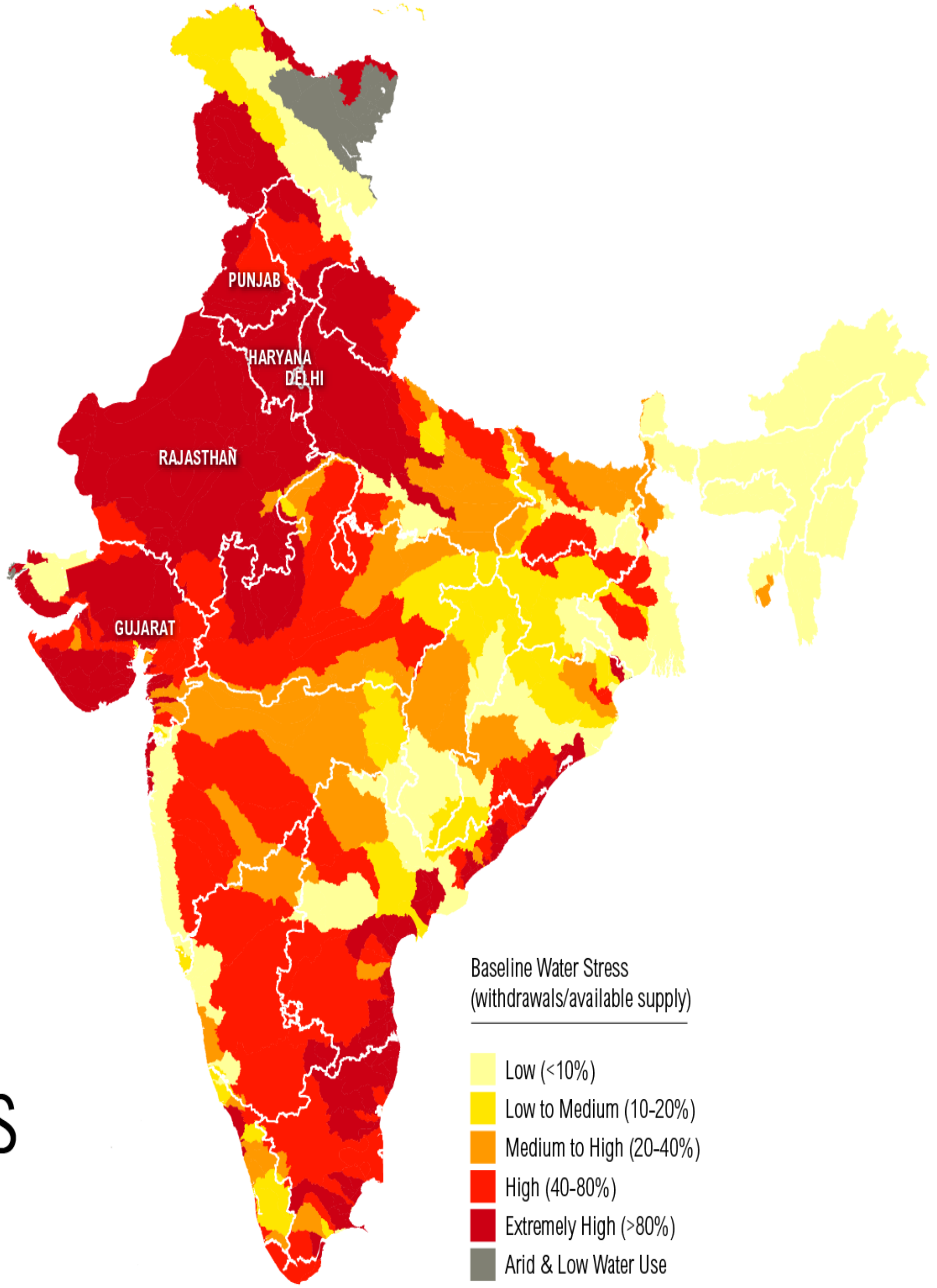
Source: Ministry of Water Resources, National Hydrology Institute

PER CAPITA WATER AVAILABILITY IN INDIA

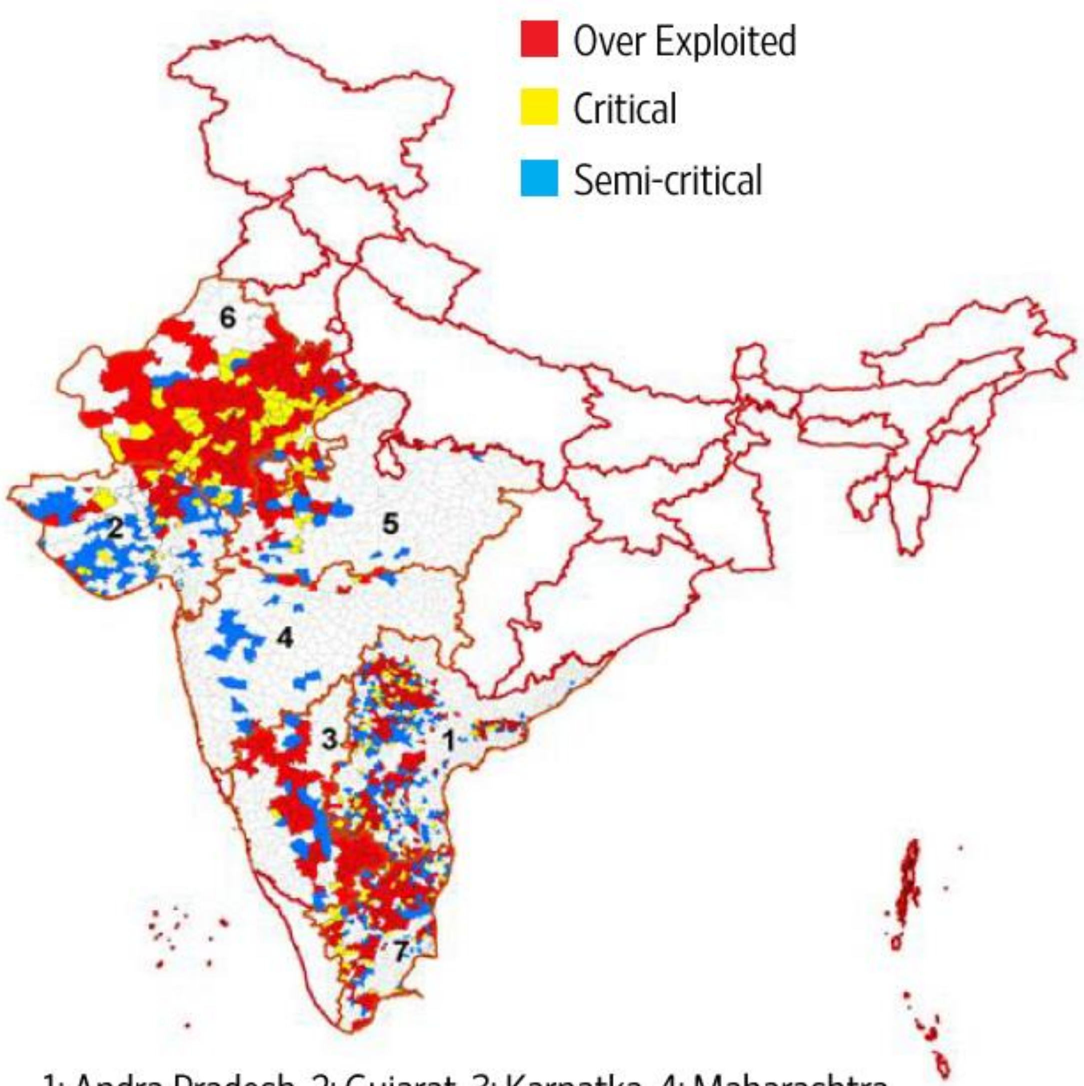
Year	Population (Million)	Per capita water availability M^3/year
1951	361	5177
1955	395	4732
1991	846	2209
2001	1027	1820
2025	1394	1341
2050	1640	1140

(Source: Govt. Of India, Ministry of Water Resources(2009)

54% of India Faces **High** to **Extremely High** Water Stress

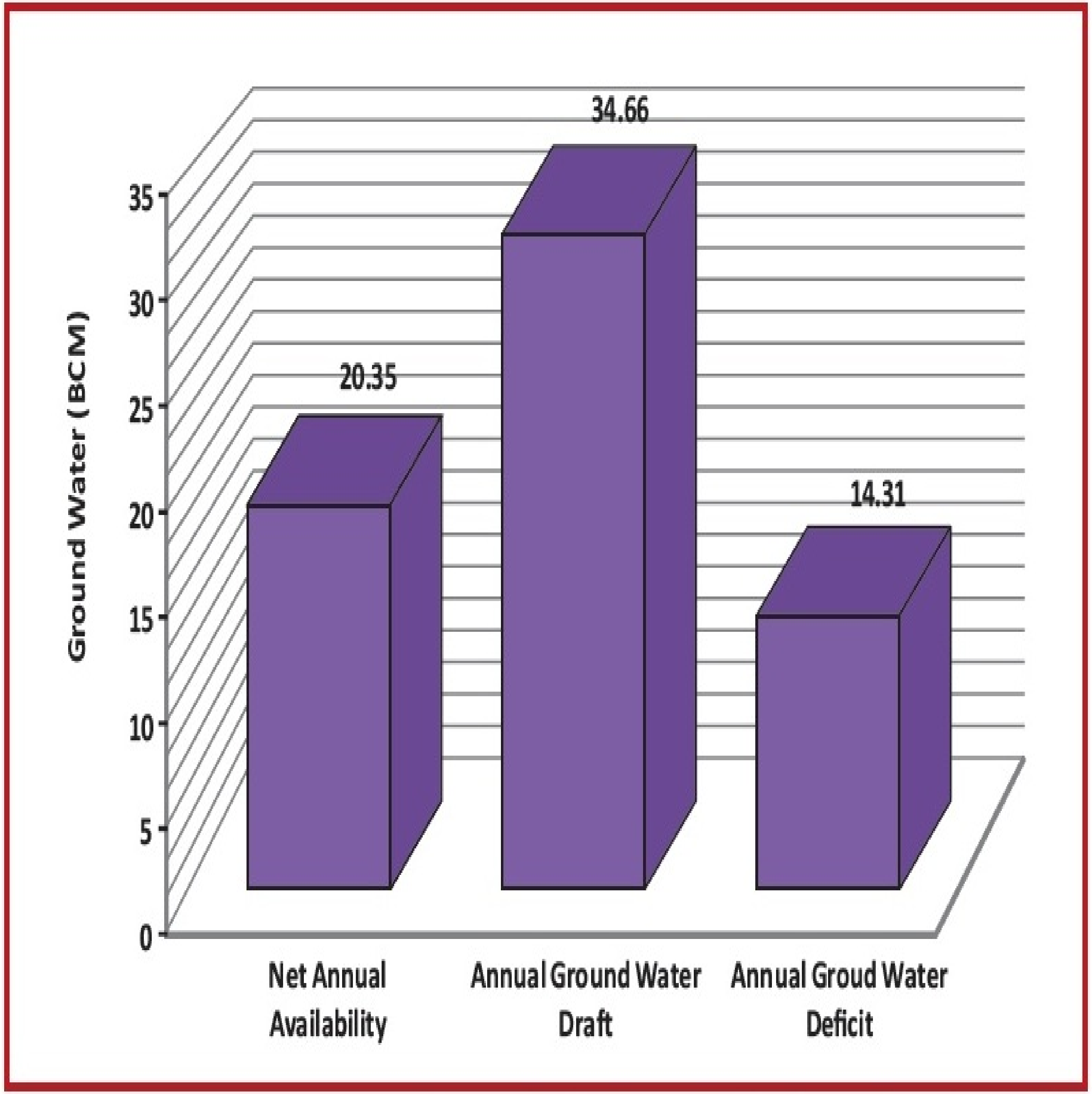


GROUND WATER STRESSED BLOCKS OF INDIA



1: Andra Pradesh, 2: Gujarat, 3: Karnatka, 4: Maharashtra, 5: Madhya Pradesh, 6: Rajasthan and 7: Tamil Nadu

Source: IWMI



Source: Central Ground Water Board, Chandigarh, 2009

Agriculture's Groundwater Crisis

Falling Groundwater...

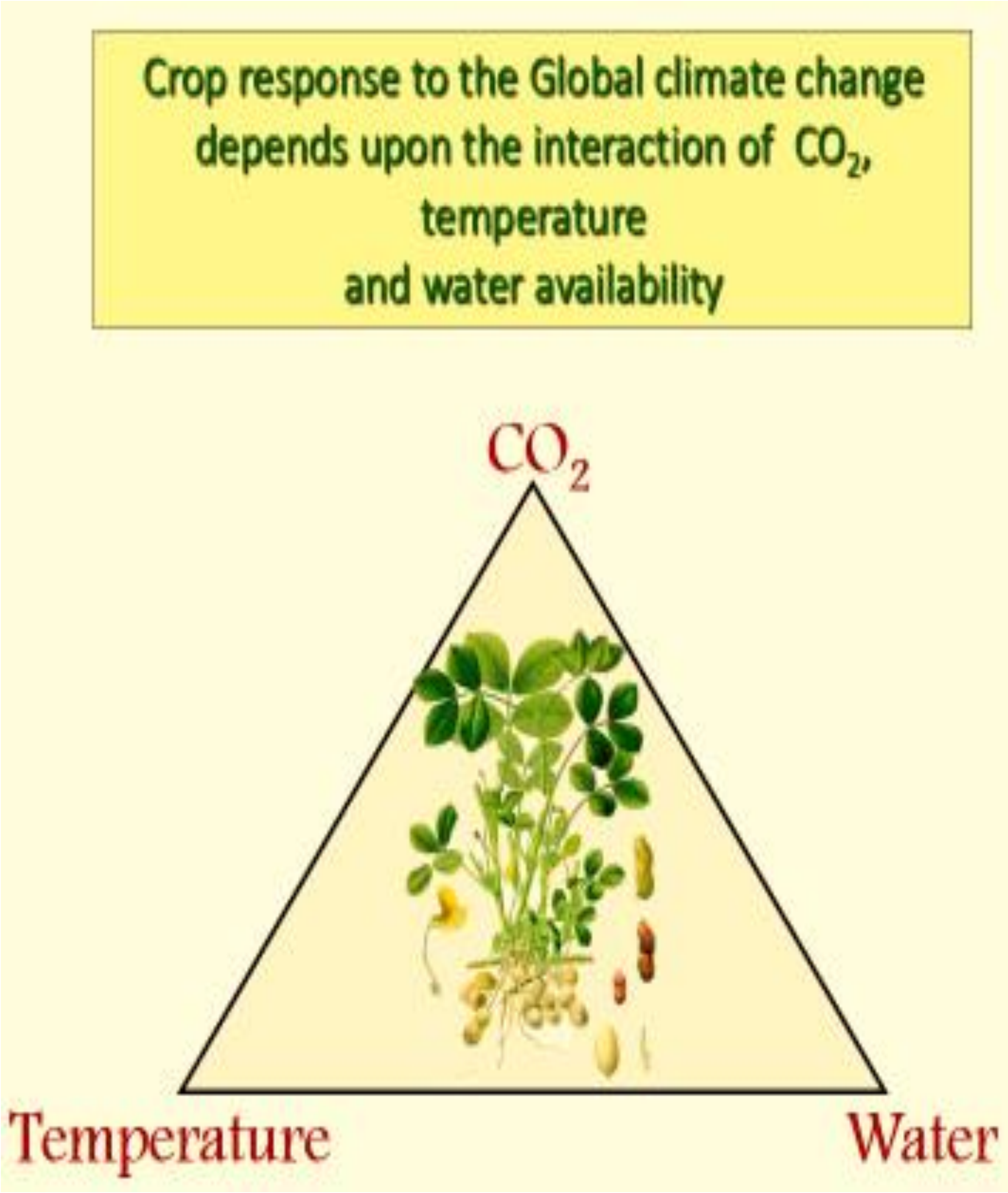
Share of groundwater in irrigation	Share of groundwater in rural drinking water	Proportion of districts seeing unsustainable water extraction
60%	80%	35%

...is Threatening Dryland Agriculture

Share of total cropped area	Share of land under food crops	Share of land under non-food crops	Share of agri subsidies*
56%	48%	68%	6-8%

*Irrigation, fertiliser and fuels

Source: 12th Plan Approach paper


Crop response to the Global climate change
depends upon the interaction of CO_2,
temperature
and water availability
CO_2
Temperature
Water


Potential Impacts of Climate Change
Air temperature
Precipitation timing
and quantity
Sea level rise
Runoff timing and quantity

Evidences of Climate Change

Physical evidence

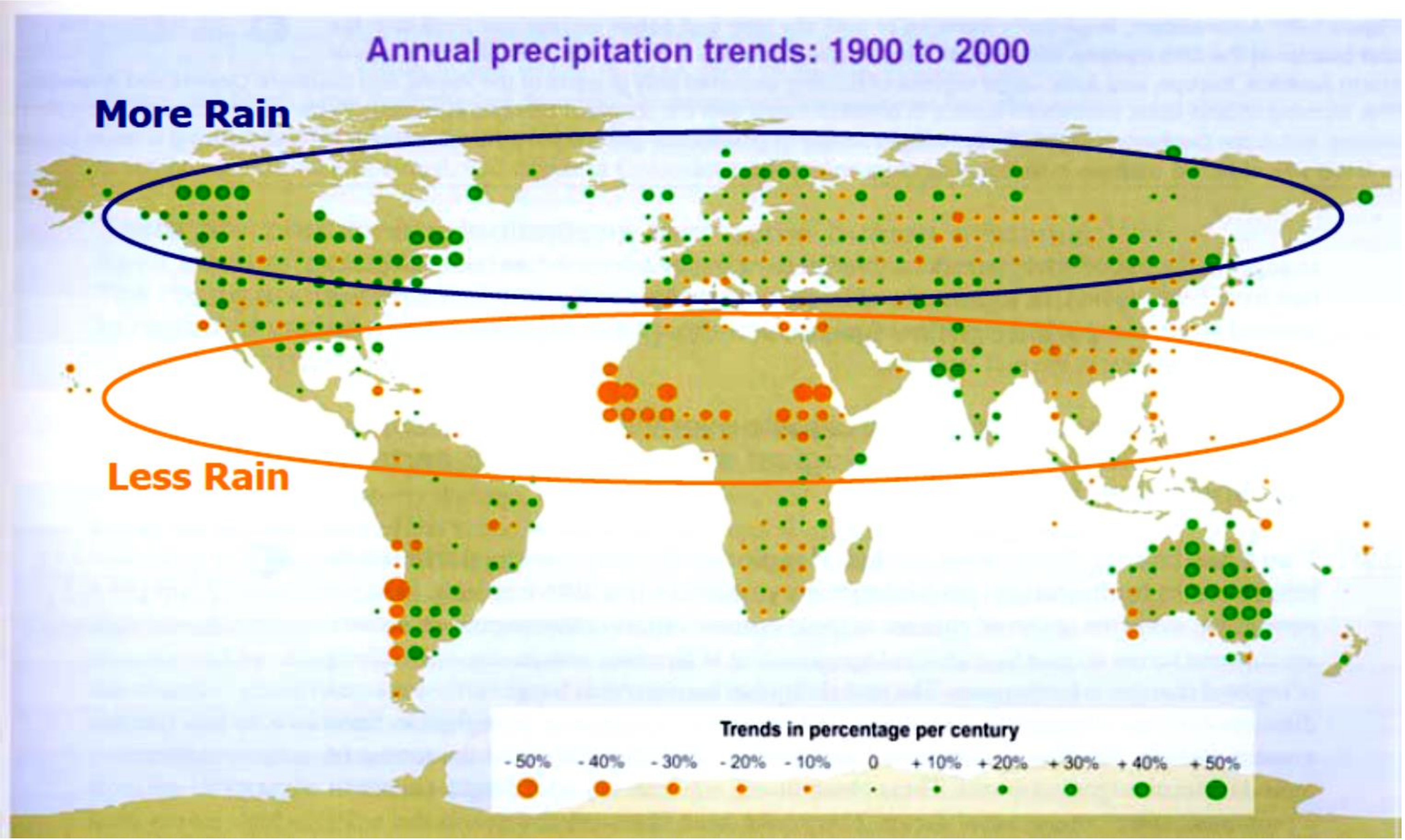
1. Rise in atmospheric temp and CO_2 level
1. Depletion in rainfall
2. Shifting and shrinking of cooling period
3. Changing pattern of monsoon
4. Occurrence of natural disaster

Biological evidence

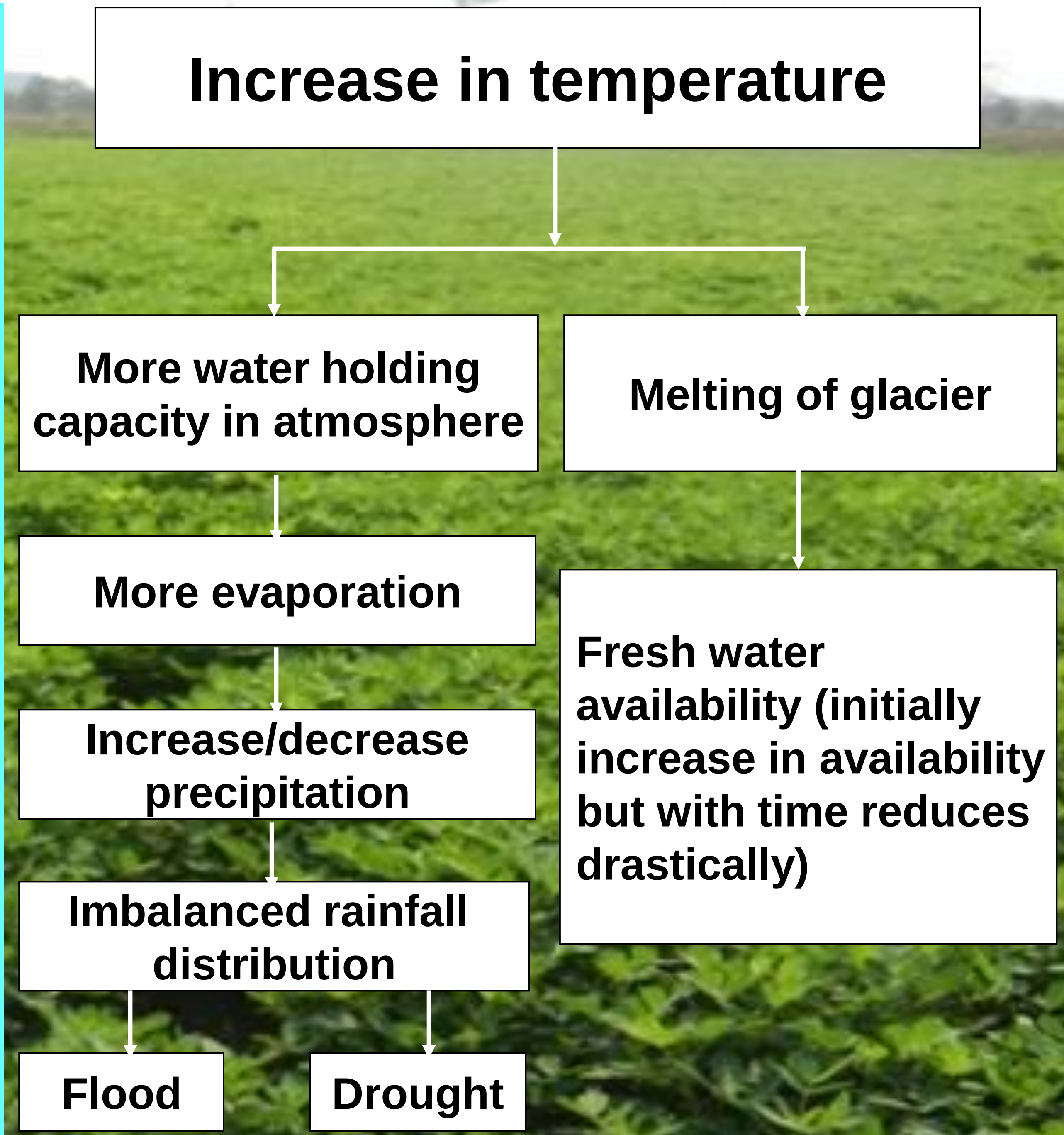
1. Early blossoming of trees
2. Appearance of grasses in Antartica
3. Changing cropping pattern

Kurukshetra, 2008

Changes in Precipitation



- Rainfall will increase by 15–31%
- 2°C rise in average temperature makes monsoon highly unpredictable.
- 4°C rise yields an extremely wet monsoon that currently occur once in 100 years will occur once in 10 years.
- More frequent droughts & floods.
- Decrease in rainy days & increase in intensity.
- With decrease in 6% of rainfall, net irrigation requirements increase by 29%.
- Impact on GWR due to changes in RF & ET Patterns.



Floods and Droughts

- Frequency
- Magnitude
- Duration

Climate Change Impact on Recharge

- Spatial and temporal changes in temperature and precipitation may act to ultimately cause a shift in the water balance for an aquifer

- For example, variations in the amount of precipitation, the timing of precipitation events, and the form of precipitation are all key factors in determining the amount and timing of recharge to aquifers

Climate Change Impact on Recharge

- The occurrence of droughts or heavy precipitation can also be expected to impact water levels in aquifers
- Droughts result in declining water levels not only because of reduction in rainfall, but also due to increased evaporation and a reduction in infiltration that may accompany the development of dry topsoils
- Extreme precipitation events (e.g., heavy rainfall and storms) may lead to less recharge to groundwater because much of the precipitation is lost as runoff

Net sea-level-rise trends from past tide-gauge data

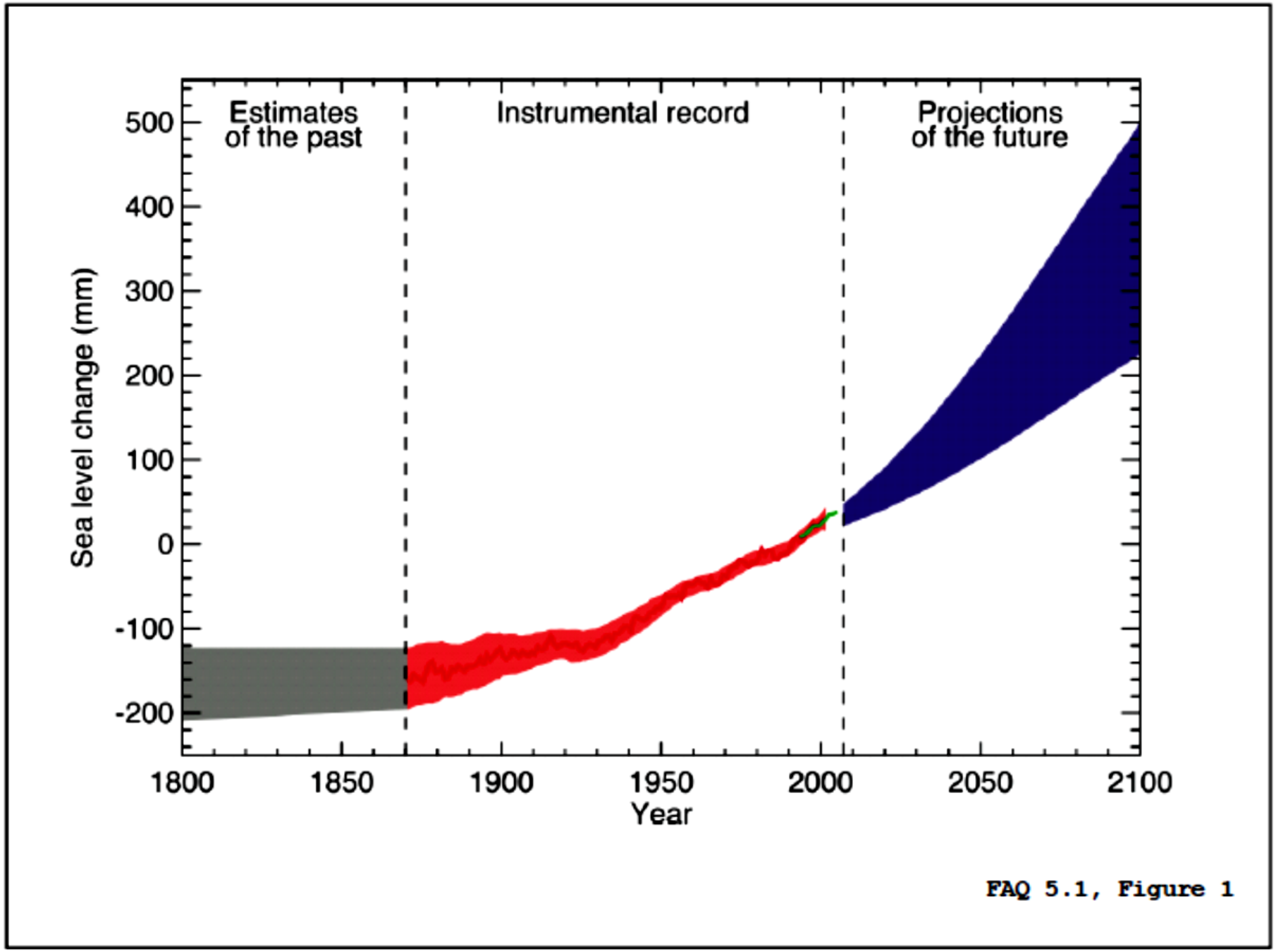
Station	No of years of data	Trends (mm/year)	GIA (Glacial Isostatic Adjustment) corrections	Net sea level rise (mm/yr)
Mumbai	113	0.77	-0.43	1.20
Kochi	54	1.31	-0.44	1.75
Vishakhapatnam	53	0.70	-0.39	1.09
Diamond Harbour (Kolkata)	55	5.22	-0.52	5.74 (sinking of delta)

Mean sea-level-rise trends along the Indian coasts are about 1.30 mm/year

Future Projections globally indicate about 0.48 m rise by the turn of the century

Unnikrishnan 2012

Sea level changes- past, present and future (Bindoff et al., 2007)

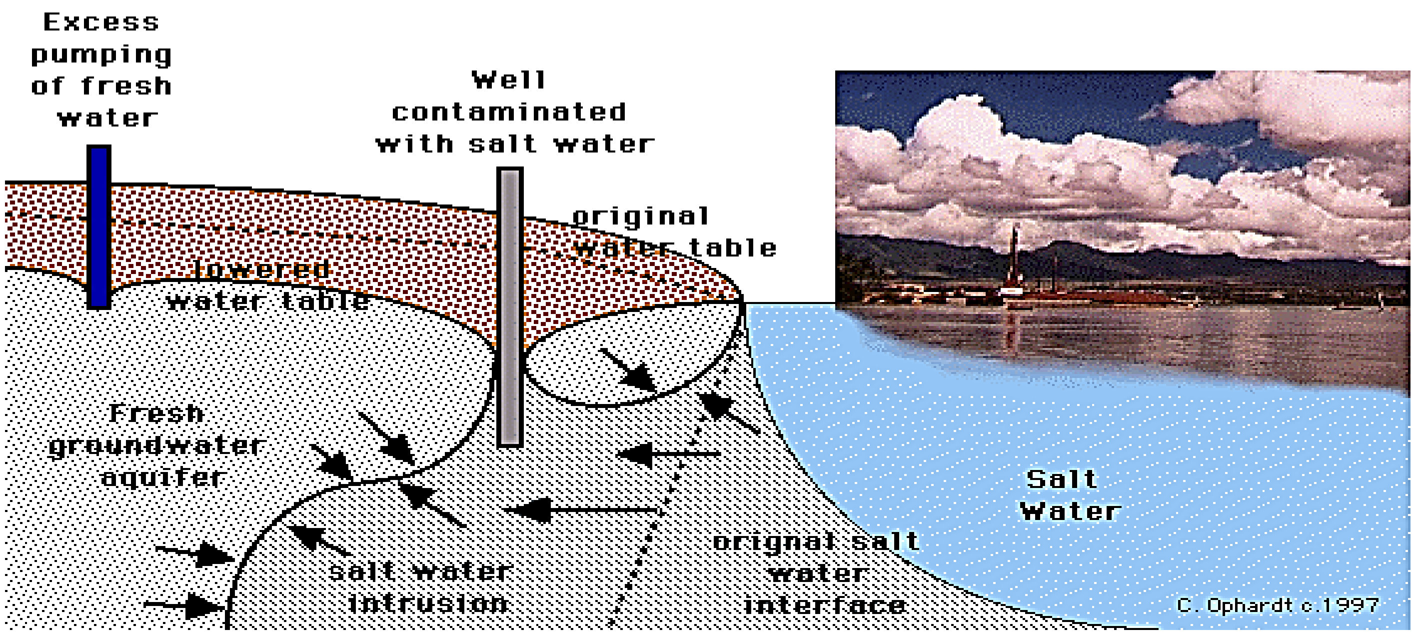


Consequences

- In the last hundred years, the sea level rose by 10–20 cm.
- In the next millennium, it will continue to rise; even greenhouse gas concentrations will stabilize due to lags in ocean warming & expansion and in the response of land ice.
- Projections of global sea-level rise from 1990 to 2100 is 0.48 m (IPCC, 2001a) which is 2-4 times the rate of rise over the 20th century.
- Present Greenland and Antarctic ice is sufficient to raise sea level by 70 m.

- **Seawater intrusion into surface waters & coastal aquifers (i.e. contamination)**
- **Raises the interface between the saline and fresh water**

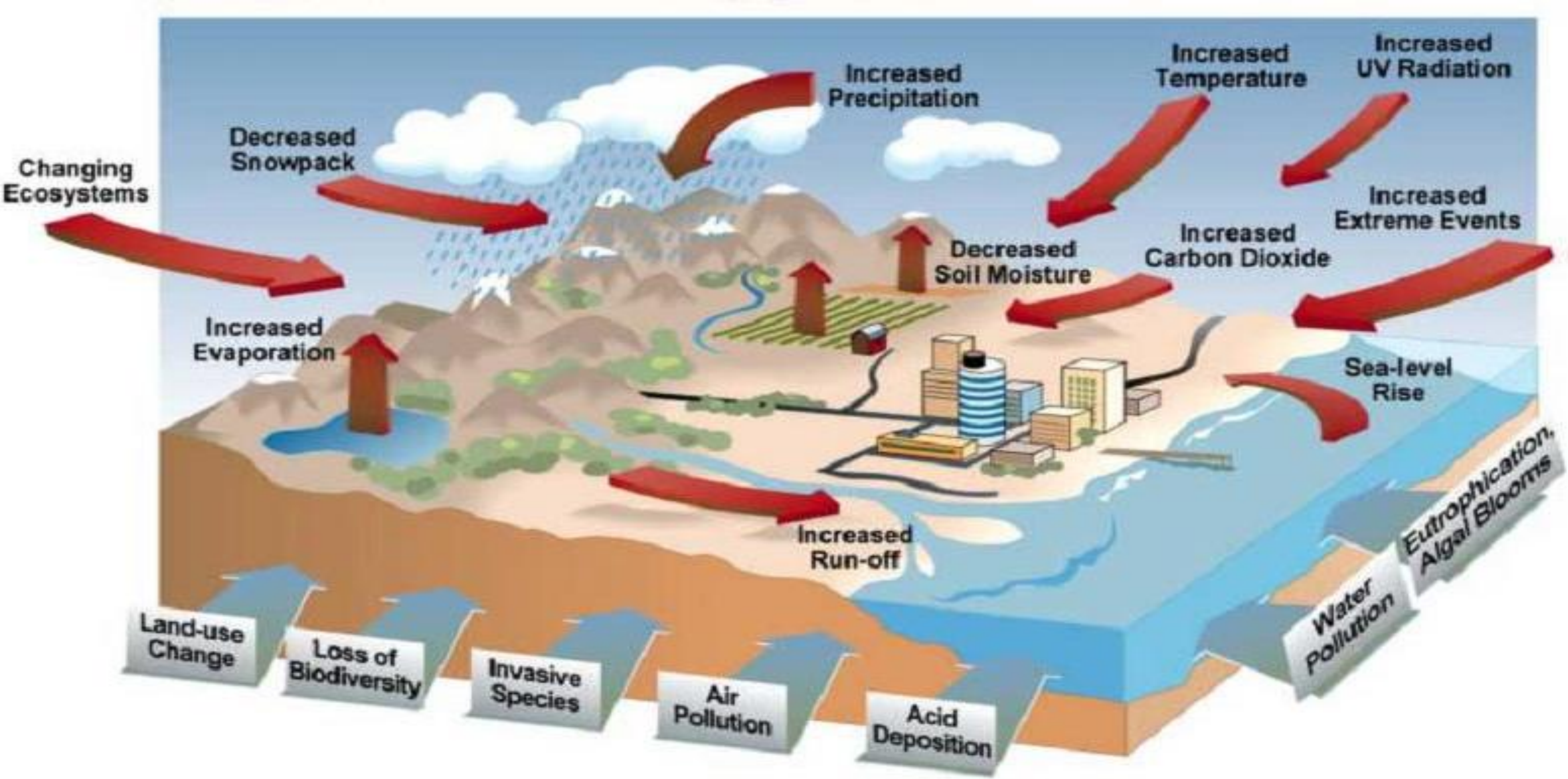
Salt Water Intrusion in Coastal Areas



Encroachment of tidal waters into estuaries and coastal river systems.

Groundwater salinization & higher water tables threaten many root crops, due to their low salt tolerance.

Multiple Stresses of a Changing Climate



Mitigation of Climate Change Effect

Advanced tools and techniques

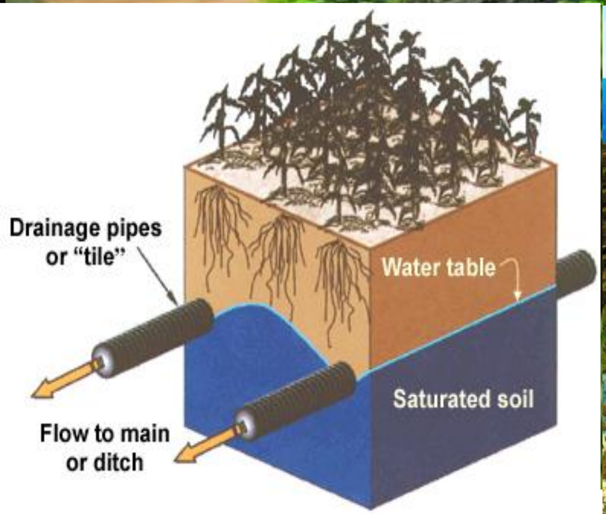
- Precision Farming: Minimum Input Maximum Output Approach
- Remote Sensing and GIS for Water Resources Management
- Water management: Micro-irrigation technologies
- Drought Relief and Rainwater Harvesting
- Reduction of Seepage and Leaks
- Water Education, Water Tariff Structures and Reuse of Grey Water
- Developing Climate-Ready Crops and Crop Diversification
- Improved Weather Forecasting and Crop Insurance Planning

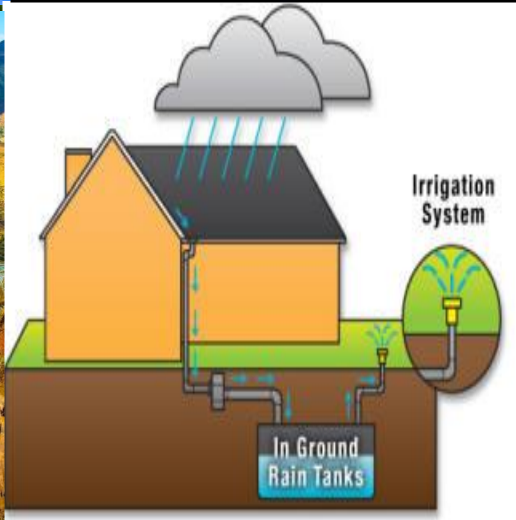
PRECISION FARMING

Challenges before India

- Limited Natural Resources
- Increasing Population
- Deforestation
- Scarcity of Water
- Limited availability of Power
- Ensuring food security
- Climatic Change mitigation

Rain Water Management





Half moon shaped micro-catchment

Cup and Saucer shaped micro-catchment

Technology Transferred

Recharge shaft

Average recharge rate 5-6 l/s
New: Rs. 40000 to 50000
Abandoned well: Rs. 10000- 15000

Roof Harvesting Structures

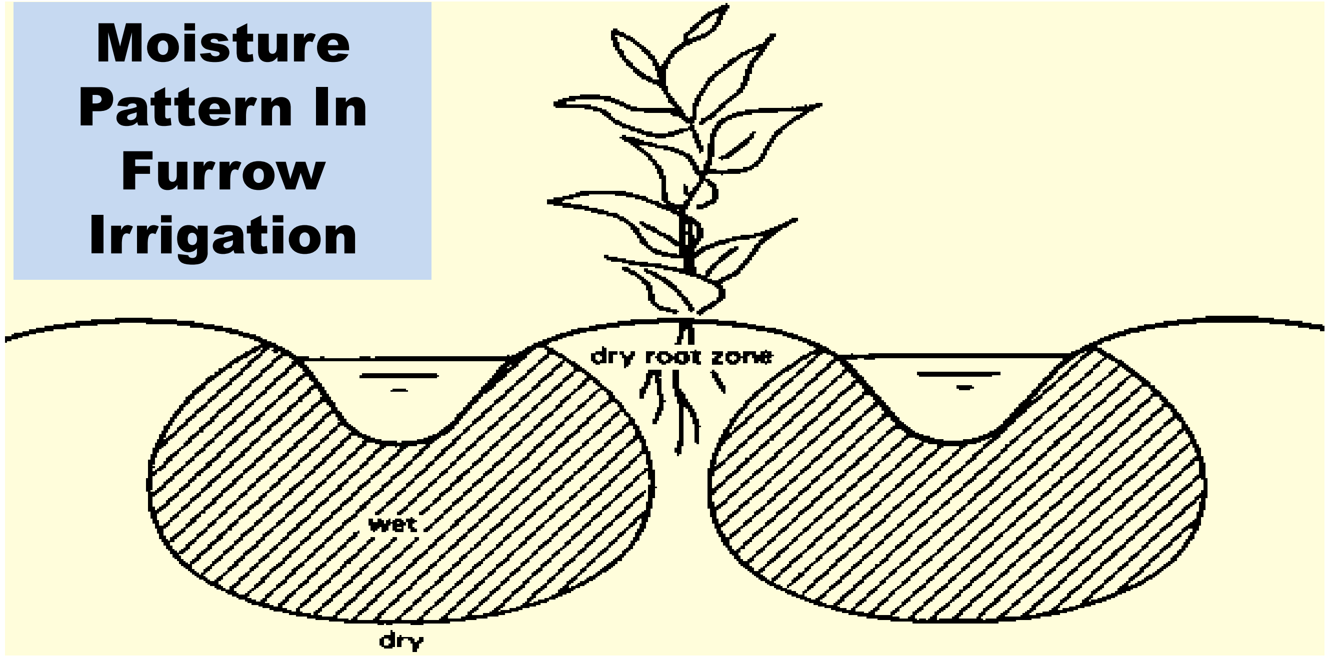
Nearly Rs. 50000 for 500 m^2 rooftop

Raised Bed Furrow Irrigation

Contour Furrow Irrigation

Ridge & Furrow Irrigation

Moisture Pattern In Furrow Irrigation



Groundnut	Pod yield Kg/ha				Net realisation Rs/ha	BCR
Sprinkler irrigation at 0.45 IW/CPE	1285	1182	1299	1255	2275	1.22
Sprinkler Irrigation at 0.60 IW/CPE	1462	1990	1563	1671	5667	1.54
Sprinkler Irrigation at 0.75 IW/CPE	1875	2493	1854	2074	9562	1.87
Surface Irrigation	1181	1448	1347	1459	6626	1.77

Source: Mehta, H.M., et al., (1993).

Yield and Water Use under Drip and Sprinkler Irrigation Method

Crop	Irrigation Method	Yield (kg/ha)	Water used (cm)	Gain over SIM (in %)		Water use efficiency (kg/ha/m^3)
				Yield	Water	
Green gram	Sprinkler method	841	14.80	39.70	49.80	5.68
	Surface method	602	29.50	--	--	2.04
Black gram	Sprinkler method 2.50cm/0.5 ratio	1405	34.30	3.30	30.40	4.07
	Surface method 5.0cm/1.0 ratio	1360	49.30	--	--	2.89
Tamato	Sprinkler method 2.50cm/0.5 ratio	12167	55.70	-26.21	30.96	21.83
	Surface method 5.0cm/1.0 ratio	16489	80.70	--	--	20.42
Groundnut	Sprinkler method 3cm/0.6 ratio	1756	59.10	19.00	-6.70	2.90
	Surface method 5cm/0.6 ratio	1476	55.10	--	--	2.68
Soyabean	Sprinkler method 5cm/1.0 ratio	1634	22.50	-2.00	29.02	3.42
	Surface method 5.0cm/1.0 ratio	1636	31.70	--	--	3.41

Compiled from Rajagopal (1998).

Rain Gun Irrigation Systems

- **Cost:**
  INR 15000 – 20000

- **Radius of Throw:**
  50 -100 feet

Focusable Research in sprinkler irrigation

- Strategies for achieving higher (> 80%) distribution uniformity (DU).
- Effect of discharge variations within the system on DU.
- Minimizing spray losses due to evaporation and wind drift.
- Evaluating optimum spacing arrangements of sprinkler heads viz., rectangular, square, and triangular.
- Optimizing the overlapping of wetted diameters under low and high wind situations.
- Fertigation through sprinkler system.
- Promoting use of plastic impact sprinklers.

Water saving over the conventional method of irrigation

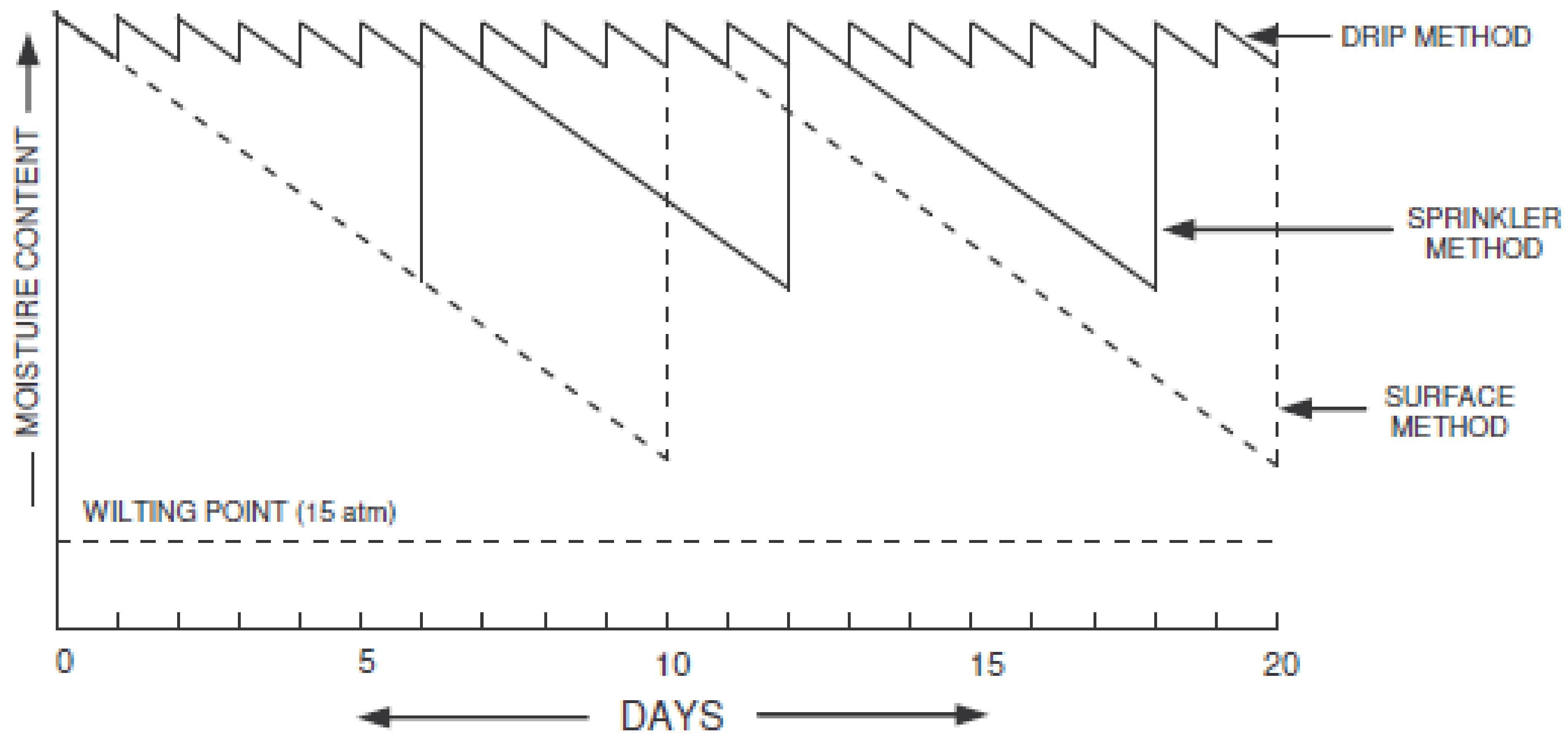
1. Vegetable crops: 12 - 40 % /ha
2. Fruit crops: 30 – 50 % /ha
3. Cotton, coconut & groundnut: 35 - 55 % /ha
4. Sugarcane: 40 % /ha

Irrigation Efficiencies under Different Methods of Irrigation (Percent)

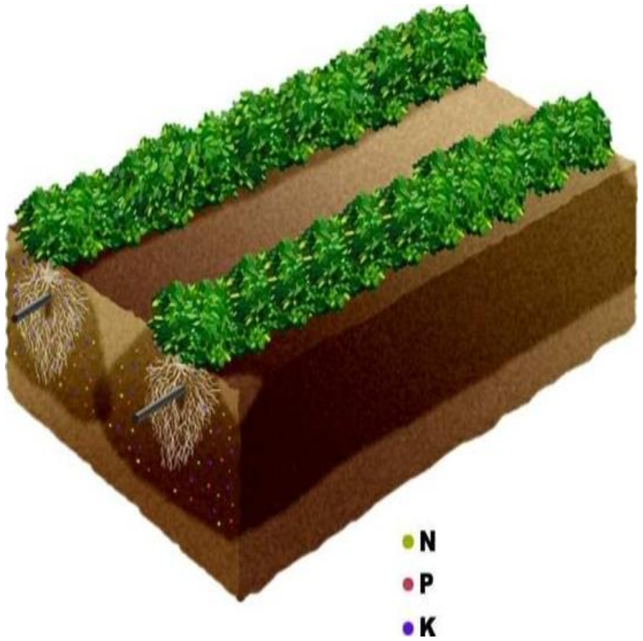
Irrigation Efficiencies	Methods of Irrigation		
	Surface	Sprinkler	Drip
Conveyance efficiency	40-50 (canal) 60-70 (well)	100	100
Application efficiency	60-70	70-80	90
Surface water moisture evaporation	30-40	30-40	20-25
Overall efficiency	30-35	50-60	80-90

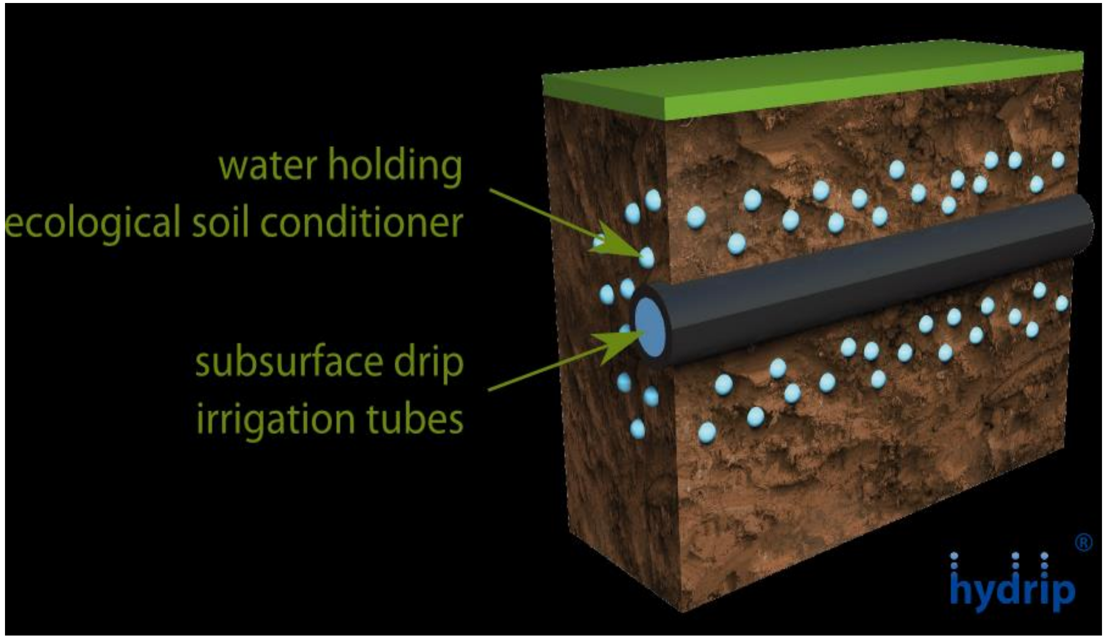
Source: Sivanappan (1998).

Moisture availability for crops under different methods of Irrigation



Subsurface Drip Irrigation





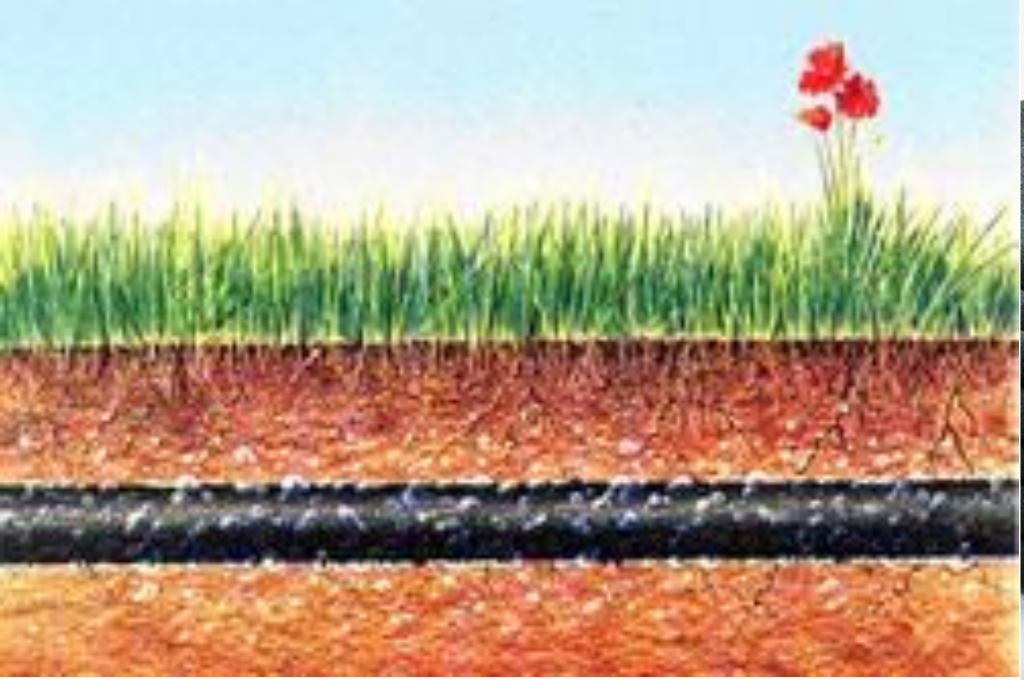
Subsurface Drip Irrigation

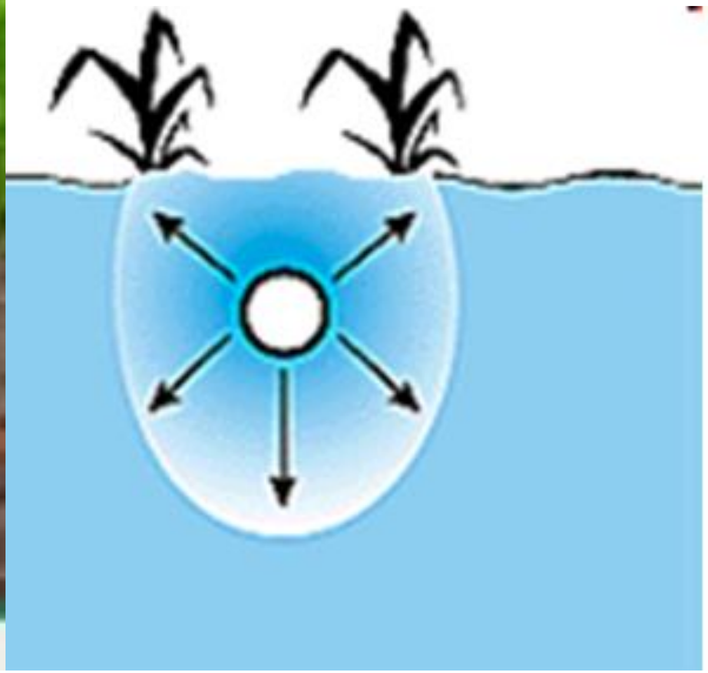
- Irrigation requirements of maize reduced by 10% or more (Lamm et al., 1995) over surface drip
- Fertilizer us efficiency can be enhanced to 15% (Lamm et al., 1997b)
- Application of wastewater through SDI greatly reduce pathogen transfer to edible crops (Oron et al., 1995; Oron et al., 1991, Oron et al., 1992)

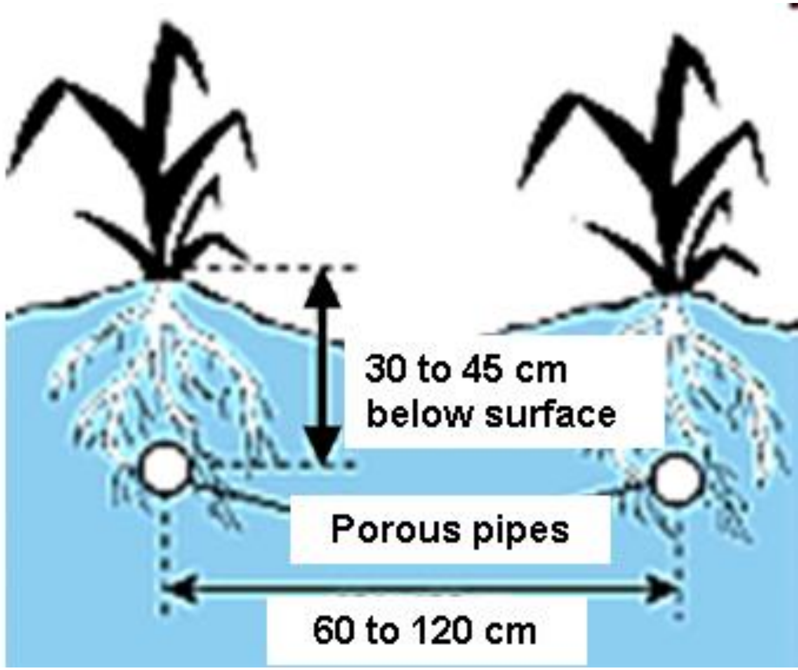
Subsurface Drip Irrigation

- Positions of placing the subsurface drip irrigation system
- Shallow - 0.5- 10cm deep
- Medium – 10- 25cm deep
- Deep – deeper than 25 cm
- Thinner wall thickness (0.15 - 0.6mm) dripper lines are used in SSD than on surface drip irrigation (0.6 – 1.2mm) system.
- When irrigating with saline water, keep dripper lines shallower to prevent built-up of salts in the active root zone.

Porous Irrigation System

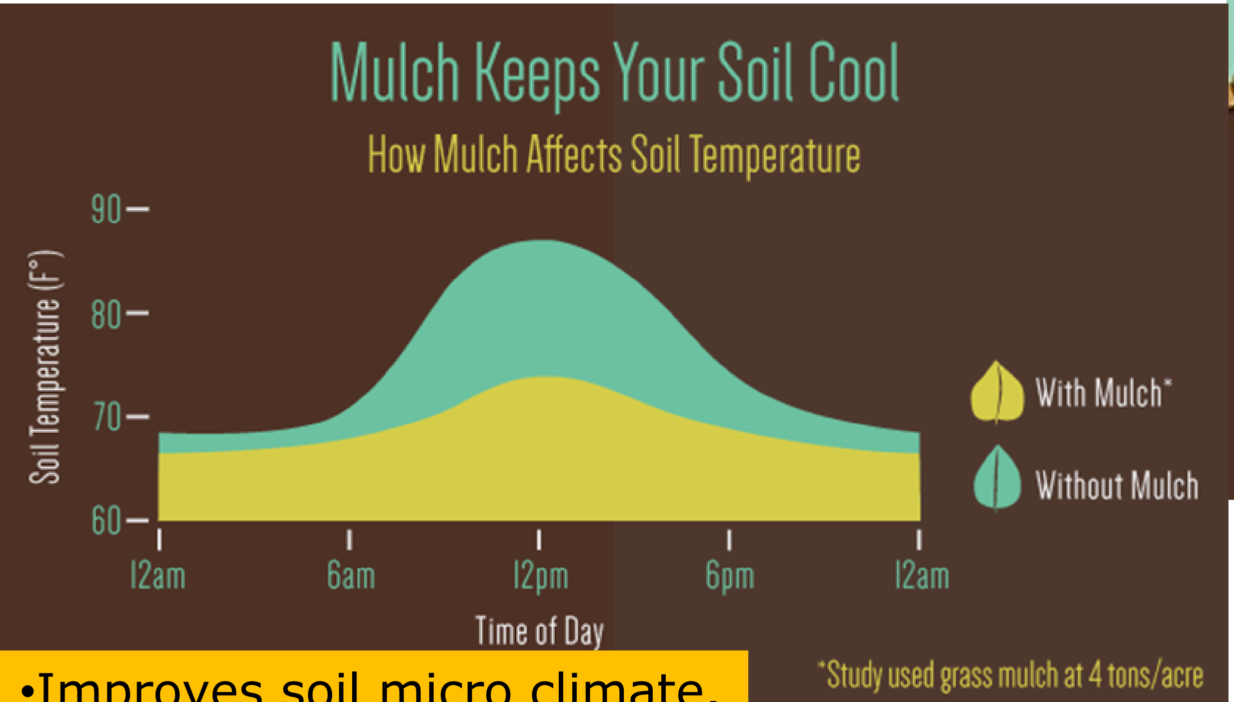









1. Prevent evaporation component of ET
2. Water saving to 40% - 70% over drip irrigation
3. Improves quality and ensure early maturity
4. Save fertilizer (30%) and labour cost (10%).
5. Control diseases
6. High Water Use Efficiency over drip



•Improves soil micro climate.

Benefits Of Mulching

Field Experimental Detail

1	Main Plot	Irrigation regimes (IW/ET_c)	I_1	0.60 IW/ET_c
			I_2	0.80 IW/ET_c
			I_3	1.00 IW/ET_c
2	Sub Plot	Frequency of irrigation	F_1	Once in a 2 days
			F_2	Once in a 3 days
			F_3	Once in a 5 days
3	Sub-Sub Plot	Mulching Material	M_1	Silver Black Plastic Mulch (20 micron)
			M_2	Biodegradable Plastic Mulch (20 micron)
			M_3	Wheat straw mulch
			C	Control (No mulch)

Silver Black Plastic Mulch

1. Irrigation water saved by 15.43%, 11.47% and 19.78% over no mulch treatment at 0.6 IW/ET_c, 0.8 IW/ET_c and 1.0 IW/ET_c
2. Highest seed cotton yield = 4661 kg/ha at 0.8 IW/ET_c and 3 days irrigation frequency.
3. Lowest observed (1431 kg/ha) in no mulch at 1.0 IW/ET_c and 5 days irrigation frequency.
4. Yielded net extra income of Rs. 81117/ha over no mulch treatment at 0.8 IW/ETc and 3 days irrigation frequency.
5. Payback period was 1.27 years.
6. Recorded good qualitative parameters at 0.8 IW/ETc and 3 days irrigation frequency.

Wind energy is increasingly becoming a viable option to meet energy needs in South Asia.

A mini powergrid enables off-grid households to have access to electricity supply.

Solar lanterns are a cleaner and safer renewable energy source for low-income people in off-grid areas.

Promoting Clean Energy use in agriculture for

- Pumping
- Farm and household lighting

Strategies to sustain crop yields in the arena of climate change

- Micro-irrigation and resource conservation technologies (RCTs), for economizing water is to be promoted
- improvements in irrigation efficiency are critical to ensure the availability of water for food production
- Wastewater (18.4 million m^3/day) needs to be utilized for irrigation after its proper treatment
- Adoption of varieties with increased resistance to high temperature and drought.

Strategies to sustain crop yields in the arena of climate change

- Adoption of efficient technologies to 'harvest' every drop of rain water on field and off field
- Development of structures to provide more infiltration opportunity time for water recharge
- Modification of crop calendars, i.e., timing or location of cropping activities to eliminate losses due to climate change
- Developing thermo resilient, salt tolerant and water logging tolerant cultivars of our major crops

Strategies to sustain crop yields in the arena of climate change

- Need to revise IDF curves
- Research to attain higher yield production systems with reduction in GHG emissions per unit of production and protect water and soil quality — a process called ecological intensification is needed
- Integrated research to raise crop yield, nutrient and water use efficiency

The Way Forward : Our Priorities

- Controlled irrigation cum drainage structures needs to be developed.
- Develop climate smart villages by integrating hydrologists, crop specialists, and agro-meteorologists.
- Develop early warning and forecasting systems village wise.
- Water grid concept should be developed at micro level.
- Subsurface irrigations needs to be prioritized.
- Development of low energy irrigation systems.
- Micro level land use planning and capacity building of farmers.

The Way Forward : Our Priorities

- Afforestation on degraded forests, wastelands as well as river banks to facilitate soil conservation, recharging of ground water and preventing flooding of rivers and siltation of water reservoirs.
- Increase of irrigation efficiency from 35% to 50% in surface irrigation systems.
- Development of 80 Mega hectares of wastelands.
- Reduce cost of cultivation by improving mechanization.
- Strengthening market linkages and supply chains for agricultural products and technologies.

The Way Forward : Our Priorities

- Training farmers to enhance agricultural yields and revenues.
- Facilitating investments through public private partnerships for expanding capacity and improving management of grain silos and warehousing.
- Compelling farmers to adopt MIS in canal and ground water command areas.
- Prevention of water pollution by banning the discharge of untreated sewage and effluent in rivers .
- Encouraging Public Private Partnership, including civil society organizations and stakeholders in water resources development and conservation.

AAU

कृणवन्तो राष्ट्र कृषि संपन्नम्

THANK YOU